Research Study No. 2021/01 *Final Report*

Estimating and Bridging the Yield Gaps in Oilseeds for Atma Nirbhar Bharat

Yogesh Bhatt

Agricultural Economics Research Centre

University of Delhi

Delhi - 110007

July, 2022

Research Team

Dr. Yogesh Bhatt, Assistant Professor, AERC Delhi

Mr. Parmeet Kumar Vinit, Research Investigator, AERC Delhi

Ms. Varnika Jain, Research Investigator, AERC Delhi

Mr. Utkarsh Yadav, Research Investigator, AERC Delhi

Mrs. Renu Sain, Research Investigator, AERC Delhi

Library and editing support

Mrs. Nandi Negi

Administrative and general support

Mr. Md. Asghar Ali

Mr. Himanshu

Mr. Pramod Kumar

Mr. Abbas Hasan

Mr. Raj Kumar

Mr. Gopal

***Acknowledgement**: The team is grateful to Prof. P. K. Joshi, Former Honorary Director and to Prof. Paramjit, Director (Acting) at Agricultural Economics Research Centre (AERC) -Delhi for their guidance and valuable suggestions in preparing this report.*

Preface

The present study has been undertaken for the Ministry of Agriculture & Famers Welfare. The study attempts to present the status of the oilseed production in India. In particular, the focus is on the oilseed yield, its variability across the Indian states and the districts across the major producing states. This research focuses primarily on the global output of oilseeds, the comparative status of India in oilseed production and productivity, oilseeds and edible oil trade by India, and the factors affecting oilseed yield. The study utilized both, the secondary as well as the primary data for analysis. The primary data is collected through field survey visits by the participating Agricultural Economic Research Centres at Vallabh Vidyanagar (Gujarat), Pune (Maharashtra) and Jabalpur (Madhya Pradesh) for the covered states.

We sincerely thank all the officials at the Ministry of Agriculture & Farmers Welfare for supporting this study. We would like to express our thanks to all the participating Agricultural Economic Research Centres, for their timely confirmation to participate in this study and active support during the planning, field survey and data sharing. We would also like to thank all the district officials in respective study states for their support during the field survey on behalf of the participating AERCs.

The idea to undertake this study was proposed by Prof. P. K. Joshi, our former honorary director at this centre. His guidance from the preparation of study proposal till the final drafting despite various odds is commendable. His enthusiasm encouraged the whole team to deliver all possible efforts to prepare this report better at our level. We are thankful to Prof. Joshi for his guidance, time and support. We would also like to thank Prof. Paramjit, our Acting Director, for his support in all respect since his joining at this centre. We also thank Prof. C.S.C. Sekhar, Prof. Sangeeta Shroff, Prof. Ranjan Ghosh and other faculty members from various AERCU/Cs, and Prof. Surender Kumar from DSE, for their support and guidance in preparing and improving this report. Last but not the least, we would like to thank our colleagues at the Agricultural Economics Research Centre, University of Delhi for their support.

July, 2022 Yogesh Bhatt and team

Table of Contents

List of tables

List of figures

Estimating and Bridging the Yield Gaps in Oilseeds for Atam Nirbhar Bharat

Executive summary

Yogesh Bhatt, Parmeet Kumar Vinit, Varnika Jain, Utkarsh Yadav, Renu Sain

Introduction

Oilseeds are an important field crop grown in many parts of India. The diverse agro-ecological conditions in the country are favourable for growing nine annual oilseed crops, which include seven edible oilseeds (groundnut, rapeseed & mustard, soybean, sunflower, sesame, safflower and niger) and two non-edible oilseeds (castor and linseed) and several perennial oil-bearing tree crops. In addition, oilseeds of tree and forest origin, which grow mostly in tribal inhabited areas contribute significantly as minor source of oil, including coconut and oil palm. Among the non-conventional oils, rice bran oil and cotton seed oil are also important, along with small quantities from tobacco seed and corn.

At present, the country is not able to meet the demand of edible oils. The existing low yield of these oilseed crops which are grown in unirrigated or less irrigated regions in many parts is an important reason to not able to increase and sustain the oilseed production. India is lagging as compared to the other major oilseed growing countries in the world. There is a lot of variation in oilseed yield among the major producing state within the country and among the major producing districts within the growing states. The low yield along with other factors impacting the yield and hence the production of oilseeds is dragging India to become the net importer of the oilseeds in different form, majorly the edible oil in crude and refined form.

On the other side, the edible oil consumption trends reflect that at present there is consumption of about 19.2 kg of edible oil per capita per year in India in year 2019-20 as compared to 3.8 kg per capita per year during year 1980-81. Due to the unmet demand, there is surge in import of the edible oils over time and any unfavourable global situation such as climatic like drought, and the war like situations have direct additional impact on the imports and hence on the price hike of edible oils and related products. There is scope to improve the oil extraction through precision technologies and organised industrial operations, focusing on the secondary and other alternative sources of edible oils including palm, rice bran, cotton seed production etc, but these may be not enough alone to meet the huge demand of edible oil.

This study highlights the global and Indian oilseed and edible oil production focusing the oilseed yield at the core. The yield gaps in the major oilseed crops are presented at the global level and within the state and district level in India. For this purpose, majorly the secondary data sources are used to reflect the trend, variations and growth rates in oilseed yields. For this purpose, the major states and districts with high acreage under the oilseed crops are selected using a suitable sampling methodology to mainstream the focus on important states and districts. The presentation of the yield gaps is preferred through the state and district level mapping to highlight the lagging regions. The yield gaps in the yield at the demonstration level results of KVKs and at the farmers plot are also highlighted to reflect the lagging status of oilseed yield within country. This is supplemented through the variety level yield performance of different oilseeds crops for major producing states. The factors impacting the yield of oilseed crops are elaborated using the secondary data based on CoC database and through the primary data collected from field survey. The perceptions of the households on important ground level issues impacting crop yield are also discussed. The status of oilseed and edible oils' trade during recent two decades is discussed and an attempt is made to highlights India's potential to produce edible oil from secondary alternative sources.

Yield gaps in oilseeds

Oilseed yield at global level

The average yield of selected edible oilseed crop at the global level has increased about 2.7 times from the historical levels of 1961. It took about four decades to oilseed yield get doubled during in 2000, and additional two decades to reach at 2.7 times in 2019. The oilseed acreage also increased about 3.3 times till 2019 from 1961. Hence, reflected the production increase of 8 times till 2019 as compared to 1961. The major oilseed crops produced in the world include – soybean (63.7% production share as of 2019), 'rapeseed & mustard' (13.6%), sunflower seed (10.7%), groundnut (9.3%) and sesame seeds (1.3%), together holding about 98.6% world oilseed production, excluding palm oil seed production. Indonesia is the largest producing country of palm fruits, holds 60% of global production under palm cultivation, followed by Malaysia and other minor producing countries - Thailand, Nigeria and Colombia.

The highest proportionate change in average global yield is witnessed for 'rapeseed & mustard' crops, the yield is increased from 0.6 tonnes/hectare in 1961 to above 2 tonnes/hectare in 2019 (increased about 2.6 times). Similarly, the yield of soybean is increased 1.5 times and yield of sunflower is doubled during this period. The average yield of groundnut and sesame is still not get doubled during this six-decade period. The production of palm oil from the fruit tree is measured in fruit bunches and yields about 14.5 tonnes per hectare. In the recent decade

2011 till 2019, the yield of palm, groundnut, sesame seed mustard and castor seed witnessed stagnation or decline.

India stands 5th in global oilseed production from field-based crops with 6% production share as of 2019 from close to 11% of global acreage share, stands 3rd in global acreage share. Brazil is the largest producing country of the oilseeds, holds about 22% of total oilseed production, followed by USA, Argentina and China in this order. Palm fruit and oil production in India is negligible as compared to other producing countries.

India is among the top producing country in the world of many of the edible oilseeds and among the top consumer of the edible oils. The computations drawn from the Global Market Analysis report of the Foreign Agricultural Service-United States Department of Agriculture for January-2022 suggests that the domestic consumption of major selected vegetable oils in India is close to 10.7% of world consumption. India also accounts for about 17.2% import of these selected major vegetable oils. India is world's largest producing country of castor seed, the second largest producing country of groundnut, third largest producing country of rapeseeds and sesame seeds, fifth largest producing country of soybean and sixth largest producing country of sunflower seeds and linseeds in the world as of year 2019.

But the country is witnessing a low yield of many of the oilseeds produced in India as compared to most of the other major producing countries. The yield of soybean in India in 2019 is less than the yield in year 2000 of all other major producing countries. India is lagging by nearly two-third of yield, as the yield is just about 35.8% as compared to the 'highest yield' country - Argentina and just about 37.4% compared to Brazil, the largest producing country of soybean. Similarly, the yield of groundnut in India is much less than, just about one -third, the yield in the largest producing country - China and highest yield reporter country - USA. The yield of rapeseed, sunflower, linseed, safflower and sesame in India is almost at the lowest level among the major producing countries except a few cases. The yield of castor seed is high in India and India is the largest producing country of castor seed and oil in the world.

The yield gaps in yield in India as compared to the highest yield country among the top producing countries of different oilseeds suggests – the yield in India is 2.1 tonnes/hectare less than the yield of soybean in Argentina, 3 tonnes/hectare less than the yield of groundnut in U.S.A., 1.7 tonnes/hectare less than the yield of rapeseed in France, 2 tonnes/hectare less than the yield of sunflower in China, 0.33 tonnes/hectare less than the yield of sesame seed (in general a low yield oilseed crop) in Nigeria, 0.9 tonnes/hectare less than the yield of linseed in Canada, 1.3 tonnes/hectare less than the yield of safflower seed in Mexico.

India's edible oil status

India produced about 116.3 lakh tonnes of edible oil from the primary and the secondary sources in 2019. The edible oil production in India witnessed an annual growth of about 2.2% since 1995-96 till 2019-20, majorly contributed from the secondary sources (3.3% per annum), compared to primary sources (1.8% per annum) which have about 68% share (as of 2019-20) in total edible oil production, declined from 75% share as in 1995-96. This reflects the increasing share of alternative edible oils in India's edible oil basket. On the consumption side, the demand for edible oil in 2019-20 is about 241 lakh tonnes which is much higher than the total production. The per capita availability of the edible oil is increased from 3.2 kg per person per year in 1960-61 to about 19.2 kg per person per year in 2019-20 whereas the per capita availability of Vanaspati is stagnated at 0.6 kg per person per year. This reflects the shift towards and the increasing demand for the edible oils in India over a period. But the production targets set for the oilseed production are hardly achieved in past many years, in only 3 out of 17 recent years, and only five times the country were able to achieve above 90% of set production targets. Whereas, for wheat and paddy, the targets were achieved in at least 11 times since 2003.

soybean is the largely grown oilseed crop in India holds about 34% production share in 2019-20, followed by groundnut (30%), rapeseed-mustard (27.5%), castor seed (5.5%), sesame seeds (2%), sunflower (0.6%), linseed (0.4%), safflower (0.1%) and niger seeds (0.1%) among these selected crops. Rajasthan holds the highest production share of these oilseeds, at about 20.4%, followed by Gujarat (20%), Madhya Pradesh (19.4%) and Maharashtra (15.6%), these four states al-together hold close to 75% of the total oilseed production in India as of 2019-20. There is about 16.3% of area under nine-oilseeds of the total area shown in 2020-21 under the major food groups.

At the crop specific level, area share of states in 2019-20 reflects - Madhya Pradesh (43.5%) and Maharashtra (43%) are two major producing states of soybean in India. Similarly, Gujarat (47%), Rajasthan (16.3%), Tamil Nadu (10.4%), Andhra Pradesh (8.5%) and Karnataka (5.1%) are is the largest producing states of groundnut. Rajasthan (46%) Haryana (12.6%), Madhya Pradesh (11.4%), Uttar Pradesh (10.5%) and West Bengal (7.8%) are major rapeseed & mustard producing states. West Bengal (20.5%), Madhya Pradesh (19.2%), Gujarat (16.4%), Rajasthan (14%) and Uttar Pradesh (10%) are the major producing states of sesame seed. Gujarat (77.7%) is the single largest producing state of castor seed. Karnataka (48.6%) is the largest producing state of sunflower. Karnataka (57.9%) and Maharashtra (34.2%) are the two largest producing states of safflower. Madhya Pradesh (37.4%), Jharkhand (19.1%) and Uttar Pradesh (15.4%) are the major producing states of linseed. Odisha (47.6%) and Chhattisgarh (23.5%) are largest producing state of niger seed.

Yield gaps in oilseeds in India

As mentioned, India is lagging in productivity of most of the oilseed crops grown as compare to the other major producing countries. Measures to be taken to enhance the productivity of these oilseed crops considering limited acreage allocation options and to reduce dependency on imports and to fulfil the unmet demand of edible oils. Though, the yield of most of the oilseed crops is improved over time, especially during the recent period (2019-20) compared to previous periods of time, but, the yield of some of the minor oilseed crops it is still very low levels.

Oilseeds' yield at state level

An attempt is made to analyse the yield gaps of the major oilseed crops at the state level. The outcome is abstracted in the summary table below by regions and state.

The growth rates of yield were analyzed for three phases - phase I (from 1966 to 1985), phase II (from 1986 to 2004) and phase III (from 2005 to 2019). For most of the oilseed crops the growth during three phases witness positive side except few cases – soybean and safflower during phase I & III, sunflower during phase I and niger seed during phase II. Groundnut, sunflower and linseed witnessed a positive yield rate over the phases while safflower and castor seed reflected a positive but declining rate over the periods mainly due to high initial growth. Rapeseed & mustard and sesame witnessed stagnating growth and soybean and niger seed reflected no clear direction of growth over the study phases.

For soybean, the highest growth in the crop yield is witnessed during the phase I, especially in the states of Gujarat and Rajasthan. Maharashtra, Karnataka and Gujarat dominated the yield growth during phase II but only later two states were able to hold it during Phase III. For groundnut, Gujarat and Rajasthan were continuing the yield growth momentum during all the three phases. For the other major producing states, the growth during the phase III is witnessed better than the previous two phases. Most of the major producing states except Uttar Pradesh growing rapeseed & mustard witnessed highest growth during phase I, mainly due to high yield seeds and improvements in irrigation facilities during yellow revolution. The growth witnessed stagnated during the phase II but the again picked up in the recent phase. The sunflower yield improved in Odisha during the recent two phases but Maharashtra witnessed a negative growth of nearly -4.6% per annum during the recent phase. The safflower yield in the major producing states is worsening over the phases. The sesame yield improved in most of the states during phase II and holding the growth except West Bengal. Rajasthan and Andhra Pradesh for castor seed, Madhya Pradesh and Uttar Pradesh for linseed; and Madhya Pradesh for niger seed also performed better in yield growth in the recent phase.

Table 1: Major oilseed crops - yield levels by region and states

Crop	High yield			Low yield		
	Region	Major states	Comment	Region	Major states	Comment
soybean	South	Telangana, Karnataka	States hold 4% area share. Not much improvement in yield	West, Central	Rajasthan, Maharashtra, Madhya Pradesh	States hold 95% area share. Yield stagnated around 0.8 to 1.2 T/Ha.
Groundnut	South, West	Tamil Nadu, Gujarat, Rajasthan	States hold 26% area share. Yield improved overtime from 0.62 to 3.92 T/Ha.	South	Andhra Pradesh, Karnataka	States hold 24% area share. nearly 2.5 times to 3 times lower yield w.r.t. high yield states
Rapeseed & mustard	North	Haryana	9-10% area share, Yield improved about 2.3 times from 1985-86	Central, West East	West Bengal, Rajasthan, Madhya Pradesh Uttar Pradesh	States hold 75% area share, Yield improved but not much, 0.66 to 1.56 T/Ha.
Sesame	East	West Bengal	16% area share, high base yield, yield stagnated around 0.6 to 0.8 T/Ha.	North, West, Central	Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat	States hold 65% area share, yield stagnated around 0.1 to 0.6 T/Ha.
Sunflower	North, East	Haryana, Odisha	States hold 11% area share; better yield in HR (1.6 to 1.9 T/Ha.), yield improved in OD (0.5 to 1.25 T/Ha.)	South, West, East	Maharashtra, Karnataka and Andhra Pradesh	States hold 72-73% area share, yield stagnated around 0.4 to 1 T/Ha.
Safflower	South	Karnataka, Telangana	States hold 54% area share, high base yield, yield stagnated around 0.5 to 0.8 T/Ha	Central, South, West	Andhra Pradesh, Jharkhand and Maharashtra	States hold 44% area share, low yield, yield stagnated around 0.3 to 0.6 T/Ha
Castor	West	Gujarat, Rajasthan	States hold 90% area share, high base yield, In GJ yield stagnated around 1.2 to 2 T/Ha; In RJ yield improved from 0.2 to 1.4 T/Ha	South, West	Maharashtra, Telangana and Andhra Pradesh	States hold 7-8% area share, low yield, yield stagnated around 0.2 to 1 T/Ha
linseed	North, Central	Uttar Pradesh, Madhya Pradesh	States hold 44% area share, low yield stagnated around 0.2 to 0.7 T/Ha	Central, East	Chhattisgarh, Jharkhand, Odisha	States hold 36-37% area share, low yield stagnated around 0.3 to 0.6 T/Ha
niger seed	East	Assam	4% area share, low yield at 0.6 T/Ha	Central, East, West	Maharashtra, Madhya Pradesh, Chhattisgarh, Odisha	States hold 87% area share, low yield stagnated around 0.2 to 0.4 T/Ha

In general, for most of the oilseed crops, the yield volatility is ranging from 10% to 20% range except few cases of high yield variability such as safflower and castor seed during phase I and phase II; and groundnut and niger seed during phase III. Considering the top 10 major producing states, for groundnut and rapeseed & mustard, there is a clear increasing trend in average crop yield but the volatility in yield is increasing for groundnut and stabilized for rapeseed & mustard. There is slight improvement in yield of soybean but no visible trend in yield variations.

The decomposition analyses these three phases reflects, on the overall basis, the change in production of oilseed crops during phase I and phase III is mainly contributed due to increase in yield of different oilseed crops but during the phase II, change in area and yield equally contributed the production increase, also reflected through the combined interaction effect. For soybean, the change in production is mainly driven by the area effect during all the three phases. Contrary to this, for groundnut and for rapeseed & mustard, with less clarity, the change is driven mainly due to the change (increase) in yield, especially during phase I and III.

Oilseeds' yield at district level

An attempt is made to analyse the yield gaps of the major oilseed crops at the district level in major producing states for the year 2018-19. The emphasis is given to the major producing states. The production of many of the minor oilseed crops is concentric to a limited number of states and districts. The list of districts within the major producing states delivered low yields are reported in the Table 8.2.

Table 2: Major oilseed crops - yield levels by region and states

Crop	State	Districts with low yield
soybean	Madhya Pradesh	Whole of the state (except Indore, Ashoknagar, Dhar, Shajapur)
	Maharashtra	Whole of the state (except Gadhchiroli, Kolhapur and Sangli)
Groundnut	Gujarat	Amreli, Rajkot, Jamnagar, Kuchchh, Porbandar, Junagarh and Surendranagar (West), Kheda, Sabar Kantha (North), Dang and Tapi (South east)
	Rajasthan	Whole of the state (except Churu, Jhunjhunu, Sikar and Bikaner districts)
Rapeseed & mustard	Rajasthan	Whole of the state (except few Eastern districts – Bharatpur, Dholpur, Alwar, Baran and Karauli)
	Madhya Pradesh	Whole of the Easter and Western part and districts of Northern part except Bhind and Morena
Sesame	Madhya Pradesh	Whole of the Central and East part; Bhind, Morena, Seopur, Shivpuri (North); Betul, Chhindwara, Seoni, Khandwa (South)
Sunflower	Karnataka	Koppal, Dharwad, Gadag, Chikmangalur, Haveri, Davangiri, Bagalkot (Central), Baijapur, Yadgir, Gulbarga (North), Raichur, Bellary, Chitradurga (East), Belgaum (West)
Safflower	Karnataka	Koppal, Dharwad, Gadag, Bagalkot (Central), Baijapur, Yadgir (North), Raichur, Bellary Chitradurga (East)
Castor	Gujarat	Kuchchh, Surendranagar, Amreli, Rajkot, Jamnagar and Junagadh (West), Panch Mahals, Bharuch, Ahmedabad, Kheda, Anand and Patan (East)
linseed	Madhya Pradesh	Whole of the Easter part; Neemuch, Mandsaur and Ujjain (West)
niger seed	Odisha	Sundergarh, Kendujhar (North), Makangiri, Kalhandi Gajapati, Kandhamal, Rayagada and Koraput (South west)

The oilseed crop yields at the 'farmer's plot' and at the 'demonstration' stage is reported by KVKs for major oilseed crops. At the KVKs level, the 'yield gap', the gap between the yields at the demonstration level with respect to yield reported at the farmer's plot is analyzed. The district level responses from the KVK stations are arranged altogether to reach at aggregate state level results. The soybean producing state Madhya Pradesh reported the highest yield gap between the demonstration level and at the farmer's plot, followed by Maharashtra. Among the minor producing states this gap is high in Chhattisgarh and Karnataka. Demonstration yield is recorded high in Maharashtra but not reflected significant at the farmer's plot. For groundnut, the highest yield gaps are observed in Karnataka and Tamil Nadu (major producing states) and in Chhattisgarh, Maharashtra and Jharkhand (minor producing states). Rajasthan perform better in yield during both the phases, compared to other major states. For mustard, Haryana is the only major producing state witnessed the highest yield during both phases, infect none of the other major producing states were able to reach at the 'plot' yield of Haryana during the demonstration level. Yield gaps reported high for Uttar Pradesh, Madhya Pradesh (major) and Chhattisgarh, Jharkhand and Assam (minor).

West Bengal perform better to deliver higher yield of sesame during demonstration stage and at the farmer's plot with low yield gaps, also witnessed in Gujarat. The higher yield gaps are observed in Karnataka (for sunflower), in Andhra Pradesh and Maharashtra (for safflower), in Chhattisgarh, Madhya Pradesh and Jharkhand (for linseed) and in Odisha (for niger seed). The results of the yield gap analysis at the variety level reflects the widening the gap range across the varieties during actual implication. There are varying yield and the yield gaps for same variety across the states and KVKs.

Factors affecting the oilseeds' yield

An attempt is also made to analyse the factors affecting the oilseed yield at the state level using the secondary data and primary data sets. Using the secondary data from the plot level Cost of Cultivation (CoC) database from year 2000 to the latest available point, the oilseed yield is modelled using the Stochastic Frontier Analysis (SFA) and the technical efficiency scores at the state, cop and year specific level are analysed. The final model specifications were reached by comparing the fixed effect model and the random effect model using the Hausman test as prior diagnosis for SFA.

The analysis resulted that there exists a positive and statistically significant relationship between labour cost and seed cost with yield. The fertilizer cost does not reflect much insignificance to the yield. The positive and statistically significant time coefficient representing technical progress taking place over the time for yield improvements. The coefficient of the exogenous variable irrigation cost is negative and statistically significant to technical inefficiency, i.e., contributing positive to technical efficiency (TE) achieved through irrigation to improve the yield.

The highest technical efficiency (TE) score is observed for soybean and rapeseed & mustard crops (at 72%), while the TE scores for safflower (66%) and groundnut crop (68%), indicates up to 32% yield enhancement is still achievable through better combinations of various inputs used. At the state specific, yield enhancement is still achievable in Rajasthan (for sesame seed) and Karnataka (for safflower). No clear trend is observed if the TE is improving over the years at the farm level, though it is close to maximum level in past couple of years.

The similar analysis of factor impacting the oilseed yield is also performed using the primary data gathered from the field surveys in the study states by the participating AERCs. The Ordinary Least Square regression model is applied to the dataset for major three major oilseed crops in study states. The results suggest that there is positive and significant effect of pest, manure and weedicide quantity use on soyabean yield in Madhya Pradesh, whereas, higher the seed, manure and weedicide cost impact the crop yield. In Maharashtra, higher the fertilizer use, seed use and machine cost, higher the crop yield, but the cost of fertilizers, higher fungicides and pesticides use impacted the yield, negatively.

In Gujarat, the farmers used higher fertilizers, seeds and labours, does not get higher yield of groundnut but the farmers who invested more on labour, seed, fertilizer and irrigation charges (as proxy to higher irrigation with uniform applicable rates) get higher groundnut yield in the state. In Rajasthan, except the increasing machine and pesticide cost, all other factors such as – higher labour, machine and fertilizer use, higher cost incurred on seed and irrigation helped farmers to get better groundnut yield. For rapeseed & mustard, seed and fertilizer use, higher machine hours and farming experience have positive effect on crop yield in Rajasthan, whereas the increasing machine and irrigation cost impacts the crop yield.

Farmer's perceptions on oilseeds' yield

Farmers perceptions are important to understand the issues those are faced by farmers in oilseed cultivation. About 50% sampled farmers are not satisfied with the yield they are getting. The 'high dis-satisfaction' with the current yield is observed among the rapeseed & mustard farmers in Rajasthan (43.6%) and soybean farmers in Madhya Pradesh (35.5%). Only 44% are able to get the improved subsidized seeds and only one-third of the farmers received the trainings about oilseed production. Groundnut farmers in Rajasthan and soybean farmers in Maharashtra are most dis-satisfied, and the soybean farmers (about training).

Better coverage of crop insurance is encouraging sign, especially for soybean but the coverage can be improved for groundnut. The soil testing is limited to about 60% farmers but of this only few are using the recommended doses. There is scope to improve the testing on regular basis. There is limited exposure of post-harvest management, especially for soybean.

The groundnut farmers in Gujarat and the soybean growers in Maharashtra and Madhya Pradesh responded the ‘seed quality’ and the farmers from Rajasthan highlighted the ‘impact of the climate’ as the most influencing factors affecting the oilseed yield. There is scope to improve the availability of weedicides and fungicides/seed treatment facilities, beside these farmers are also not aware about the doses of these inputs. Most of the farmers in Maharashtra and more than half of the farmers in Rajasthan are impacted through drought in recent 5 years.

The farmers are not satisfied with most of the inputs, especially of the fertilizers and pesticides, followed by that of weedicides. In general, the high input cost, effect of changing climatic condition and lack of irrigation facilities impacting yield of the dis-satisfying farmers. While, improving the input’s quality, encouraging awareness of farmer through training programmes improving the irrigation facilities are the important suggestions from farmers to improve oilseed yield.

Broadly, the study highlights that in Maharashtra the frequent prevailing drought conditions impacting the soybean yield leaving farmers with the less output available and hence denting the profit gains. In addition, the quality of seed and soil, fertilizer use and irrigation issues also influence the yield of the soybean. In Madhya Pradesh, the farmers growing soybean facing very limited or no exposure to trainings. limited awareness among the farmers on inputs use especially on seed treatment, fungicides, fertilizer and weedicides. The dissatisfaction among the farmers over the fertilizer, weedicides and seed treatment/fungicide prices. The farmers are not much aware on post-harvesting, and face high transportation charges, lack of remunerative price and malpractices in market.

The groundnut growers in Gujarat face issues such as un-time availability of the fertiliser, pesticides and seeds during the season, crop losses due to bad quality seeds and wild animals, erratic rainfall as major problems. Farmers expects from government to encourage processing facilities to support groundnut selling in local regions. In Rajasthan, groundnut farmers are unaware about variety use, non-availability of human labour during weeding and harvesting time, erratic electricity supply for irrigation. Farmers are willing to get support on better irrigation, better marketing for groundnut and opening of processing facility in the local region.

In Rajasthan, the marginal and small farmers growing rapeseed & mustard are unaware on marketing related information and not able to get support price. The erratic electricity supply, untimely and non- availability of good quality of seed, irrigation related issues are the major problems for these farmers. The improved and high yielding varieties, technological extension, irrigation facility through regular electricity supply can help them to enhance the crop productivity. There is need to trained and aware the farmers on marketing related issues.

Prudence and optimism

The unmet demand of edible oils in India is fulfilled through import of edible oils. At present, India is the net importer of the edible oils. India imported nearly 135 lakh tonnes of edible oil in 2020-21. The import of edible oils has increased sharply recently. The import is ranging continuously above 140 lakh tonnes since 2015-16 for major edible oils except the year 2020-21. Of the India's total import of edible oils of nearly 135 lakh tonnes as in 2020-21, nearly 56.4% share is of the palm oil, followed by soybean oil (27%) and sunflower & safflower oil (16%). The major importer countries of palm oil are Indonesia, Malaysia, Singapore and Thailand. The soybean oil is imported from Argentina and Brazil in large quantity. Ukraine holds nearly 80% and above share in the sunflower and safflower oil import to India. Belgium and Russia are the largest importers of rapeseed & mustard to India.

The import of edible oil is witnessed an annual growth of about 10.6% during the period of 1995-96 to 2019-20 as compared to annual growth rate of about 2.2% in production. The export and industrial use of edible oil is stagnant during this period to close to about 10 lakh tonnes. In the recent year 2020-21, India has also imported nearly 6.3 lakh tonnes of edible oilseeds but at the same time above 11 lakh tonnes of oilseeds are also exported during 2020-21. This reflects the broader picture that India is importing edible oils in huge proportion but at the same time exporting the raw material - edible oilseeds and the by-products - oil cake in large quantity to the world. Indian edible oil market is much influenced by the international markets. The constant increase in consumption, low productivity of oilseeds and high price of traditional oils in India and low price in international market and liberalisation of trade policies resulted in the shift from self-sufficiency to highly import dependent in edible oils.

But India has a huge potential to produce edible oil from secondary oil sources to reduce this import dependency and to be self-sufficient again, especially during the current trade adverse and high inflation phases. For this purpose, an attempt has been made to present scenarios for potential production through increase acreage under palm oil trees and ensuring raw material supply to the mills and other extraction points to produce oil from maize, rice bran and cotton seeds at a specific and improved extraction rate for basic understanding.

The global palm fruit production in 2019 is reported at 410. 7 million tonnes which is higher than any of the field grown oilseed crop production. India produced nearly 279 thousand tonnes of crude palm oil in 2018-19. The growth in the global production of palm fruit is mainly driven by the increase in acreage in major producing countries during past six decades. The yield of palm fruit is declined in all the major producing countries and the decline rate is sharpened during recent decades. The yield of palm fruits is reported highest in Malaysia. The yield of oil palm fruits in India is comparatively very low at just 4.36 tonnes per hectare which is only above the yield in the Nigeria may be mainly due to being in initial phase of encouraging plantation. But the oil extraction rate from palm fruit is about 17% indicating positive signals.

Andhra Pradesh is the largest producing state of the palm oil in India contributed nearly 83.5% production share in India. This is followed by Telangana (13.3%). As per the assessment committee report in 2020, India can utilize nearly 28 lakh hectare acreage under palm trees plantation across the states. Assam, Tripura, Maharashtra, Arunachal Pradesh, Madhya Pradesh, Bihar and Meghalaya having potential to increase area above 1.2 lakh hectare in each. The potential production of fresh fruit bunches of palm in India under two reported scenarios may increase up to 126.27 lakh tonnes and the potential crude palm oil production can be increased above 6 times. This appears a reasonable better status as it will not be fulfilling the huge import gaps but will help to reduce the dependency of India on the top imported edible oil.

The 'total availability/the demand' of fresh fruit bunches of palm for the year 2019-20 is calculated at 1500 lakh tonnes, including the import equivalent of fresh fruit bunches of palm, at 1484.2 lakh tonnes. To meet this demand, and considering the best possible scenario among the discussed scenarios, the country need to increase the current acreage under palm tree plantation by 48.5 times compared to the area under palm tree plantation as in March 2020, and by 6.15 times compare to the potential area assessments of the re-assessment committee-2020. There are expectations that the promotion of GM oilseed crops may increase oilseed production by nearly 15 to 20 %. Also, the increasing the MSP for the edible oilseed can bring more acreage under oilseeds. Additionally, the impact of linking the import duty to the MSP may further be explored. Many of such planes are already demanded by various stakeholders over the time.

Rice bran oil is one of the fastest-growing edible oils and their imports have been increasing over the past few years. The long-term road map through the central and state government coordination is required to explore the potential of rice bran oil production in India through mainstreaming all the stakeholders from various rice clusters in India. The timely investment in enhancing the capacity building of the rice mills for better oil extraction may pay in the long run to meet the demand and reduce dependency on importing countries. The illustration showing the prospects of rice bran oil production can be increased up-to 2.5 million tonnes by utilizing 50% of paddy for bran at 4% extraction rate. But the path and the targets are not so simple to achieve without impacting the main and by products supply chain and considering the importance of food security issues in India.

Similarly, the cottonseed skin and maize skin contains about 7% and 12-14% oil. The maize oil production has almost doubled in India in past few years. The crop is also an important raw material for various industrial uses. The edible oil production from the maize and cottonseed also has huge potential in India and to be further explored through formulating long term guidelines and policies on time.

India's concerns on the edible oil import considering the challenging global situations to be addressed carefully and the country is progressing well in this direction, be it the recently slashed basic import duty on edible oils, reducing the agricultural infrastructure cess, cutting the import duty on various products, speculating the processors margins, revising the minimum support price and tracking and revising the interest rates to fight inflation etc. At the same time there need to take the long-term measures which can bring the country back to the minimum importing edible oils status.

Conclusions

For most of the oilseed crops, India's production share is high as compared to the acreage share at the global production and area, among the major producing countries. Reflects low yield of most of the oilseed crops in India compared to other major producing countries, especially for the minor oilseed crops. This suggests, the country is missing or lacking some common factor to not able to enhance oilseed yield, be it the climatic condition, farming practices, input use resources, policy measures, technological laggardness for various operations, or many other factors. The farmer is one of the important stakeholders at the centre to reflect the results of the efforts made by all other stakeholders to improve the implementation inefficiencies caused by such factors. The past study findings as well as the present survey findings suggest that the farmers are not much aware about the input-use and technology-use precisions.

Many of the Indian farmers just have received the basic education and not much aware about the basic techniques and have limited resources, most importantly the financial resources. There is much need to invest in technological demonstration to the farmers. The theoretical trainings alone are not enough to encourage the farmers. Building a resourceful training network of field experts to provide basic common agricultural operational practices will help the farmers, especially the marginal and small farmers with limited exposure, knowledge and resources.

They also need authentic guidance about the input use, what is exactly needed for productivity enhancement out of various available inputs, their brands, compositions, doses, timings, requirements etc. Most of the cases, they follow what is influence them to use through the local venders based on their experience. There is need to enhance the supply of good quality, improved and hybrid seed varieties to the farmers before the sowing starts. There is also need to encourage farmers about efficient water use practices and techniques. This will help to enhance yield, saving input cost to farmers and sustaining the diminishing natural resources. There is also limited exposure of mechanization for the oilseed production in general, from field preparation, intermediary operations to the harvesting and digging operations. Considering the huge supply gaps, the farmers are need to be encouraged to consider growing oilseeds as preferred choice, realising the better price expectations. Pin-pointing various regions for effectively adopting IPM, INM, RCT, CCP etc. where these practices need the most.

Other than these yield enhancement centric measures, there is also need to support the production through enhancing the efficiency of the oilseed processing sector, enhancing production share of edible oil through secondary sources through raw and by product utilization for oil extraction such as rice bran, maize and cotton; region specific area enhancement under tree born oils such as oil palm; ensuring farmers interests while framing marketing, trade and price policies will also encourage farmers to stay in oilseed production.

Some specific highlights reflecting through this report indicates that:

- The yield of the minor oilseed crops in many producing states is still very low and have huge potential to support production. Also, the yield of many of the crops in some of the major states is stagnating over the time.

- There are huge yield gaps across the states, even in the same agro-regions and geographical regions, the lowest yield gaps are ranging from -42% to -86% for various oilseed crops.
- It is observed that the whole specific region or most of the districts of a particular region within the state reported the lowest yield of the oilseed crop.
- There is at least 16% to 45% higher yield across the major and minor producing states of major three of the oilseed crops during the demonstration phases as compared to the actual implementation at the farmer's plot. The yield gaps are ranging from at least 11% to 87% across the varieties during these two phases for major states.
- The crop-specific, states within crop specific and time-based efficiency analysis suggests that there is still about 30% scope to enhance the yield through using different combinations of inputs.
- The country can produce up-to 6 times to the present crude palm oil production if able to utilize this potential area for palm production as per the recommendations of the assessment committee report 2020. Also, there is huge unexplored potential to enhance edible oil production through rice bran, maize and cotton seed utilization.
- India is importing edible oils in huge proportion but at the same time exporting the raw material - edible oilseeds and the by-products - oil cake in large quantity to the world but the growth in oil export and oilseed export is exceeding the oil cake export, increased (about 10 times in value terms and about 4-5 times in quantity terms, 5-year period cumulative basis, since 2000-01).
- The less exposure to formal and technical education, limited resources, small land holding of farmers in India to take risk, followed by unawareness about input use and lack of training and demonstration impacts farmers agricultural decisions.
- There is need to include all stakeholders on policies on imports of edible oils and trade to reduce the volatility in the edible oil sector. Also need to promote technology with respect to seeds to strengthen the oil processing units.
- These is also need to invest in warehouses to reduce the storage losses, high-quality planting material, protective irrigation in drought regions and drought years and machinery for harvesting suitable for small farms.
- Field survey highlights that the shortage of the improved and quality seed; limited or no exposure to trainings; limited awareness among the farmers on marketing related information, post-harvesting and inputs use especially on seed treatment, fungicides,

fertilizer and weedicides; frequent prevailing drought conditions; timely availability of inputs etc. are major factors impacting oilseed yield.

Policy suggestions

i. There is need to pay special attention to increase the yield in states with high oilseed area but low crop yield. The specific states, regions within the states and the district withing the state regions with highest yield gaps are also need to be in focus in policy formulation.

ii. Emphasis should be on the major producing states of the oilseed crops with higher yield gaps during the demonstration phase and at the farmer's plot. Similarly, the varieties reflecting higher yield gaps need to be further explored.

iii. Priority to the region-specific factors in research and investment; measures to increase the irrigation coverage; promoting pest-resistant and high yielding varieties; encouraging oilseeds production through secondary and alternative sources with focus on non-traditional areas and industrial capacity enhancement; research and investment in low-cost technology; promotion, training and demonstrations to aware farmers, provisions to encourage domestic competitiveness in the oilseed sector.

iv. Considering the huge potential to utilize more acreage under tree-based oils, and oil extraction from other secondary sources, there is needs to invest on the primary and secondary oilseed industrial infrastructure such as mills and extraction points to meet the future requirement.

v. The country has huge potential to balance the trade deficit of edible oil import through exporting the oilseed and edible oil based processed products but the high growth in oilseeds and edible oil export need attention.

vi. Ensuring the timely availability of inputs to the farmers such as improved and quality seed along with other inputs is important.

vii. Provisions for frequent training and demonstration to the farmers on various theoretical and technical aspects, precision in input and resource use and on other related agricultural practices for yield enhancement.

viii. Strengthening a stable domestic and trade policy with a long-term vision including all the stakeholders on all edible oil products to strengthen industry and farmers to stabilize prices, technological developments, smooth flow of raw materials and to enhance the industrial efficiency.

**

Chapter 1: Introduction

Introduction

Agriculture is an important activity, source of income and lifeline of rural India. India has witnessed the time phase when the country was not self-sufficient in food grain production. The state of food grain insufficiency turned into sufficiency in current context. The collective efforts by all the stakeholders play an important role in this. The field crops are majorly categorised as food grains, oilseeds, pulses, cash crops such as sugarcane, cotton and other minor crops. Oilseeds are another important field crops. The present production status of oilseeds is not the true potential of the country to achieve the diverted self-sufficiency which was achieved during the 'yellow revolution' phase during early 1990s after the implementation of the scheme on oilseeds. There is need to combine the success stories behind that phase and the bottlenecks we mismanagement after that success to lagged behind to reach at current state.

Few visible factors behind this off-stack status are at the core. The existing lagging yield as compared to the global level of the oilseeds grown in the country is the most prominent reason. Clearly, the country has not performed well to withstand as compared to the other major oilseed growing countries. The other factors are related to the technical, industrial, policy and trade aspects. On the other hand, the comparison is not fully justifiable due to some reasons. India is a vast country in terms of existing population, its varied cultural preferences, the food habits towards fresh food as well as the street food. Precisely, the demand of edible oils supplemented by the changing consumption pattern of various food articles. This is reflected through the trends that at present the consumption of edible oil per capita per year in year 2019-20 is about 19.2 kg as compared to 3.8 kg per capita per year during year 1980-81. This trend is witnessed for some other food articles such as sugar (close to 19 kg per capita per year in 2019-20 from 7.3 kg in 1980-81) and for beverages such as tea, coffee. But, during the period 1980-81 to 2019-20 the consumption of vanaspati is reduced to half from 1.2 kg to 0.6 kg on per capita per year basis. Hence, the demand side factors necessitate or pressurise the supply of edible oil in India.

The unmet demand of edible oil is balanced by the surging import of the edible oil. What if the country exporting the edible oil to India witnesses any saviour drought? In past, we witnessed the price hike for the pulses. India is the largest producing country of the pulses as well as the importer country. The situation for the oilseed is not that much similar in many senses but India is there among the major producer and consumer of the edible oils too. India produces nearly 33.4 million tonnes of oilseeds during 2019-20 (*Directorate of Vanaspati, Vegetable Oils and Fats, 4th Adv. Estimates*) Similarly, the edible oil production is about 7.9 million tonnes and 3.7 million tonnes of edible oils from primary and secondary sources, respectively, in 2019-20, adding at 11.6 million tonnes. The total import of edible oils was about 13.4 million tonnes during 2019-20, ensuring the total availability of edible oils at 24.1 million tonnes excluding exports of about one million ton during this period.

The production and trade scenarios of the Indian oilseed industry necessitates the efforts to be taken to increase the oilseed production through increasing crop yields without putting any additional burden on the land use, and also to make the processing industry more efficient through technology, distribution and logistics improvements. The yield of most of the oilseeds grown in India is way below the global averages and many a times less than the major producing countries. India can nearly double its oilseed production of major oilseed by just improving yield up-to the global level. There are various states within the country and many districts which are way below the national and state level yield, respectively. For many of the oilseed crops the acreage distribution is too much skewed and centric to a specific geographical and agro-ecological regions. The prospects are brighter to enhance or shift the oilseed acreage within the country, which is also got impacted by the changes in cropping pattern, considering the underlying yield gaps for the specific oilseed crops. Lack of awareness and change in cropping pattern leading to significant decrease in area under oilseeds production (NABARD, 2020).

The yield of oilseed crops is impacted mainly due to input resource utilization and due to lack of attention towards the distribution of such resource use. The proportionate irrigated area under oilseed crops is much less as compared to the food-grain and cereal crops. Similarly, the proportionate use of quality seeds of edible oilseed crops is very low as compared to the other major food crops, i.e., at just 0.53 million tonnes for oilseeds as compared to 2.3 million tonnes for cereals as of 2019-20 (*Department of Agriculture, Cooperation & Farmers Welfare*). There is need to improve government policies on cultivation and trade of oilseeds and marketing of GM seeds (Business Line, 2021).

Background information:

India has made phenomenal progress in oilseeds production. Their production remarkably increased from 5.16 million tons in 1950-51 to 32.26 million tons in 2018-19. The quantum jump in production was mainly due to yield expansion, which went up from 481 kg/ha to 1285 kg/ha during the same periods. Despite impressive performance in production of oilseeds, India became net importer of edible oil, which has steeply risen overtime. Edible oil is the third biggest importing items by India after crude oil and gold. India spends over Rs 70,000 crores to import about 15 million tons of edible oil to meet annual requirement of 25 million tons. There are projections that the imports will further expand if the production of edible oil and oilseeds is not increased efficiently. Therefore, there is a need to increase production of edible oil in the country to become self-reliant. The precondition is to efficiently augment yield levels of major oilseed crops.

Indian yield levels are way behind than many oilseed growing countries. For example, soybean yield in Brazil, Argentina and United States of America is more than 3 tons/ha compared to mere 1.2 tons/ha in India. For groundnut, the yields in China and United States of America are 2.5 to 3.5 times higher than Indian yield (1.4 tons/ha). The same is for other oilseed crops. The key challenge is to step-up yield of different oilseeds and improve efficiency of edible oil processing to compete globally and become self-reliant. Recently, honorable Prime Minister has announced to transform India and make it self-reliant (*Atam Nirbhar*). One of the commodities is edible oil, which has huge potential to become self-reliant through improved technologies and effective policies.

Need and scope of the study

There are wide yield differences of oilseed crops across different agro-ecoregions. For example, the average yield of major oilseeds in Tamil Nadu and Haryana is more than 2 tons/ha compared to 0.85 tons/ha in Karnataka and 0.6 t/ha in Andhra Pradesh. Therefore, the first challenge is to step-up yields in lagging states to increase production of oilseeds. The second challenge is to harness the potential yield of major oilseed crops across different agro-ecoregions. The current yields are 80-100% lower than the potential yields achieved under frontline demonstrations of Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize (ISOPOM) and Krishi Vigyan Kendra (KVK). The proposed study intends to measure the yield gaps of major oilseed crops and identify constraints in bridging the gaps for increasing their production.

The study will use both secondary and primary data for estimating the yield gaps. The secondary data will be used to examine inter-state comparison of yields and economics, and reasons for their differences. The primary data will be used to measure the yield gaps and analyze constraints in harnessing the potential yields. The study will specifically examine the seed sector and supply chains of oilseed crops. The study will also explore the perspective of edible oil industry to reform the sector for making it self-reliant.

The present work is an attempt to discuss the various prospects of encouraging oilseed production in India keeping into consideration the global prospects and trade burdens. The emphasis of the work is mainly to identifying and presenting the yield variations at the state and district level to highlight the focus areas. In specific, the study analyses the global overview of oilseed and edible oil production. Yield of the nine-oilseed crop which are the primary source of vegetable oils in India are analysed. The exiting yield gaps for the oilseed crops at the global and national level are analysed and further extended the analysis at the state and district level. The factors impact the yield of the oilseeds, the dependency on the oil and oilseed import and the prospects of oil cake trade are discussed. The prospects of exploring new areas such as promoting palm oil production, alternative sources such as cotton and rice bran oil are discussed.

Objectives of the study

The objectives of the study are:

i. Analyze spatial and temporal changes in yields of major oilseed crops across different agro-ecoregions.
ii. Estimate existing yield gaps in oilseed crops across commodities and agro-ecoregions.
iii. Identify constraints in harnessing the potential yields of different oilseed crops under different agro-ecoregions.
iv. Explore the industry perspective in reforming the entire sector to make self-reliant in edible oil.
v. Prioritize commodities and agro-ecoregions for future research, extension and market opportunities.

Database, coverage and methodology

Data, sources and time period

The study mainly utilises the secondary data, supplemented by the primary data.

The secondary data is collected from various data sources majorly includes - Directorate of Economics and Statistics, Ministry of Agriculture and Farmer’s Welfare (MoAFW) for state and district level data on area, production and yield; FAOSTAT database for global production and trends; DGCIS database for trade of oilseeds, oils and oil cakes; KVK stations database etc. Household-level data collected by the Ministry of Agriculture &

Farmers Welfare for the Comprehensive Cost of Cultivation Scheme is also used. The related departments of various ministries are also explored as and when required. The major documental sources of secondary data were office records, government documents, published articles, annual reports and newspapers. The global level data is collected from 1961 and the state data is collected from 1966 onwards to the latest time period - 2019-20, the district level data is collected and analysed from 1997 onwards till 2018-19. The data on oilseed trade is analysed from 2000 onward to the latest available time 2020-21.

The primary data is collected by conducting the field survey using the detailed questionnaire and schedules structured by the coordinating centre (AERC Delhi) to explore the farmer's responses on the potential yield increase and factor impacting the crop yield (Appendix 1). Questions on problems associated with farmers and their suggestions were also included. The field survey is conducted at the end of year 2021.

Study coverage

The secondary data analysis at the Phase-I provides a macro perspective of oilseeds and edible oil and determine how government policies and programs contributed to enhance oilseed production and meet the growing demand for edible oil. This part of work presents the broader overview on oilseed production with a focus on analysing the yield of important oilseeds produced in India using the secondary as well as primary data. The secondary data analysis covers the global production overview of the important oilseeds' crops. This is followed by the national level, state level and district level analysis of the acreage and yield of major oilseed crops. The crop and country specific trade of important oilseeds, oils and oil-cakes by India is also covered. The yields of the important oilseeds grown in India are analysed, the trends in yield, growth rates, yield-gaps at state and district levels are discussed. The overview of the past policies on the oilseed sector are discussed briefly.

The second phase of the work is based on the primary survey in the major oilseed producing states. The survey is conducted by sharing the sampling frame, sampling methodology and questionnaires with the partner AERCs. In this phase, micro-level attempt is made to identify the constraints to increase oilseeds production. It will also contribute to better understand farmers' behavior and their decision-making processes in acreage and input allocation towards oilseeds. Based on the sampling frame available and the sampling criteria adopted for field survey, at local level, the study will cover three major oilseed crops, namely soybean, groundnut and rapeseed & mustard. These crops cover nearly 91% of the nine-oilseed produced in the country as of 2019-20. Four states, namely Rajasthan, Gujarat, Madhya

Pradesh and Maharashtra have been selected, as these cover 75% of total oilseed production in the country in year 2019-20. These are finalized after consulting the partner AERCs. The sections for micro analysis broadly include - demographic profile of the households, cropping details and acreage under oilseed crop, marketing of oilseeds, labour and machine used, operational costs of oilseed production and perceptions of the households on yield enhancement.

Methodology

Broadly, the following analytical approaches will be employed to achieve the objectives:

a) Growth patterns and trend analysis of area, production and yield of the important oils and oilseeds at the global, national, and state level will be undertaken for different time periods.

b) Yield gaps at the demonstration level and at the farm level to be compared for the major oilseed crops in all the states. Trends in yield gaps across different states for all the oilseed crops will be analyzed and their drivers for bridging the gaps will be identified.

c) Frontier functions for each crop will be estimated for estimating technical and allocative efficiencies. This analysis will provide the factors of improving efficiencies and yield levels across different farm categories.

d) District and state level mapping of yield gaps of important oilseed crops will be developed to prioritize development and research agenda to increase oilseed production in the country.

Most of the statistical analysis performed for secondary and primary analysis are basic in nature. The basic descriptive, statistical and mathematical calculations are used for data analysis along with the econometric analysis of oilseed yield to study the factors impacting the yield. The tabular and graphical representations are made based on such analysis. Some basic formulae and techniques used are:

Measures of central tendency and dispersion

$$\text{Average} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

$$\text{Standard deviation} = \sqrt{\frac{\sum (x_i-\mu)^2}{N}} \text{ for any population}$$

$$\text{Measure of Volatility} = \text{Standard deviation (Growth rates)} \quad (\text{for any specific period})$$

Trend Analysis

The simple linear trend model is:

$$y_t = \beta_0 + \beta_1 t + e_t$$

Where, β_0 is the constant, β_1 reflects the average change from one period of the next, t is the value of the time unit and e_t is the error term.

Growth rates

$$Growth\ rate = (logest(range) - 1) * 100$$

the 'logest' function calculates an exponential curve, this is often applied to calculate the growth rate, the slope of such regression line reports the growth rate for easy interpretation in percentage terms, if multiplied by 100. By taking logarithms on the both sides, the exponential form of the model can be converted to a linear form. The range is the time period for which the growth rate is to be measure.

Decomposition analysis

There are various forms to compute the decomposition of the output as contributed through various components. We consider the simplest approach to decompose the production. If A_0 and Y_0 represents the area and yield of the oilseed crop at the base year of the analysis period and A_n and Y_n represents the same at the nth year, respectively, then we have

$$P_0 = A_0 * Y_0$$
$$P_n = A_n * Y_n$$

The change in production, area and yield is represented as:

$$\Delta P = P_n - P_0$$
$$\Delta A = A_n - A_0$$
$$\Delta Y = Y_n - Y_0$$

From above,

$$P + \Delta P = (A + \Delta A) * (Y + \Delta Y)$$
$$P = \frac{A_0 * \Delta Y * 100}{\Delta P} + \frac{Y_0 * \Delta A * 100}{\Delta P} + \frac{\Delta A * \Delta Y * 100}{\Delta P}$$

Production = Yield effect + area effect + interaction effect

This reflects the decomposition of production into three components i.e., yield effect, area effect and the interaction effect due to change in area and yield of the oilseed crop.

Stochastic Frontier Analysis (SFA)

The typical Stochastic Frontier Analysis (SFA) function given by Aigner et. al., (1977) is presented in the form of

$$ln(Output_{it}) = \ln f\ (Labour_{it}, Capital_{it}, T, \beta) + (v_{it} - u_{it})$$
$$u_{it} = f(z)$$

This is an extension of the classical production function with the possibility to deviate from the production frontier due to technical inefficiency. Kumbhakar (1990) modelled technical efficiency effects as a product of an exponential function of time involving two parameters as well as a time-invariant non-negative random variable. Battese and Coelli's (1992) also presented a modified model to measure the technical efficiency effect.

We considered the Stochastic Frontier Analysis (SFA) function given by Aigner et. al., (1977) in the form of

$$ln(Output_{it}) = \ln f\ (Labour\ cost_{it}, Fert.cost_{it}, Seed\ cost_{it}, irrig.cost_{it}\beta) + (v_{it} - u_{it})$$
$$u_{it} = f(z)$$

The final model specifications are tested by Hausman test to select between fixed effect and random effect model. The presence of technical inefficiency is tested using the Likelihood Ratio (LR) test. The final Maximum Likelihood Estimates (MLEs) are run and the scores of the technical efficiency are generated.

The Ordinary Least Square (OLS) Regression

The yield of different oilseed crops is analyzed to measure the effect of different input variables used by the farmers. For this purpose, field survey data is utilized and the OLS regression model for yield estimation is used. The basic OLS regression model used to estimate the oilseed yield in the following form:

$$Yield = f(Labour, Fert., manure, biofert., fungicide, weedicide, pesticide, irrig., others;\ error\ effect)$$

where, the *labour use* is the manual and machine labour used in numbers and hours, respectively. Also, the manual labour cost and the machine cost, both in hired and owned, is combined to reach at the final cost. *Fertilizer use* (*and/or fertilizer cost*) is the total combined quantity of different types of fertilizers used (and/or total cost of fertilizers) by the farmers. Similarly, the quantity used (and /or cost) of *manure, bio-fertilizers, fungicides, weedicides and pesticides* is also utilized as the independent variables. The *cost of irrigation* is considered as to measure the effect of irrigation on the crop yield. The other independent variables include the effect of education, gender, farming experience, family size and family type. The detailed model explanation is in the relevant chapter of field survey data analysis.

Sampling technique

The sampling framework or the study road map was finalized by the coordinating centre – AERC Delhi. The detailed questionnaire and the sampling frame along with the study proposal was shared with the partner AERCs and the final versions were prepared after discussion, consultation and agreement from the participating centres. On the basis of the final study proposal, the participating centres proceeded to conduct field survey in their respected covered state.

The state-wise analysis is undertaken for all nine oilseed crops. The primary survey covers three major oilseed crops and four major producing states. The multi-stage stratified sampling approach will be used to select the final sample for collecting the primary data.

The detailed approach followed for primary data is given below:

Stage 1: For each oilseed crop, four strata of districts will be formed using the following criteria: (i) high yield-high area districts, (ii) low yield-high area districts, (iii) high yield-low area districts, and (iv) low yield-low area districts.

Stage 2: Out of the four strata, only two will be considered from the two categories, namely high yield-high area, and low yield-high area, for selecting the districts.

For each of the selected state, two districts will be chosen from category (i) and (ii), i.e., one district from each category, based on the higher area share among all districts.

Stage 3: Three villages from each of the district will be selected randomly.

Stage 4: From each village, a sample of 30 oilseed crop growing farmers will be surveyed. For selecting farmers of different holding size, probability proportionate criteria will be used.

Following the above steps, the oilseed crops for different states and their districts are selected and given in Table 1.1. The partner AERCs could plan Stage '3' and '4' utilizing the expertise and/or on random basis. The detailed survey questionnaire finalized after discussion with the partner AERCs is reported in the Appendix 1.

Table 1. 1: District selection based on sampling procedure

Crop	State	District selection: Based on stage '1' and '2'	
		Category (i): High yield - High area	Category (ii): Low yield - High area
Soybean	Madhya Pradesh (44%)	Ujjain (9.3%)	Rajgarh (7.1%)
	Maharashtra (43%)	Nanded (8.7%)	Latur (10.7%)
Groundnut	Gujarat (47%)	Banas Kantha (8.8%)	Junagadh (14.5%)
	Rajasthan (16%)	Bikaner (35.5%)	Jodhpur (16.6%)
Rapeseed & mustard	Rajasthan (46%)	Alwar (9.0%)	Tonk (9.8%)

Note: The 'high area' districts are top districts covering 80% area share in the state as per district level data available from Ministry of Agriculture for the year 2018-19. The 'High' and 'low' yield district are selected based on yield range of a particular crop in the study state. From the defined categories for 'area' and 'yield', the district covering highest area among the list of such districts is to be preferably selected in each of the above two categories (as mentioned in the Table above). In unavoidable situations, the district with second highest or subsequent area share in a particular category may be considered for survey. The figures in the brackets represents the area shares in percentages. The detailed sampling frame is reported in the Appendix 2.

Review of past studies

Oilseeds occupy an important position in the agricultural economy of India. The country is among the largest producing nations of oilseeds in the world but the growth in the domestic production of oilseeds has not been able to keep pace with the growth in the demand in the country. Low and unstable yields of most oilseed crops and uncertainty in returns to investment are the major factors leading to this situation of wide demand-supply gap.

There were various issues discussed by various authors in the past related to the oilseed cultivation. Analysing the trends of oilseed production for the period of 1930 to 1980 period, *Chhattrapati (1980)* highlighted that the oilseed crops do not receive their share of the increasing irrigation facilities and despite higher yields under irrigation, oilseeds cultivation is not as remunerative as other crops at the present levels of cultivation technology. *Jhala (1984)* tried to identify the factors responsible for the situation the country has been forced to go in for large imports of edible oils since the domestic production of oilseeds falls short of demand. He also suggested the short-term price forecast model considering various other factors into consideration.

Ninan (1987) suggested that the green revolution appears to have affected the growth performance of oilseeds as the output of most edible oilseeds having either declined, stagnated or reporting lower growth rates during the post-green revolution period. He suggested various measures such as - regional approach to boost the edible oilseeds output and investment in location- specific research, special measures to increase the coverage of irrigated oilseeds, introduce high yielding and pest-resistant varieties of oilseeds, and encouraging oilseeds cultivation in non-traditional areas. *Ninan (1989)* highlighted the technology factor as the main constraint for increasing oilseeds production in the country and suggested that development of cost- effective or high yield low-cost technology can itself change the scenario for oilseed sector. The study suggests that the benefit of a price rise has gone more to the trader than the oilseed grower due to dominance of private traders in the trading of oilseeds and oils. The study also emphasis on institutional intervention through mechanism such as co-operatives, regulated markets, in order to help oilseed growers.

Gulati and Sharma (1997) suggested that promoting resource use efficiency (RUE) in domestic cropping patter in India and frees up imports and exports of agricultural products at zero duty can reap significant gains from trade. The increased oilseeds production after the launch of TMO is because of the increase in inputs, cropping area and price incentives *(Rao, 1991, Gulati et. al., 1996)*. Priorities to be reassessed for resource allocation for investment in oilseeds research in the country with focus on groundnut and soybean crops for greater profitability and generation of surpluses *(Chandel and Ramarao, 2003).*

Chand et. al. (2004) cautioned that lowering of edible oil import tariffs under the WTO may leave India with less scope to provide protection to its domestic oilseeds industry, considering India's high import dependency especially in the situation of global price volatility and insisted for the high need to encourage domestic competitiveness in the oilseed sector within the country and efforts to raise production of oilseeds through cost-reducing technologies. Prior to 1994, edible oil was on the negative list of imports in India and the country resorted to an ad hoc and flexible import regime to manage domestic shortfall in production during late 1990s. The country needs a long-term edible oil policy to improve competitiveness by bridging the existing technology and yield gaps. The components of price support and input supply made significant improvements in increase in area and production during the period of yellow revolution as well as in green revolution. Maintaining a price band for all edible oils through adjustment of import tariffs is a precondition to rejuvenate the yellow revolution and to provide stable prices for farmers and processors *(Reddy, 2009). Jha (2011)* performed the yield gap analysis between on–farm demonstrations and actual farm yield and suggested that the it has failed to show appreciable reduction but the gap between potential yield of varieties and research station yield has increased over the past two decades.

Venkateswarlu and Prasad (2012) cautioned that the continuous decline in groundwater levels, growing deficiency of major and micronutrients, declining factor productivity and looming threat of climate change are issues impacting food production and suggested improving yield gaps in rain fed regions, increase yields through rainwater harvesting and recycling, soil fertility improvement, crop diversification and effective dissemination of technologies can improve the production of crops grown in rain fed areas. *Hegde (2012)* highlighted the need of 17.84 Mt of vegetable oils in India to meet the average fat intake of 29 g per head per day as nutritional fat needs of projected population of 1685 million by 2050 and suggested to focus on the supplementary sources of oil like rice bran, cottonseed, coconut, oil palm, corn, etc. along with bridging the yield gaps of various primary oilseed sources through effective technology transfer to this sector. *Nyein, et. al. (2013)* examined the impact of alternative trade liberalization policies on the social welfare of Myanmar 's oilseed sector using a partial equilibrium multi-market mode. They suggested that the liberalizing groundnut seed trade has a positive net effect on the whole oilseed sector while sesame trade liberalization is better for the major edible, hence the country should not ban potential groundnut and sesame trade.

India, despite being the third largest producing country of oilseed brassica after Canada and China in the world, the country is heavily depended on imports as the productivity levels are very low due to rainfed cultivation. proper multi-scientific inputs, planned and targeted strategies, technological interventions, stable price systems and suitable policy framework is required to improve production *(Jat, et. al, 2019).* There is high variability in oilseed yield across the states and low growth in area and production of oilseeds as compared to other cereals. High need to reduce the yield gap and adoption of new technology to improve oilseeds production and to make India self-sufficient in oilseeds *(Kumar and Tiwari, 2020).*

Many authors have made attempts to estimate and analyse the yield and yield-gaps in major oilseeds of country but very few scattered and specific district and state level studies have been conducted during the last two decades. Only a few comprehensive studies have been undertaken on the topic. The study by the Indian Agricultural Research Institute (IARI) in 2010 but did not respond on how to bridge the yield gaps and also did not capture the industry perspective. *Jha, et. al. (2012)* outlined the demand and supply of edible oilseeds in India and gave policy implications. The reason of lower average oilseeds yields is the high-risk cultivation area, as there is uncertainty of returns on the investments. During the time period 1951-2009, there has been an increase in the area, production and productivity of oilseeds, indicated a compounded rate of growth. Moreover, the highest rate of growth in area and production has been exhibited by soybean, and highest rate of growth in productivity has been exhibited by castor, sunflower and rapeseed-mustard. The substitution of non-remunerative crops (for instance, millets), minor food crops and rise in cropping intensity are the reasons for growth in the area of production of oilseeds. The study found that Rajasthan, Madhya Pradesh and Maharashtra showcased a robust rate of growth in the fields of area, production and productivity. The report stated that, because of the enhancement in the irrigated land and accessibility of HYV seeds during 1980-2009; the area, production and productivity has seen a growth. They inferred that the improvements in the yield growth would help in lowering of the dependence on the imports of edible oils; whose share was only 3% in 1970-71 but had increased up to 56% by 2009-10. Further, policies like Technology Mission on Oilseeds (TMO) and new trade regimes by WTO could be helpful. They detected that, technical limitations for oilseeds production were there and it seeks for efficient field management of the crop using technical advancements. The research also consisted of field survey for groundnut and rapeseed-mustard in the Junagadh and Bharatpur districts; and the researchers observed that for groundnut the most significant constraint was the unsatisfactory price of the produce, for rapeseed-mustard; it was marketing and price of the produce which were hampering the growth of those oilseeds. The report suggested that, to have advancement in the yield, there is a need for seed varieties having, biotic and abiotic stress tolerant seeds and there is a requirement of growth in the related field of research. There should be incentives by the government in the areas of processing and value addition for the private industries. Authors concluded that the growth of oilseeds would be of great benefit to Indian economy, and this can be achieved by enhancing local capacities and reinforcing institutions by establishing social, environmental and economic sustainability.

Sharma (2014) performed the study coordinated by the Agro-Economic Research Unit (IIM-Ahmedabad) with several Agro-Economic Research Centre (AERCs), which addressed the changing patterns in production of oilseeds in different states of India. The data used in this coordinated study was until 2009-10, after that several changes have been initiated in agriculture sector. Though, the yield gaps of different oilseed crops were not analyzed. This study examined problems and prospects of oilseeds production in India by analysing performance of the sector, identifying major problems/ constraints facing the sector and options for increasing oilseeds production in the country. The study utilized both primary and secondary data pertaining to major edible oilseeds. Seven Agro-Economic Research Centre participated in the study covering major oilseed growing states of India and collected household data from about 2000 oilseeds growers. Oilseed production recorded the highest growth rate (5.8%) during the 1980s, followed by 2000s (4.89%) and the lowest (0.57%) during the 1990s. Yield variability found to be a major factor for production variability during all decades, which indicates high yield risks associated with oilseeds. Current yields of major edible oilseeds found to be much below the world average and potential yields and there are large variations in crop yields across different states/regions. A yield gap analysis showed that yield gaps between potential and achievable yields, between achievable and farmers' yields and total yield gaps between potential and farm level yields are quite high. Instability in area, production and productivity of oilseeds computed using coefficients of variation, showed that the highest variability has been observed in the case of production, followed by productivity and the lowest in area under oilseeds. The report concluded that production of oilseeds can be increased only if productivity is improved significantly, and farmers get remunerative and attractive prices, better market access, technology and other infrastructure facilities. Lack of suitable varieties, high-costs and timely availability of inputs, incidence of diseases and insect pests, low and fluctuating prices, shortage of human labour, poor irrigation facilities, weak linkages between oilseed producers and processors found to be major reasons for low yield and higher yield gaps and need to be addressed.

Bhatia et. al. (2008) examined potential yields and yield gaps of rainfed soybean in India. They did field experiment and pot experiment of soybean in the regions of Patancheru (2001), Bhopal (2003) and Indore (2003) with different water and biotic conditions. Further, they estimated soybean's potential yields and yield gaps in 21 locations in central and peninsular India, using CROPGRO-Soybean model. They found that if the soil moisture conditions are not adequate, then there would be a 28% reduction in yield of soybean. Moreover, yields in water limiting and water limited potential was found to be unwavering and was significantly correlated with solar radiation. At all the locations, the crop season rainfall had a positive and a curvilinear relationship with water limiting potential and actual yield. There was discrepancy in the yields in the areas where with less crop season rainfall and more crop season rainfall for of water non-limiting and water limiting crop. They concluded that this yield gap associated with rainfed environment was caused, because of lower crop management activities and it requires monitoring for improvement. They furthermore, recommended that, to close the yield gaps of soybean; conservation of rainfall and drought resistant varieties in less rainfall and mitigating water-logging or the usage of water-logging tolerant varieties in more rainfall would be helpful. Lastly, in improving crop yields in India, rainwater harvesting during excess rain and utilising it for additional irrigation would be beneficial.

Pawar et. al. (2017) used the study by Krishi Vigyan Kendra (Deesa) to estimate the yield gaps of groundnut in Banaskantha district of Gujarat. From 2014-15 to 2016-17, Front Line Demonstration (FLD) and farmer's practice (FP) of kharif groundnut undertaken in 3 distinct villages identified as sub-tropical and semi-arid weather for evaluating yield gaps. For the experiment, the farmers were made aware about the production technology which could help in improving the groundnut production, additionally informed about the adequate amounts of fertilizers, pesticides and weed reduction strategies. This Front-Line Demonstration Programme assessed that there was a significant difference in the average pod yield of groundnut in the (Intervention Practices) IP and (Farmers Practices) FP, and that former was higher than the latter. There was technological and extension gap for IP and FP, further, there was greater gross return and net benefit- cost ratio in IP than in FP. They summarised that this FLD resulted in bridging the technological gap and helped in boosting the productivity. Furthermore, training programs, technical assistance by NGO's, KVK, ATMA to the farmers in order to improve their sustenance.

Nainwal et. al. (2019), used the study of Front-Line Demonstration by Krishi Vigyan Kendra, Almora to assess the yield gaps and constraints of rainfed black soybean, in Uttarakhand hills. The experiment was conducted during 2016 and 2017 kharif season, in

Almora district. The yield of black soybean was found to be significantly higher in FLD technologies than farmer's practices, giving farmers a higher share of profit. Although, there was an increased cost of cultivation in case of FLD than farmer's practice, but the B: C ratio of black soybean was higher in case of FLD than farmer's practice, due to improved technologies. They concluded that to increase the productivity and returns to farmers, improved practices which was there in FLD could be used. They further recommended that training, interaction and field demonstration could be organised in order to strengthen the farmer's return.

Kidula, et. al. (2010) examined the yield gaps in Kenya for research and non-research farmers for groundnuts crops. They collected data from 249 groundnuts producing farmers in Ndhiwa District. They found contrasting results; in Southwest Kenya the average yield of non-research farmers was higher than research farmers. The reason is not yet clear why there is yield gap, even though farmers were in constant support of researchers and were using high yielding varieties seeds. They assumed that there are other variables which are beyond the farmer's control. Further, they found female research farmers and non-female research farmers were getting different yields for groundnuts. They concluded that to enhance the production of groundnut, training to farmers is needed and further study is required for finding out the variables for lower yields of the groundnut.

Dhandhalya and Shiyani (2009) analysed the yield gaps and growth potentials of groundnut and sesame of Saurashtra region, Gujarat. During 2003-04, they collected data of 120 farmers in the seven districts of Saurashtra region during the kharif season, using multi-stage sampling technique. To evaluate the degree of yield gaps, they have used the International Rice Research Institute's methodology. They found that in Saurashtra region, there has been a huge yield gap in major oilseeds crops and were significant in groundnut and sesame. The reasons could be limited water and other biotic limitations like tikka diseases in groundnut and brown angular spot in sesame and poor soil quality. They suggested increasing the use of water dripping system, relating the soil fertility, availability of power supply and boosting extension services.

Nehbandani et. al. (2021) estimated yield gaps in soybean in Iran. They have used Soybean Simulation modelling approach (SSM-iCrop2) and Geographical Information System (GIS) for evaluating the yield gaps of soybean in Golestan Province of Iran. They have gathered weather data from 24 weather stations and data of the soil. They found yield gap in the province's potential and the actual yield and stated that the province has the capability to improve soybean yield. There was yield gap due to the different levels of water availability and differences in the solar radiation in the eastern and western areas of the province. They summarised that if 80% of the yield gap is curtained, then it could lead to a growth in the production of soybean by 66%.

Kumari et. al. (2019) analysed the yield gap of rapeseed and mustard seed in Bihar, India. The research was formulated on plot level data for the year 2015-16 using Comprehensive Cost of Cultivation Scheme in Bihar and secondary data was collected from various KVKs. A simple linear regression was carried out to evaluate the factors influencing yield gaps in rapeseeds and mustard crops. They found that seed variety, level of education among farmers and irrigation were the significant variables of yield gap of rapeseed and mustard seeds in Bihar. Factors such as seed rate, mechanization influences yield gap negatively. Lastly, as the farmers are marginal and small, the community of farming is poor and hence biotic and abiotic conditions of agro-climatic zones may be other variables.

Meena et. al. (2016) analysed the yield gap of rapeseed and mustard in Rajasthan state of India. The study found the yield gap of rapeseed and mustard through Front Line Demonstrations and Farmer's Practices research conducted at Krishi Vigyan Kendra, Rajsamand, in fifteen villages, for the period 2006-07 to 2010-11 during Rabi season. The researchers found a significant difference in the yield of actual farmers and potential yield. The reason could be farmer's apprehension towards improved variety of mustard seeds. They also suggested that to minimize technology gap, scientific methods can be utilized in mustard farming. In order to lessen the extension gap, there should be technical support given to farmers in the form of farming education and extension methods by the extension agencies of the district. The farmers also got persuaded to adopt intervention, as there was promising benefit-cost ratio in the FLDs.

Bhatia et. al. (2006) incorporated simulation modelling to study the yield gap of soybean and groundnut in India. The study dealt with data of soybean and groundnut production in 34 areas across various states of India. Average rainfed potential yield and water balance was estimated using CROPGRO-soybean model. They evaluated yield gap I, which is the difference between potential and achievable yield and yield gap II, which is the difference between achievable and actual yield. The yield gap I was small, which could signify to improve the technology of the production process and to make new varieties which could achieve good results in any specified environment. On the other hand, there was a huge degree of spatial and temporal differences reported in the yield gap II, which means that better management in the form of better variety, management in the soil fertility and integrated pest and disease management in the rainfed conditions could improve soybean production. And in low rainfall conditions, supplemental irrigations would be useful for soybean and groundnut production. They suggested that the surplus water be harvested and conserved and could be used for supplemental irrigation, and also to conserve the fertile soil. For instance, technologies like effective watershed management, crop production on effective land configurations (like broad bed-and-furrow, ridge-and-furrow systems), and water conserving cultural methods (like residue recycling) could be adopted for efficient production of soybean.

Persaud and Landes (2007) discussed the importance of policy and structure of industry for oilseeds in India. The report mentioned the significance of trade policy in the oilseed economy. In the early 1994, imports of edible oil had increased because of the ease in the trade quantitative restrictions, however, prohibitive tariffs and sanitary regulations were still in place. During 1989-94, when government of India launched Technology Mission on Oilseeds to become self-sufficient in the production of edible oils, there was restriction on imports. Although, after 1994, India had to follow the rules of WTO and had to allow unlimited imports constrained by applied tariffs and were under Open General License (OGL). To safeguard the interest of the producers of oil and oilseed in India, there has been a huge debate among the policymakers. Using 'Tariff rate values' system, the government impacts the cost of imported oil and those were conditional on world prices adjusted on every period. There has been price sensitivity in the Indian domestic market for edible oils and due to the lower price of palm oil, there were 75% imports in the period 2003-05, and import of soybean was 23%. On the other hand, sunflower oil and other traditional oils related to Indian diet were expensive and hence, lower amounts were imported. After mid-1990s, as US exports moved from concessional shipments to commercial sales, the soybean oil imports changed from US to Argentina and Brazil. Earlier soybean meal was highly competitive at the global level; however, with the increase in the domestic demands from poultry industry has resulted in rise in the prices of soybean meal and hence, decreased its competitiveness. The report suggested that technically efficient production plants could decrease the operating cost and lead to competitive prices

Fischer, Byerlee and Edmeades (2009) analysed if technology can improve the yield by 2050 for the cereal crops wheat, rice and maize. They evaluated more than 20 "breadbasket" countries in order to find out the farm yield (FY), potential yield (PY) and yield gap. In developing economies, the yield gap was found to be higher and is slowly contracting excluding maize in Iowa and major cereals in Egypt. The reasons for lower FY could be weak infrastructure, higher costs of farm gates, skills of the farmers and farmer's hesitation regarding adoption of new technologies. They suggested that if technology has a crucial impact on the improving the yield of the resource-poor farmers, then it needs to be taken care of. The research discussed that there is a huge potential for the productivity to increase by adopting technologies like conservation farming approaches including no tillage, Genetically Modified (GM), both of which are using below 10% of world's cropland and for modern inputs, information and communication technology (ICT) is effective. Moreover, in Sub-Saharan Africa, adoption of technologies like fertilizers is a necessary requisite. The paper proposed that private sector should also be involved in the production of rice and innovative partnerships could be other way out to help 800 million small farmers across the globe. To conclude, advantageous policies related to staple food in R&D investment, which would strengthen the input use and enhance yield, would improve food security.

Malathi et. al. (2019) reported the involvements of KVKs in oilseeds production through Cluster Frontline Demonstrations in reducing its yield gap. With the support of Krishi Vigyan Kendras (KVKs), cluster FLDs were conducted by ICAR, from 2015-16 to 2017-18 for rabi, kharif and summer season. During rabi season of 2015-16, a total of 1312 cluster FLDs were held in the states of Andhra Pradesh, Telangana and Maharashtra and found that yields generated through demonstrations were more than that of yields generated through ongoing practices. During kharif season of 2017-18, a total of 1442 cluster FLDs coordinated through 48 KVKs of Andhra Pradesh, Telangana and Tamil Nadu. Krishna district recorded the highest production of groundnut, Theni district of Tamil Nadu performed best among sesame seeds, Kurnool district of Andhra Pradesh reported highest production among castor hybrid, Chittor of Tamil Nadu displayed the highest average yield for sunflower and Karimnagar district of Telangana achieved the highest average yield for sesame during summer season; all were due to the improved variety and recommended practices by the FLD workers.

The term 'technical efficiency' is defined as relative productivity over time or space, or both. Technical efficiency can be output-oriented (i.e. improve output given the same level of inputs) or input-oriented (i.e. reduce the inputs given the same level of output). There are various methods to measure the technical efficiency (TE). To measure the TE by estimating a production frontier was initially developed by Debreu (1951), Farrell (1957) by using non-parametric frontier approach. This was further explored by Banker, Charnes and Cooper (1984), Färe, Grosskopf and Lovell (1985). The corrected ordinary least square (COLS) method was introduced by Winsten (1957). The Stochastic Frontier Analysis (SFA) developed independently by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) is the parametric frontier approach to estimate a stochastic non-deterministic production frontier. Further, the stochastic data envelopment analysis (SDEA) had been introduced by Li (1998) and Cooper et al. (2007). The Data envelopment analysis (DEA) evaluates the performance of a set of factors responsible for converting inputs into outputs (also called decision making units) to decomposition of Overall Technical Efficiency into pure technical efficiency and scale efficiency in envelopment surface.

Many authors worked on the yield variations and analysed the technical efficiency of the crops. *Murat Külekçi (2010)* in Erzurum, Turkey revealed the technical efficiency of sunflower oilseed farms. The study found labour as a significant factor, which could mean that there are more laborers employed in the farms than optimal (disguised employment). Another factor was family size which was positively significant, implying that large families have less efficiency. Further, variables like information score and credit usage were insignificant, meaning that they did not have any impact on the efficiency of the sunflower farms. The paper concluded by suggesting that improved extension services and farmer training programs by the Extension Service of the Provincial Directorate of Agriculture, to improve the technical efficiency and hence appropriate usage of fertilizers to strengthen the production of sunflower oilseeds in Erzurum province.

K. Kalirajan (1981) analysed yield variability in paddy output using econometrics technique. This research has taken into consideration stochastic production frontier, an extension of the conventional production function to estimate the variation among the firm's productivity, in case of technology. The study found that the technical inefficiency among the farmers was one of the crucial reasons for yield variability. The variability of the actual and maximum yields was due to significant factors including extension workers interaction with the farmers and the apprehension among the farmers regarding technology. The researcher has suggested that extension programs should be strengthen in the area, to reduce the inefficiencies related to technology, by explaining the farmers, the practices and the timing of application of inputs.

Surjit S. Sidhu (1974) analysed the relative efficiency of Punjab's wheat production. The research has used the Lawrence Lau and Pan Yotopoulos L-Y model, the profit function concept. The research could not find significant differences in the small and large wheat farm's technical efficiency and price efficiency. The author has shown the comparison of Indian wheat varieties with Mexican varieties in terms of economic performance. The research summarized that better allocative efficiency in production frontiers have limited growth prospects. Further, the analysis could not reveal any significant difference in the wheat farms which were operated by tractor and non-tractor. Furthermore, this research could not find any significant difference in the large farms and small farms, and hence on difference could be found in technical and price efficiency.

Dalheimer et. al. (2021) verified technical efficiency of smallholders of palm oil in Indonesia. The survey was conducted in Sumatra, Indonesia, of smallholder palm oil farmers and had incorporated short panel data in order to evaluate the technical efficiency using a two-stage approach. The research estimated that technical and land efficiency is low among smallholders. The study further found that land-sparing opportunities can be attained by reducing the yield gap. The Technical Efficiency (TE) gains which lead to potential land savings are threatening because of rebound effects. They suggested that the partial rebounding effects should be known to policymakers and policies should be adopted by them which would help in minimizing the deforestation in that area.

Prochorowicz and Rusielik (2007) evaluated the relative efficiency of oilseeds of European farms and of other countries. The data of 26 farms, using International Farm Comparison Network IFCN was collected and Data Envelopment Analysis (DEA) was incorporated to find out the technical efficiency. The rapeseed was used as the indicator and MtRE (Metric tonne Rapeseed Equivalent) was revalued. The results revealed that soya seeds and sunflower seeds be a rival to the rapeseeds, when comparing for the technical efficiency. Further, the paper found the impact of donations on the production efficiency, as there was a significantly lower cost associated with the farms which got donations than those farms which did not get.

Similarly, the work on technical efficiency measurement is extended to other fields of research as well. *Bhattacharya et. al. (1997)* examined the efficiency of Indian banks using a two-step procedure, DEA technique to determine the technical efficiency and then applying stochastic frontier approach to explain variation in calculated efficiency. *Mitra (1999)* estimated the time-variant technical efficiency and TFPG by using panel data for 15 major states and 17 two-digit industry groups. *Das (1999)* used DEA approach to evaluate and compare various efficiency measures PSBs for the year 1998.

Various authors studied the effect of each of the component such as yield, area, prices and their interaction effects on the total output using the decomposition analysis technique. This method is developed, redeveloped and used by various researched in past in various form. Minhas and Vidyanathan (1965) discussed the decomposition using additive model, used four and seven factors - area, yield, cropping pattern and various interactions. Since then, various studies have been undertaken using various forms of the decomposition approach. The further extensions such as introduction of location component and price factors, static and dynamic effects, etc. have been analysed over time. *Bisaliah (1977)* compared new technology of Indian Ferozepur district of Punjab's wheat production with Mexican wheat production, using decomposition analysis.

Sing, et. al. (2015) analysed the North-eastern oilseed's growth rate and decomposition of output. To study the oilseeds in the states of Northeast India, they incorporated component analysis method to find out the trends in area, production and yield using secondary data. The study found that over the three periods for the oilseeds production, the growth rate of area, and yield had fallen sharply. The research further found stunted rate of growth in production in half of the region. *Pattnaik and Shah (2015)* examined the trends in area, production and yield of major crops and the pattern of growth in Gujarat's agriculture during the year 1990-99 and 2000-10. The decomposition analysis suggests that the individual effect of price alone has increased over time along with a reduction in the yield effect. The study implies most of the crops for which there was substantial price increase show favourable change in yield and area.

Government policy initiatives for oilseed crops

Directorate of Oilseed Research (DOR) was established in 1977, to guide the research & development in nine mandate crops. The establishment of Technology Mission on Oilseeds (TMO) in 1986 encouraged oilseed production. Yield of oilseeds increased significantly after launch of technology mission but it has become stagnant in last one decade. The Integrated Scheme for Oilseeds, Oil palm, Pulses and Maize Development Programme (ISOPOM) to provide flexibility to the states in implementation based on regionally differentiated approach to promote crop diversification. The Pradhan Mantri Annadata Aay Sanrakshan Abhiyan (PM-AASHA) scheme promote robust procurement mechanism and ensure remunerative prices to farmers. In January 1989, the Government announced an "Integrated Policy on Oilseed " (IPO)" in which the major areas have been focused namely - technology and inputs Support to farmers, imported oils would be supplied at a price not below the cost of production of domestic oil, fixation of a price band, committee to monitor the implementation of the integrated policy by the cabinet secretary.

Some of the oilseed crop specific initiative also initiated to help oilseed production and marketing. Such as for soybean, the amendment of the APMC Act has enabled licensed in Maharashtra state in which direct marketing agencies and private markets participated actively in direct purchase of agricultural commodities. Also, to encouraged private investment in infrastructure development and agro- processing the State Agricultural Produce Marketing (Development and Regulation) Act in 2006 also established. The farmers' survey revealed that modern agronomic practices taught under extension activities are effective and also appreciated the support provided by stakeholders in helping them achieve improved soybean yield. The conversion of breeder seed to foundation and certified seed program for soybean cultivation is needful. Availability of high yielding certified seeds have major bearing on improving productivity of soybean. Farmers are also facilitated with the SMS Service on daily basis to update about soybean market price.

Similarly, groundnut program in Gujarat (*Pro Nutiva Sada Samrudh*) aims to increase the productivity and enhance the quality of groundnut crop by applying sustainable agronomy practices. These practices including proper training, technology interventions and farm mechanization. The outcome of the program reflected in increase in overall yield in terms of plants per square meter and more flowers and pods per plant. The outcome reflects the pod yield increased by 132%, the fodder yield increased by 125% and oil yield increased by 26%.

The initiatives were also taken for the rapeseed and mustard crop by the government to organize market structure development, rationalization of the tax structure of the rapeseed/mustard oil , transparency in the regulated mandis, technological improvements, prevention of adulteration of the oil and to address this problem, branding of the rapeseed/mustard oil must be strengthened to ensure that other oils are not taking market share away from legitimate rapeseed/mustard oil producers, and to explore export opportunities in the market and the supply side management.

To boost oil palm cultivation, government of India had implemented a special program on oil palm area expansion under RKYY with an objective to bring 60,000 hectares area under oil palm cultivation during 2011-12 to March 2014. During the 12th FYP, a new National Mission on oilseeds and oil palm has been launched under mini mission (MM)-II is dedicated to oil palm area expansion and productivity increases. Interventions of MM-II are being shared in the ratio of 60:40 between the central and the state governments in case of general states and 90:10 in case of north eastern states from the year 2015-16. The developmental programs have resulted in the expansion of area under oilseed production to 8585 ha in 1991-92 to 3,00,510 ha in 2015-16. Similarly, the fresh fruit bunches production and crude palm oil have increased from 21,233 MT to 1,134 MT respectively to 12,82,823 MT TO 2,17,258 MT respectively during the year 2015-16. Recently, the assessment committee report in 2020 has assessed the potential area under the palm oil trees. This report suggest that India can utilize nearly 28 lakh hectare acreage under palm trees plantation across the states.

The National Food Security Mission – Oilseeds and oi palm (NFSM-OS&OP) implemented in 2018-19 an effort to augment the availability of vegetable oils and to reduce the import of edible oils through yield and production increase of major nine oilseeds and through area expansion under various tree-based oils including Oil palm. The support from the government in this direction to incentivise farmers to produce foundation and certified seeds and their distribution, distribution of seed mini-kits, to buy of breeder seeds, front line demonstrations, training to the farmers mechanisation, improvement on irrigation supply and micro irrigation, various seed treatments, and managing inputs such as pesticides, bio-fertilizers, bio-agents and micronutrients etc, are some long-term policy measures.

Chapter plan

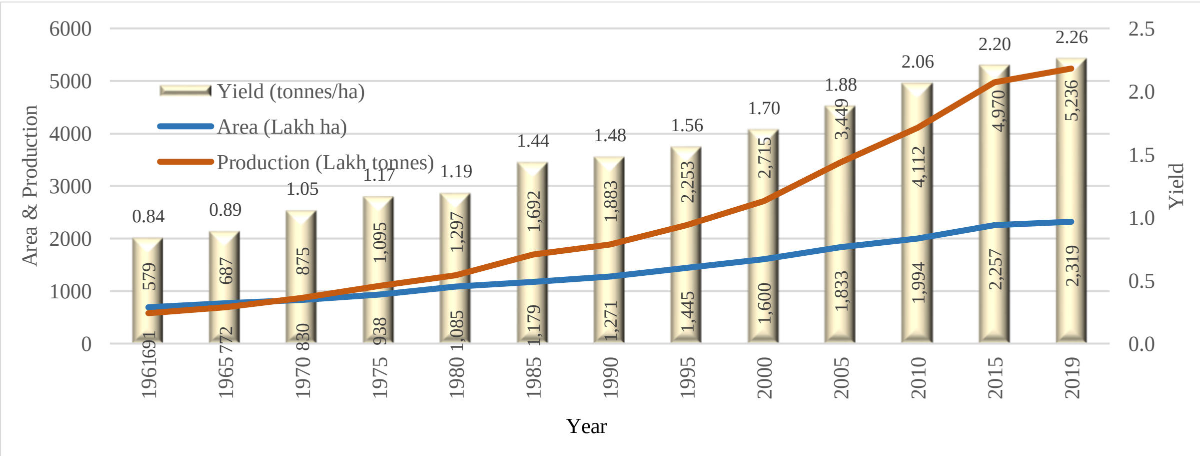
The present chapter provides the brief information and background of the study including the objectives, methodology and sampling approach. Chapter 2 presents an overview of the oilseed production at global level, the yield of oilseeds in major producing countries and the existing yield gaps are discussed. Chapter 3 covers the oilseed production status of India, the yield of major oilseeds the state level and growth rates, variations in yield are highlighted. The details on the yield gaps at the state and district level along with the factors impacting the yield of oilseeds are discussed in Chapter 4. Chapter 5 highlights India's potential to produce edible oil from secondary alternative sources. The status of oilseed and edible oils' trade during recent two decades is discussed in Chapter 6. Chapter 7 deals with the primary data, highlighting the factors impacting the oilseed yield in the major oilseed producing states covered during field survey for major oilseed crops. The perceptions of the households are also discussed in this chapter. Chapter 8 deals with the important ground level observations from the investigators' point of view. The industrial perspective is discussed in Chapter 9. Finally, the summary, conclusions and policy implications are provided in the last Chapter.

Chapter 2: Oilseeds production at global level

Global production of oilseeds

The world produced nearly 523.65 million tonnes of oilseeds in year 2019 (*FAOSTAT*), excluding the Oil Palm fruits. Oilseed includes – soybeans, rapeseed & mustard, sunflower seed, groundnuts (with shell), sesame seed, linseed, castor seed, safflower seed and other oilseeds. The production growth during the period 2011 to 2019 witnessed nearly 3.78% annually. The growth is comparatively less, as compared to previous two decades, i.e. 4.1% and 4.6% during 2001- 2010 and 1991-2000 periods, respectively. The alternative primary and secondary sources of oilseed crops have tremendous growth prospects. In addition to the total oilseed production in 2019, the Oil Palm fruits contributes an additional 410.7 million tonnes in 2019. Figure 2.1 represents the trend in area, production and yield of total oilseed (excluding Oil Palm fruits) at the global level.

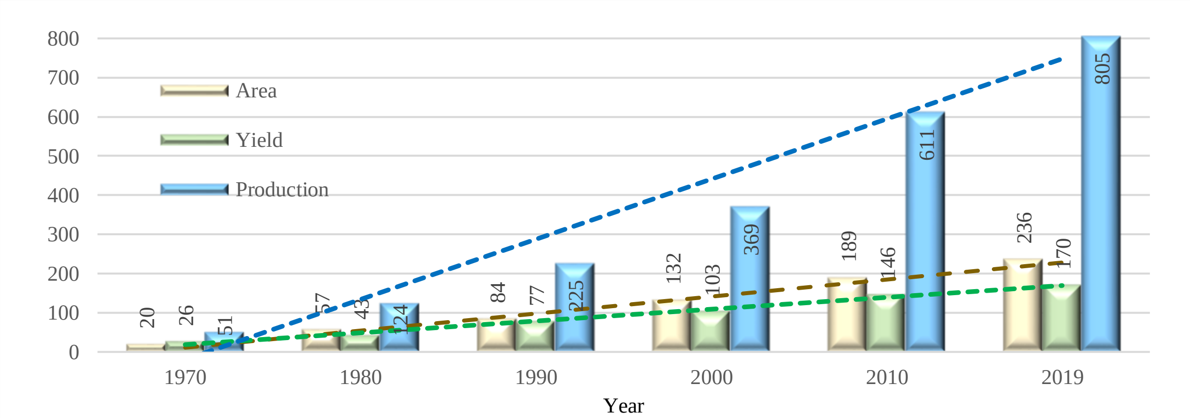
Figure 2. 1: Area, production and yield of oilseeds in the world



Source: Author's computation from FAOSTAT database

The yield of oilseed crops has doubled (at 1.7 tonnes/hectare in 2000 from 0.84 tonnes/hectare in 1961, and rose further to 2.26 tonnes/hectare as compared to 1961, an increase of about 2.7 times (Figure 2.2). It took about 40 years to get doubled and additional 20 years to reach at 1.7 times from the year 2000 level. The acreage under oilseed crops witnessed higher acceleration during this period (increased about 2.3 times till year 2000 and 3.3 times till 2019), from 1961 level. This reflects about 3.7 times change in production till year 2000, and eight-fold increase in production till 2019 as compared to 1961. Assuming the same trend, the production of oilseeds can improve to nearly 1000 million tonnes by 2030. Figure 2.2 reflects the simple percentage changes in area, yield and production of oilseeds as compared to base year 1961.

Figure 2. 2: Change in area, production and yield of oilseed as compared to 1961 (base) – (in %)

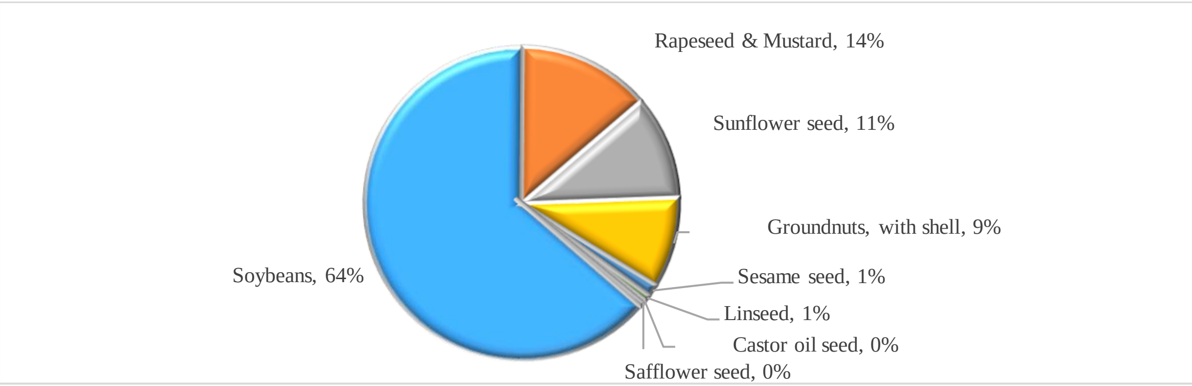


Source: Author's computation from FAOSTAT database

Major oilseed crops and the oilseed producing countries

Among the major selected oilseed crops produced in the world, soybean holds the largest share (nearly 63.7%) as of 2019 (Figure 2.3). The production share is stable at 63.3%, a long-term average share, since 2001. This is followed by 'rapeseed & mustard' (13.6%), sunflower seed (10.7%), groundnut (9.3%) and sesame seeds (1.3%), together holding about 98.6% world oilseed production, excluding Oil palm seed production. These oilseed crops stand similarly in global area share as soybean (52%), 'rapeseed & mustard' (15%), groundnut (12.8%), sunflower seed (11.8%) and sesame seeds (5.5%). The global oilseed production is about 523.65 million tonnes excluding Oil palm fruit, of which 333.7 million tonnes is from soybean, followed by rapeseed and mustard, about 71.2 million tonnes, which is mostly by rapeseed. Adding the Oil palm fruit production of about 410.7 million tonnes, the global oilseed production is about 934.7 million tonnes in 2019.

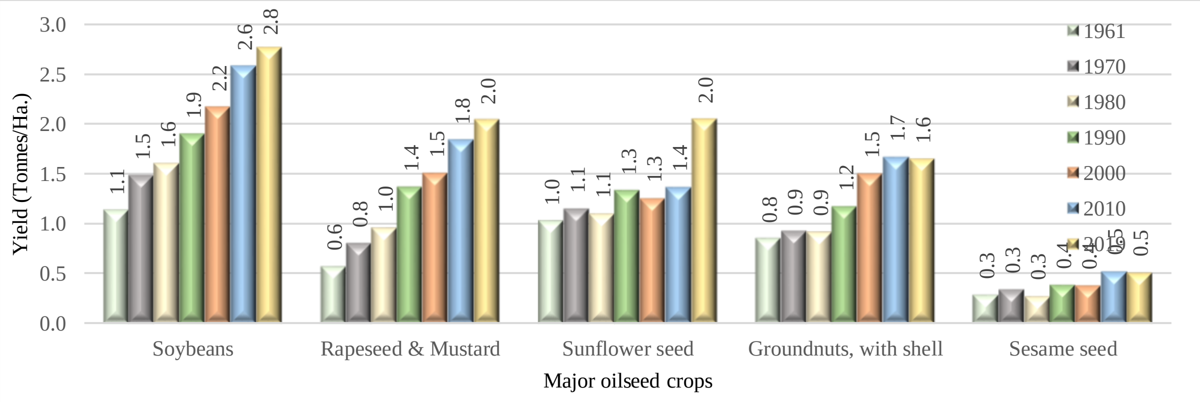
Figure 2. 3: Production share (%) of major oilseeds in the world - 2019



Source: Author's computation from FAOSTAT database

During this period from 1961 to 2019, the highest proportionate change in yield is witnessed for 'rapeseed & mustard' crops, the yield increased by 2.58 times from less than 0.6 tonnes/hectare in 1961 to more than 2 tonnes/hectare in 2019. The change in yield of soybean is 1.45 times and sunflower just doubled during this period. The yield of other major oilseeds, groundnut (94%) and sesame (78.5%) also showed impressive increase. The decadal yield of some of the major oilseed crops is reported in Figure 2.4.

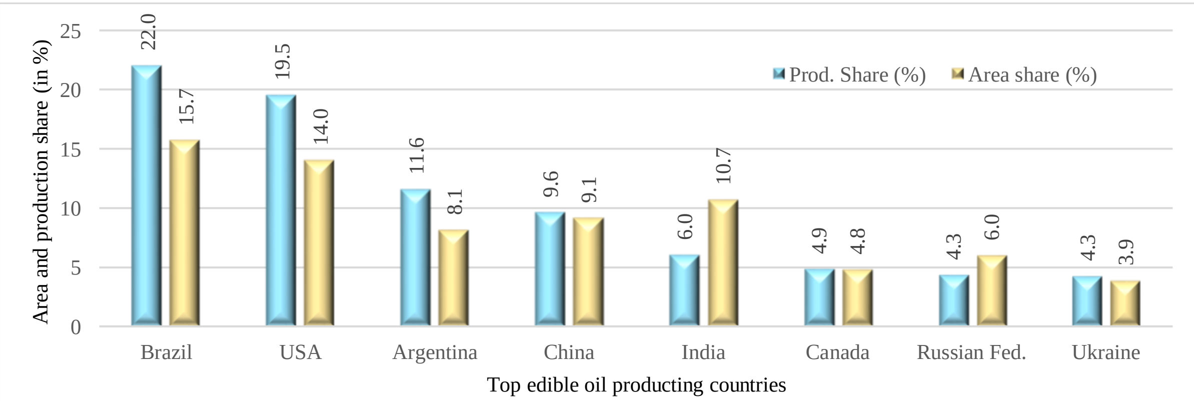
Figure 2. 4: Decadal yield of major oilseeds crops (in tonnes/hectare)



Source: Author's computation from FAOSTAT database

At the country level, Brazil is the largest producing country of the oilseeds, holds about 22% of total oilseed production, followed by USA, Argentina and China sharing about 19.5%, 11.6% and 9.6% of oilseed production as of 2019, respectively (Figure 2.5). India stands at 5th place with 6% production share of global oilseed production from close to 11% of global acreage share (stands 3rd in global acreage share). The production and area shares are calculated excluding the oil palm produced majorly (about 60% of global production) in Indonesia. No other top producing country has global production share less than the global acreage share except India and Russian Federation.

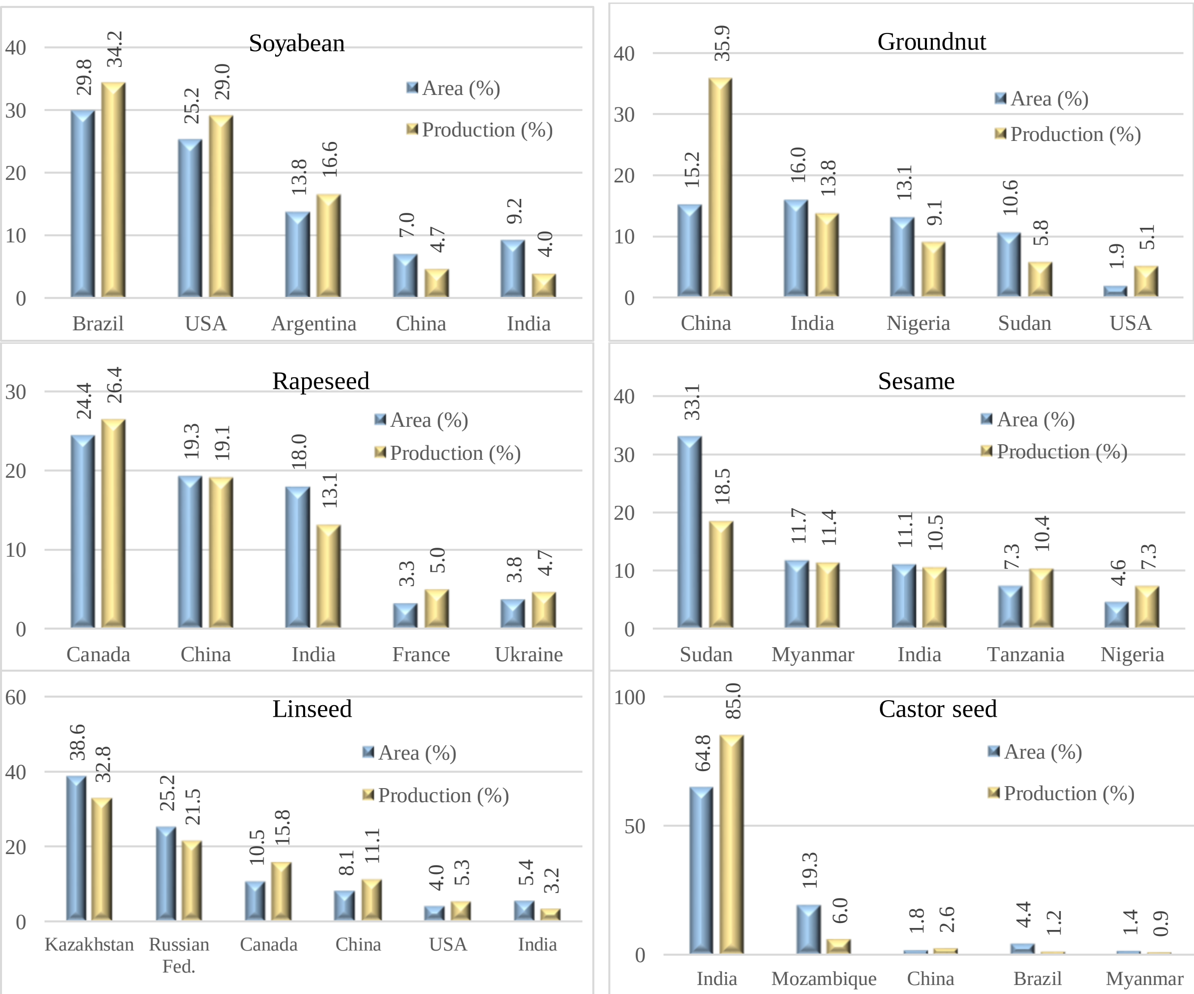
Figure 2. 5: Area and production share of oilseeds in major producing countries - 2019

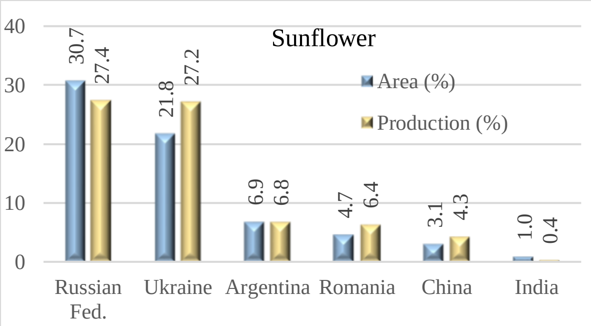


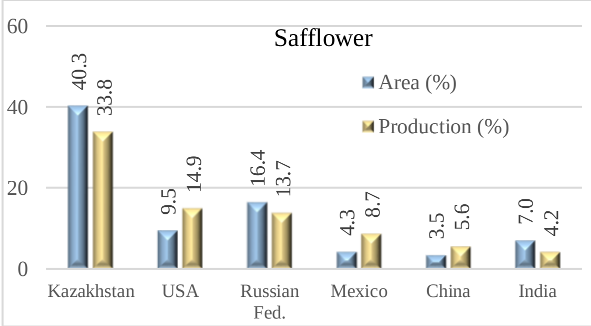
Note: Excluding Oil Palm fruit production. Oilseeds include soybeans, rapeseed & mustard, sunflower seed, groundnuts (with shell), sesame seed, linseed, castor seed, safflower seed and other oilseeds. Source: FAOSTAT database.

At the country level, considering the specific oilseed crop, Brazil is the largest producing country of soybean, holding nearly 34.2% global production and 29.8% global area share, followed by USA, Argentina, China and India (Figure 2.6). Similarly, China, Canada and Sudan are the top producing countries for groundnut, rapeseed and sesame crops, respectively. India is among the top five producing countries for some of these oilseed crops. The developed countries produce more oilseeds from less acreage while India and most of the developing countries have higher share in global area compared to their contribution to the share in global production. Similarly, groundnut is largely produced in China, contributes nearly 36% share in world groundnut production from 15.2% of global land share. India is the second largest groundnut producing country at 13.8% production global share from 16% global area share.

Figure 2. 6: Area and production share of major producing countries of oilseeds crops – 2019 (in %)





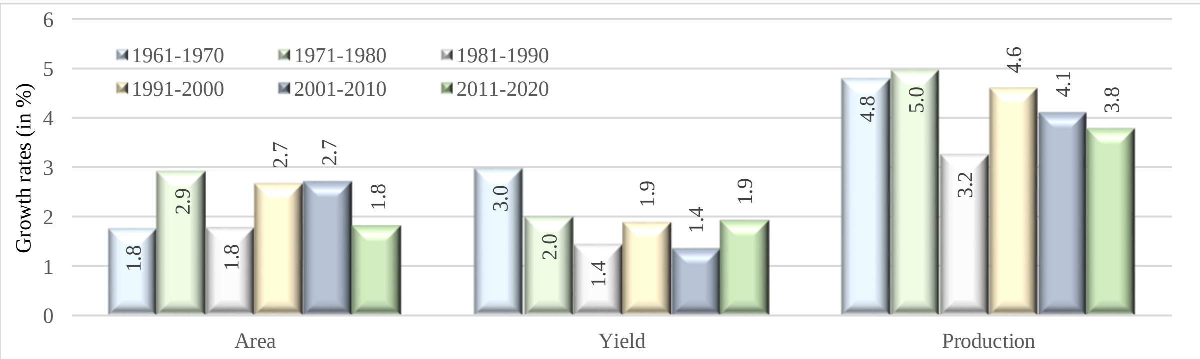


Source: Author's computation from FAOSTAT database

Growth rates in area, production and yield of oilseeds

The oilseed production in the world witnessed the annual growth of above 3% in each of the past 6 decades, ranging from 3.2% (during period 1981-1990) to 5% (during period 1971-1980). The recent period from 2011 to 2019 witnessed an annual growth of just 3.8% till 2019, stands the second worse decade in six decades. The production growth during first decade (1961-1970) was mainly driven by growth in acreage under oilseed crops, while this growth during other decades was mainly driven by increase in yield of oilseed crops. The decadal growth in global area, yield and production of oilseeds is reported in Figure 2.7. The growth rates of major oilseed at global level are reported in Table 2.1.

Figure 2. 7: Decadal growth rate in area, production and yield of overall oilseeds in the world (%)



Source: Author's computation from FAOSTAT database

Soybean, the largely grown oilseed crop with highest area and production share in the world, witnessed an annual production growth of 4.5% during recent period, which is little improved than previous decade but below the annual growth witnessed during three out of four decades. Soybean production growth rate suddenly dipped during 1981-90, just 2.41% annual growth, which is very low as compared to the previous decade (from 7.34% during 1971-80). This is because in four out of five major producing countries – Argentina, Brazil, India and U.S.A., the production growth rate for the decade was way below compared to the previous decade. The production growth rate dropped mainly because of both area and yield growth declined during the decade. Area growth rate dropped in these four countries and the yield growth dropped mainly in Argentina and Brazil. In another major producer – China, production growth rate was higher as compared to previous decade mainly contributed by yield increase.

Table 2. 1: Decadal growth rates of area, production and yield of major oilseeds – world

	Crops	Growth rates for various decade (in %)					
		1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2019
Area	Soybeans	2.72	5.85	1.49	3.41	3.03	2.31
	Rapeseed & Mustard	2.00	2.69	4.60	3.59	4.22	0.19
	Sunflower seed	2.75	4.00	3.07	2.62	2.58	0.92
	Groundnuts, with shell	1.51	-1.19	0.93	1.45	0.97	2.17
	Sesame seed	1.37	0.53	0.30	0.77	2.13	4.85
	Linseed	-2.00	-0.63	-1.50	-3.06	-2.15	4.83
	Castor oil seed	1.87	-1.32	-0.26	0.65	1.36	-6.53
	Safflower seed	2.14	4.18	0.55	-2.85	0.07	-2.96
	Other oilseeds	0.97	1.48	2.92	1.42	0.42	-1.28
	Selected oilseeds	1.76	2.91	1.78	2.66	2.71	1.82
Production	Soybeans	6.43	7.34	2.41	5.08	3.90	4.52
	Rapeseed & Mustard	6.40	4.33	7.52	5.21	6.88	1.72
	Sunflower seed	5.27	4.09	5.01	2.77	4.52	4.49
	Groundnuts, with shell	1.87	-0.16	2.76	4.20	1.79	2.15
	Sesame seed	2.34	-0.11	1.52	2.08	4.07	2.80
	Linseed	0.70	-0.48	0.95	-0.29	0.27	5.30
	Castor oil seed	4.96	-1.89	2.12	1.19	5.48	-6.56
	Safflower seed	4.41	4.10	0.16	1.16	1.69	-2.01
	Other oilseeds	2.58	1.48	0.45	2.91	2.01	1.41
	Selected oilseeds	4.78	4.97	3.25	4.59	4.10	3.78
Yield	Soybeans	3.62	1.41	0.91	1.61	0.84	2.15
	Rapeseed & Mustard	4.31	1.60	2.79	1.57	2.54	1.52
	Sunflower seed	2.45	0.08	1.88	0.14	1.89	3.53
	Groundnuts, with shell	0.36	1.04	1.82	2.71	0.81	-0.02
	Sesame seed	0.96	-0.64	1.22	1.30	1.90	-1.96
	Linseed	2.76	0.15	2.49	2.86	2.47	0.45
	Castor oil seed	3.04	-0.57	2.38	0.54	4.07	-0.04
	Safflower seed	2.22	-0.08	-0.39	4.13	1.62	0.98
	Other oilseeds	1.60	0.00	-2.40	1.46	1.58	2.73
	Selected oilseeds	2.97	1.99	1.44	1.88	1.35	1.92

Source: Author's computation from FAOSTAT database

The 'rapeseed and mustard' performed the worst during the recent period (1.7% annual production growth) in six decades, as the growth is way below the previous worse growth of 4.3% during 1971-80. All other four decades witnessed more than 5.2% annual production growth which is mainly driven by increase in acreage under this oilseed crop except the first decade and the worse performing current decade, indicates stagnation in acreage (0.2%). The crop witnessed stagnation in acreage in recent period. The decadal yield growth is also worse since 1961 for rapeseed and mustard. The dropped production growth rate is mainly due to drop in the production growth rate of the rapeseed crop, as there was drop in area and yield growth rates to 0.13% and 1.58%, respectively during recent period 2011-2020 (from 4.36% and 2.47% annual growth in area and yield, respectively, during 2001-2010). All the major producing countries of rapeseed crop – Canada, China, India, France and Ukraine, witnessed drop in the production growth rate during 2011-2020 as compared to previous decade, contributed by both, decline in area and yield growth rates.

Sunflower seed holds about 11% of global oilseed production share reflects annual production growth (4.5%) similar to soybean during current decade and own previous decadal growth. This oilseed crop witnessed worse production growth of just 2.8% during 1991 to 2000 decade. This was largely contributed by the stagnation in yield of sunflower at 0.14% annual growth rate. Four out of five major producing countries – Russia and Ukraine, Romania and China reported the negative growth rate of sunflower yield close to 2%. During the recent period - 2011-2020, the annual production growth rate was about 4.5%. The area nearly stagnated witnessed just 0.9% annual acreage growth but the yield reflects the best performing decade with 3.5% annual growth.

For groundnut, in contrary, there is stagnation in yield in recent period (-0.02%) which is worse performing decade but the acreage has increased with close to 2.2% annually during current decade, the highest ever annual acreage growth in past six decades. This leads to the annual production growth rate at 2.15%. Though, the highest production growth was reported during period 1991-2000 at 4.2% annually – contributed by production growth in China and Nigeria. During the same period, India and U.S.A witnessed decline in production. China and India are the two major producing countries of groundnut, witnessed negative annual growth in area during two decades (India – in past three decades consecutively) and the production growth is mainly contributed through yield increase.

Among the minor oilseed crops, sesame seed and linseed reported best annual acreage growth (4.85%, each) during recent period, resulting highest ever increase in production compared to previous decades (2.8% and 5.3%, respectively), but the yield of sesame seed is declined (-2%) in recent decade, while yield of linseed is almost stagnated (0.5% annual growth). The production of safflower seed and caster seed witnessed decline in production by annual rate of -2% and -6.6% in current decade driven by decline in acreage under these crops, performing worse in terms of annual growth during six decades.

Oilseed yield in major producing countries

The yield of these oilseed crops is analysed and the yield gaps are worked out. The yield levels for major producing countries are reported for three time periods for year – 2000, 2010 and 2019. India witnessed a low yield as compared to most of the other major producing countries. The yield of soybean in India for the year 2019 is less than the yield of all other producing countries for year 2000, about two decades before (Figure 2.8). In fact, it is less than the yield in India for year 2010. Similarly, the yield of groundnut in India is about 1.4 tonnes/hectare in 2019, which is much less than the largest producing (China) and highest yield reporter country (USA). For some other major oilseed crops, rapeseed and sunflower, the yield is reported least for India among the major producing countries. France and China reported the highest yield in 2019 for rapeseed and sunflower, respectively. For some of the minor oilseeds produced, the yield in India again reported among the less economically developed nations, except the Castor seed yield which is second largest after China, as of 2019 (Figure 2.9). India reported lowest yield among top producing countries for linseed and safflower, and second lowest for sesame seed after Sudan.

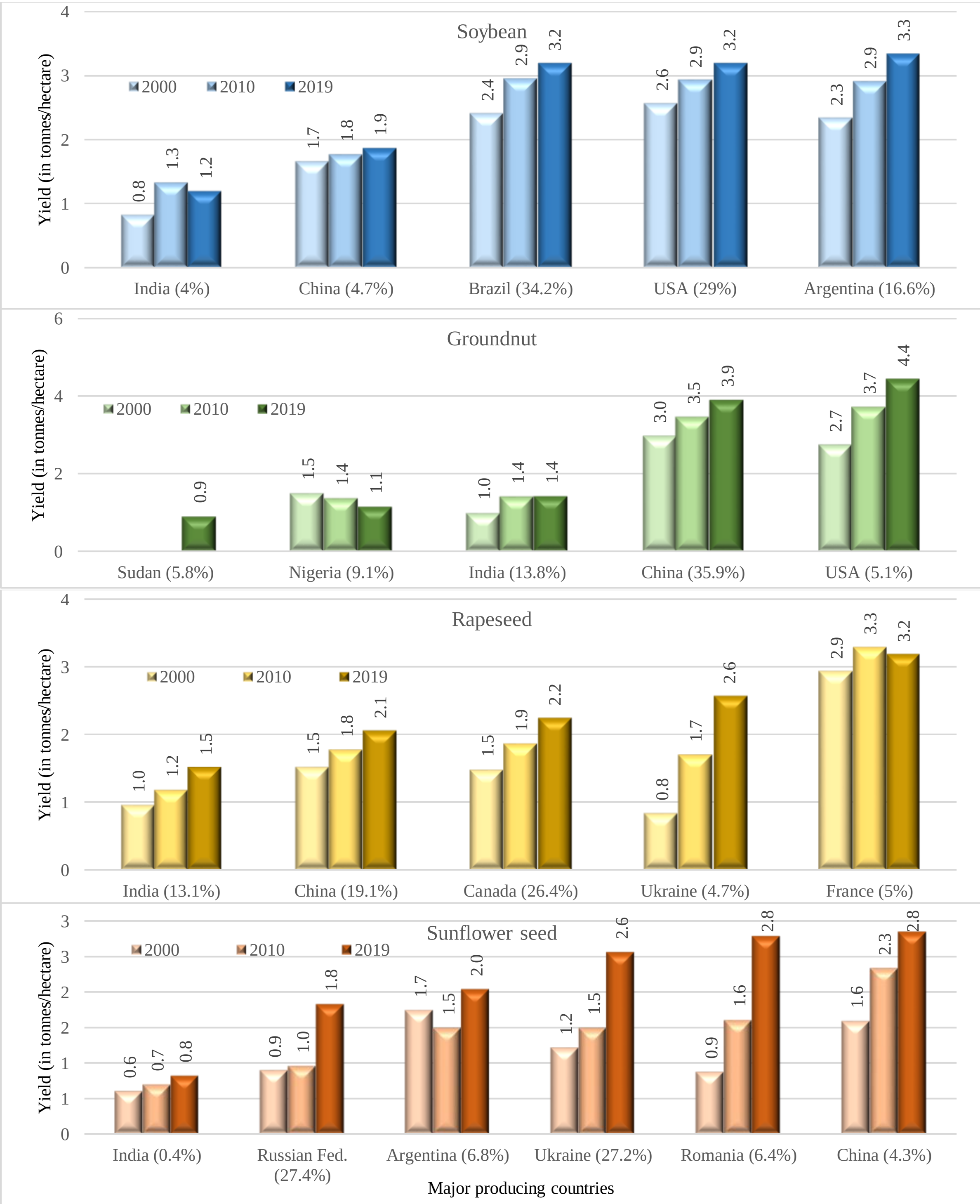
Yield gaps for oilseeds in major producing countries

There are large gaps in the oilseed yield across the countries, especially in the developing countries, the oilseed crop yield is very less. For soybean, the yield in India is just 1.19 tonnes/hectare, which is very less as compared to other major producing countries (Table 2.2). The yield of soybean in Brazil is 3.18 tonnes/hectare. The highest yield among the top producing countries is recorded in Argentina (3.33 tonnes/hectare). India is lagging behind by nearly two-third of yield, the productivity is just 35.75% as compared to the 'highest yield' country and about 37.4% compared to Brazil, the largest producing. The yield of soybean in USA and Brazil in 1965 was higher than the yield in India in 2019. Although, in USA, the soybean yield witnessed a stagnation over a long period as compared to other major producing countries including India.

There is a huge yield difference in groundnut crop too. USA reported the highest yield of 4.43 tonnes/hectare and China with yield at 3.89 tonnes/hectare are closely 3 times higher than India at just 1.42 tonnes/hectare. Similarly, India witnessed below 30% of the yield of highest yield country for sunflower and safflower crops. The country stands at 40% and 48% yield of the highest yield country for linseed and rapeseed crops, respectively. So, for six of the reported oilseed crops, India is way below the highest yield country, even not at the 50% level and at least 70% below the largest producing country of these oilseed crops. This reflects there is scope to enhance yield and hence the production to meet the demand and reduce import burdens. Other than these edible oilseeds, India holds nearly 65% of global acreage under castor seed, which is majorly a non-edible oil with various applications in other non-food industries. India produces nearly 85% of global castor seeds and the yield is comparatively up-to the global levels equivalent to China which produce below 3% of global production.

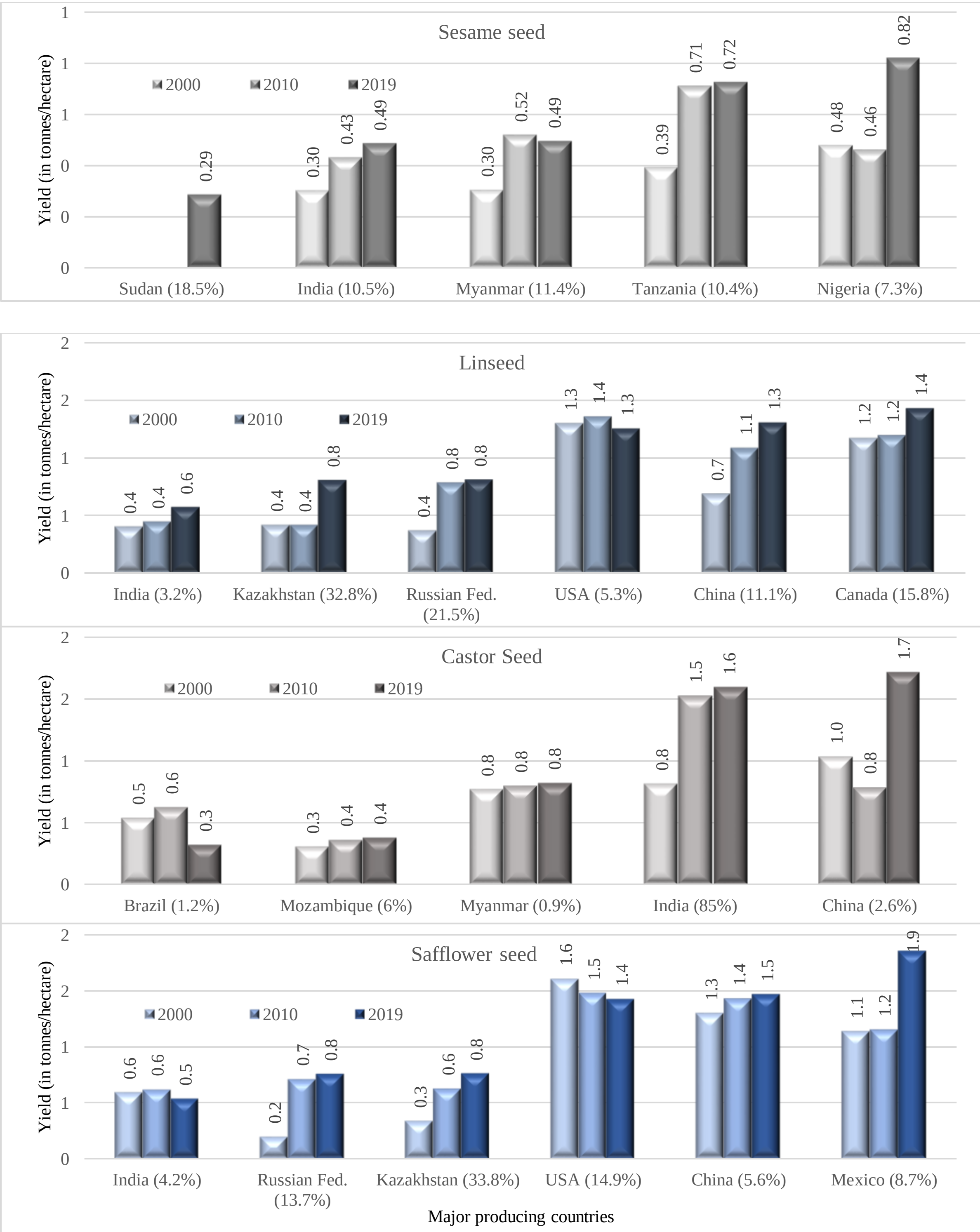
The oilseed yield in tonnes per hectare in year 2019 and the yield gaps in India along with other major producing countries are reported in Figure 2.10 and Figure 2.11, for major and minor oilseed crops, respectively.

Figure 2. 8: Yield of major oilseeds in top producing countries (Tonnes/Hectare)



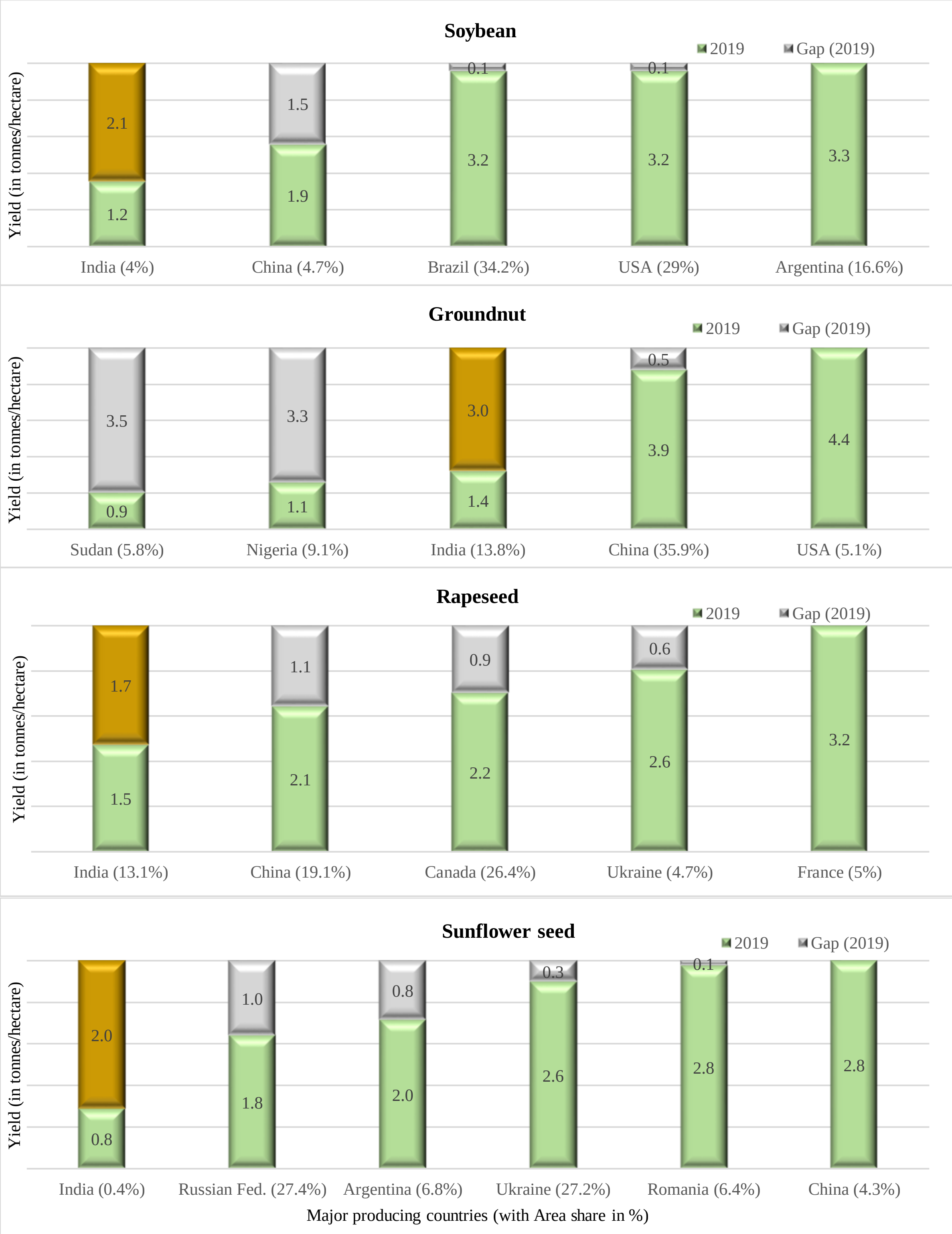
Source: Author's computation from FAOSTAT database

Figure 2. 9: Yield of minor oilseeds in top producing countries (Tonnes/Hectare)



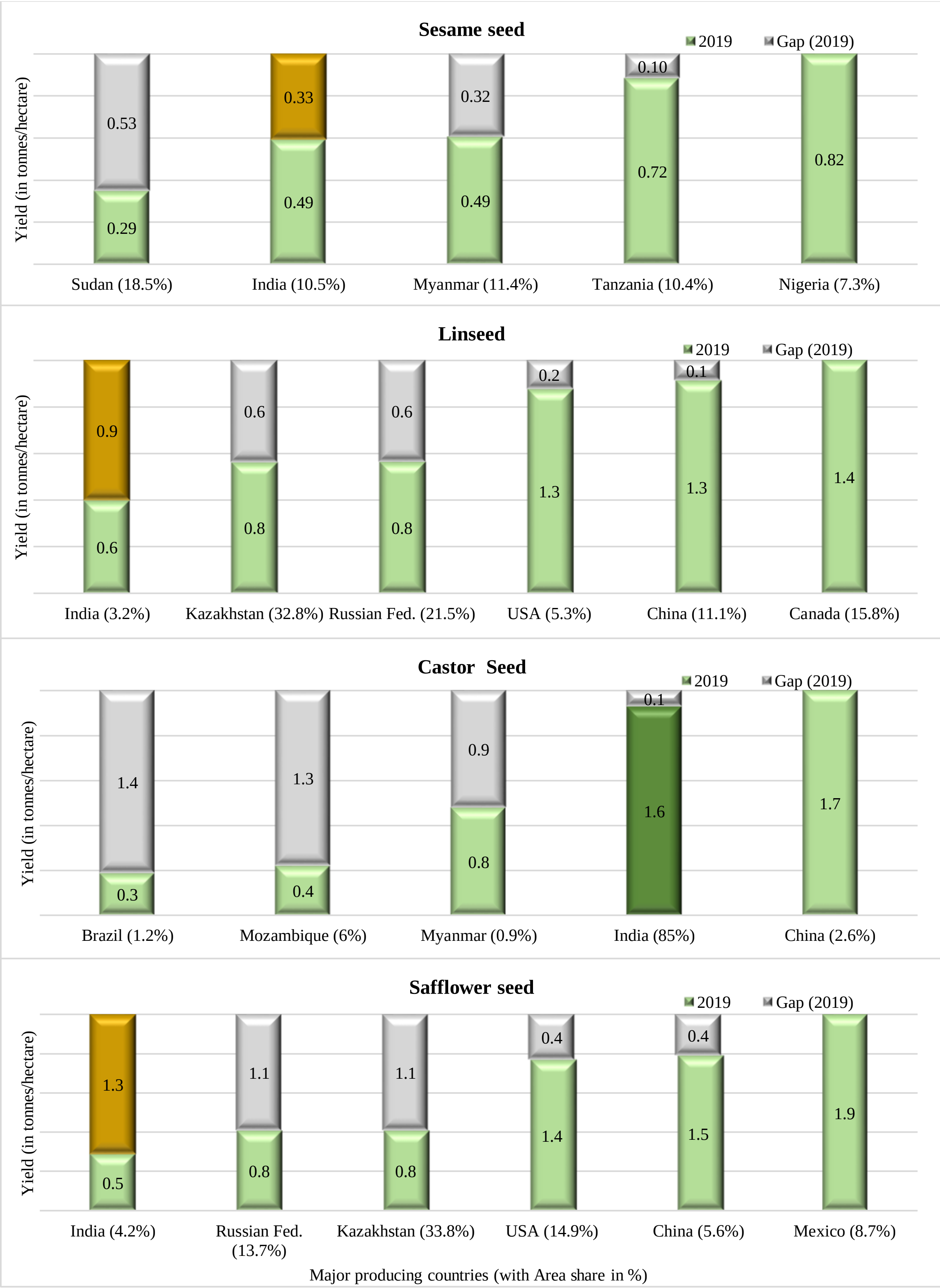
Source: Author's computation from FAOSTAT database

Figure 2. 10: Yield (Tonnes/Hectare – 2019) and yield gaps for major oilseeds in producing countries



Source: Author's computation from FAOSTAT database

Figure 2. 11: Yield (Tonnes/Hectare – 2019) and yield gaps for minor oilseeds in producing countries

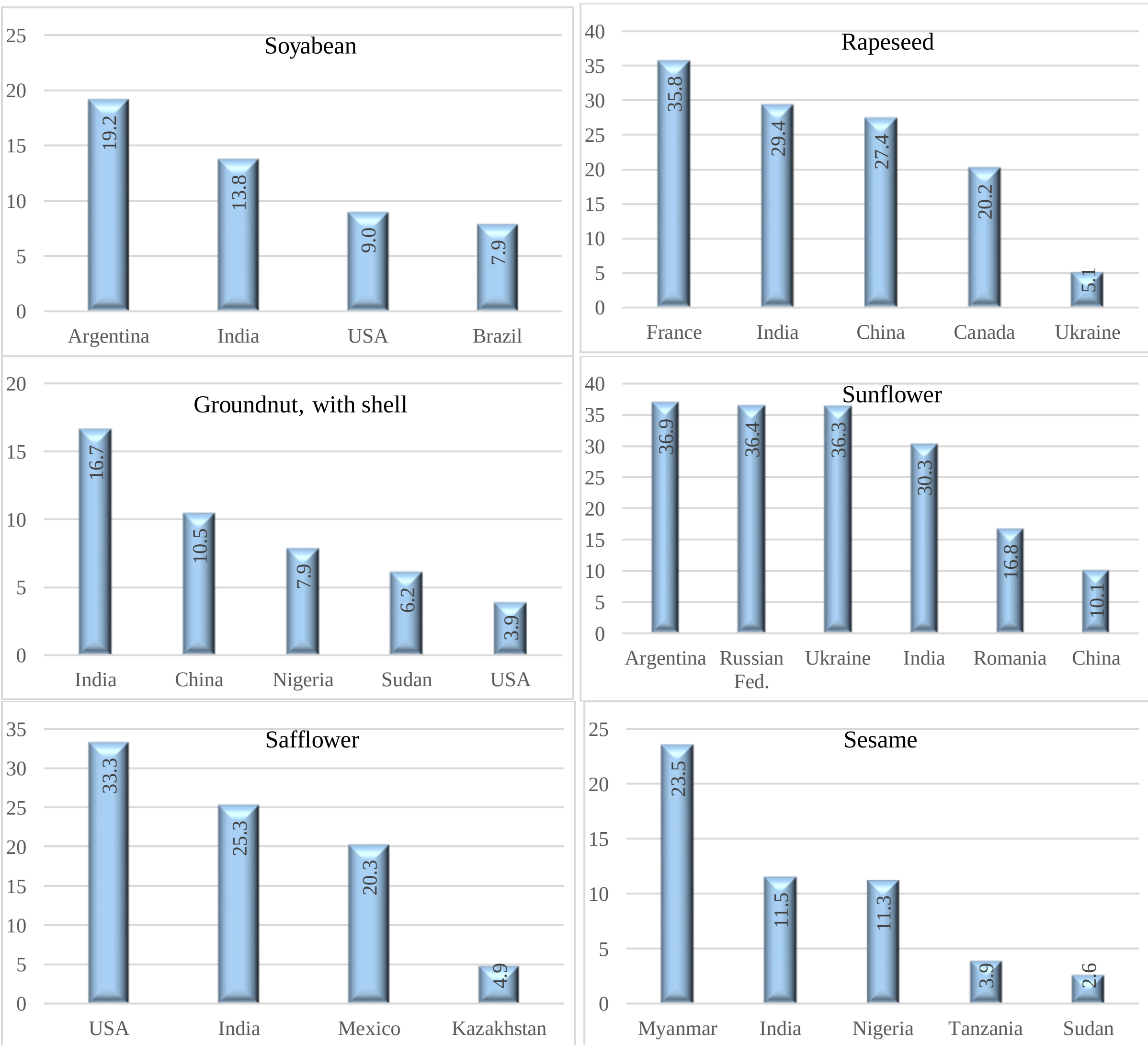


Source: Author's computation from FAOSTAT database

Oil extraction rates for major oilseed producing countries

The oil extraction rates for major oilseed producing countries are worked out for year 2018, using the FAO database for 'oilseed' and 'oil' production. Few of the major producing countries were also excluded due to data unavailability. For major oilseed crops such as soybean, rapeseed and groundnut (with shell), India performed very well as the rates are comparatively better than some of the developed countries. But the outcomes are to be further validated in some of the cases such as – the extraction rates for groundnut are for groundnut with shell, and the results appear surprising as the least extraction rate is witnessed for USA. There is high variation in the extraction rates across the countries for most of the oilseed crops. The extraction rates for few oilseed crops are reported in Figure 2.12.

Figure 2. 12: Oil extraction rates for major producing countries for few of the oilseed crops (in %)



Source: Author's computation from FAOSTAT database

Table 2. 2: Top producing countries of major oilseeds and the yield comparison with India

Oil crop	Production share (in %) and Yield (Tonnes/Ha.) in		Yield India (T/Ha.)	Yield	
	Top producing country	Highest yield country		w.r.t top producing country	w.r.t. highest yield country
Soybean	Brazil (34.2%, 3.18)	Argentina (16.6%, 3.33)	1.19	37.43	35.75
Groundnut	China (35.9%, 3.89)	USA (5.1%, 4.43)	1.42	36.53	32.13
Rapeseed	Canada (26.4%, 2.24)	France (5%, 3.18)	1.51	67.42	47.49
Sunflower seed	Russian Fed. (27.4%, 1.83)	China (4.3%, 2.85)	0.83	45.17	28.99
Safflower seed	Kazakhstan (33.8%, 0.76)	Mexico (8.7%, 1.86)	0.54	70.62	28.92
Sesame seed	Sudan (18.5%, 0.29)	Nigeria (7.3%, 0.82)	0.49	170.3	59.31
Castor oil	India (85%, 1.59)	China (2.6%, 1.71)	1.59	n.a.	92.91
Linseed	Kazakhstan (32.8%, 0.81)	Canada (15.8%, 1.43)	0.57	70.90	40.04

Source: Author's computation from FAOSTAT database

Chapter 3: Oilseed's production in India and Yield

Overview of oilseed production in India

India is among the top producing countries of few of the edible oils and oilseeds. India produces about 10.7% of the world's oilseeds, excluding oil palm, from about 6% of the global acreage under these oilseed crops as of 2019. India is world's largest producing country of castor seed, produces nearly 85% of worlds castor seed from 65% of the area share, the second largest in groundnut production, third largest in rapeseed and sesame seed production, fifth largest producing country of soybean and ranked sixth in sunflower seed and linseed production in the world (Table 3.1).

Table 3. 1: India's share and rank in the world oilseed production

Oil crop	Share (%) - 2019		Yield - Growth Rates in India						India's Rank	Countries ahead
	Area	Prod.	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2019		
Soybean	9.2	4.0	-0.37	2.16	2.64	1.66	3.35	-0.39	5	Brazil, USA, Argentina, China
Groundnut	16.0	13.8	0.34	0.93	1.20	0.56	2.76	2.96	2	China
Rapeseed	18.0	13.1	1.66	-1.34	5.24	0.07	2.30	2.59	3	Canada, China
Sunflower seed	1.0	0.4		-3.18	-1.29	-0.07	2.96	0.76	21	Russia, Ukraine, Argentina, Romania, China & 15 other
Safflower seed	7.0	4.2	3.22	4.53	-0.39	4.32	4.21	-3.50	6	Kazakhstan, USA, Russia, Mexico, China
Sesame seed	11.1	10.5	1.39	-0.36	3.49	1.06	-0.42	1.65	3	Sudan, Myanmar
Castor oil Seed	64.8	85.0	4.90	4.33	2.41	1.52	6.72	0.79	1	N.A.
Linseed	5.4	3.2	0.02	-2.20	1.85	1.87	1.20	3.12	6	Kazakhstan, Russia, Canada, China, USA

Note: Rank is based on production share in 2019. Source: Author's computation from FAOSTAT database

Table 3. 2: Availability, consumption and trade of major vegetable oils in India (in Million Tonnes)

Year	Production	Crushed	Imports	Exports (Protein meal)	Domestic Consumption	Ending Stocks	Import to Domestic Consumption (%)
2017-18	35.4	27.8	14.5	2.8	21.7	2.6	66.7
2018-19	35.1	29.2	15.3	3.1	22.1	3.1	68.9
2019-20	36.0	29.6	13.7	1.9	22.0	2.2	62.4
2020-21	38.3	31.6	13.8	3.1	22.2	1.5	62.1
2021-22	40.5	32.5	14.9	3.2	22.6	2.0	65.9
India % of World							
2017-18	6.1	5.7	18.9	3.1	11.3	10.2	
2018-19	5.8	6.0	18.5	3.3	11.2	11.8	
2019-20	6.2	5.8	16.6	2.0	10.9	8.2	
2020-21	6.3	6.2	16.9	3.2	10.8	6.2	
2021-22	6.4	6.2	17.2	3.2	10.7	8.3	

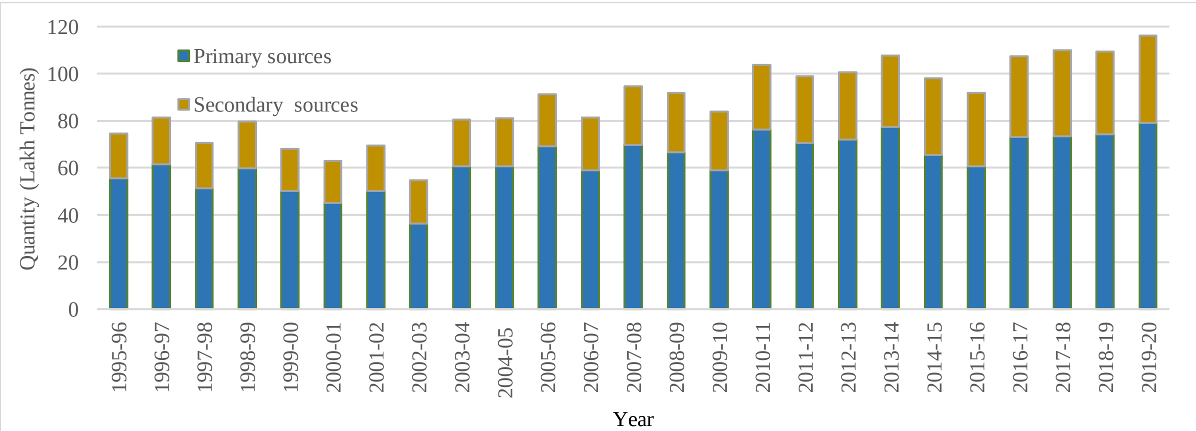
Note: Major vegetable oils includes Coconut, Cottonseed, Olive, Palm, Palm Kernel, Peanut, Rapeseed, Soybean, and Sunflower seed oil. Protein Meals -Copra, Cottonseed, Fish, Palm Kernel, Peanut, Rapeseed, Soybean, and Sunflower Meal. 2021-22 data is till Dec.
Source: Foreign Agricultural Service/USDA, Global Market Analysis report, January-2022

Production and consumption of edible oils in India

India produced about 116.3 lakh tonnes of edible oil from the primary and the secondary sources in 2019 (Figure 3.1). This is based on the fourth advance estimates released by Ministry of Agriculture and Farmers' Welfare on August 2020. The edible oil production in India witnessed an annual growth of about 2.2% since 1995-96 till 2019-20. The primary sources of edible oils include - groundnut, rapeseed & mustard, soybean, sunflower, sesamum, niger seed, safflower, castor and linseed. The secondary sources include - coconut, oil palm, cottonseed, rice bran, solvent extracted oils and tree & forest origin.

The edible oil production from the secondary sources witnessed a higher growth, at 3.3% per annum, as compared to the growth from primary sources, witnessed just about 1.8% annually. The share of primary sources and total edible oil production is about 68% in 2019-20, which declined from 75% in 1995-96.

Figure 3. 1: Edible oil production in India from primary and secondary sources (Lakh Tonnes)

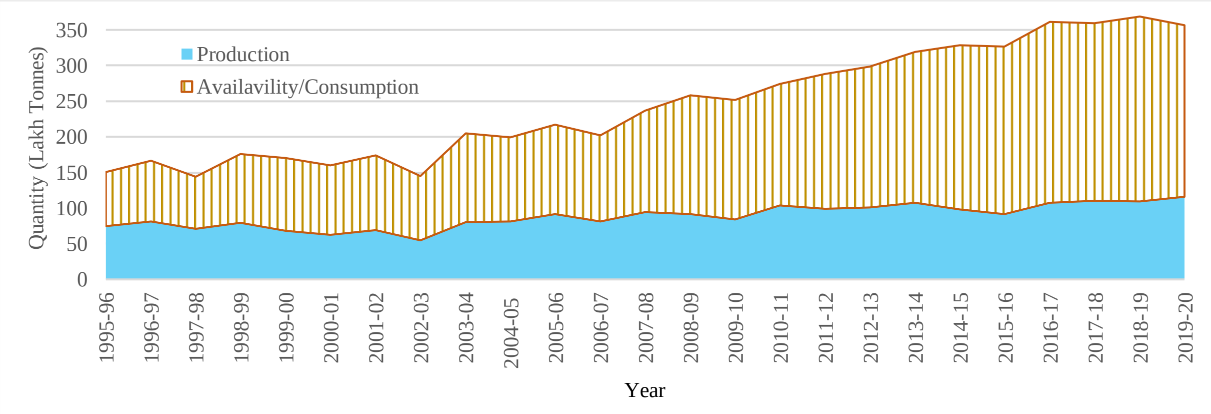


Source - Directorate of Vanaspati, Vegetable Oils and Fats

On the consumption side, the demand for edible oil in 2019-20 is about 241 lakh tonnes which is much higher than the total production (Figure 3.2). The unmet demand is fulfilled through import of edible oils. The domestic consumption of major vegetable oils in India is close to 10.7% of world consumption as of December 2021-22 (Table 3.2). To fulfil the unmet demand, the country imports nearly 65% of vegetable oils of the total domestic consumption. The import is about 17% of total world import of vegetable oils. The country also exports some of the oilseed meal, which is about 3% of world for specific crops and products.

The import of edible oils has increased sharply compared to production growth. The import of edible oils witnessed an annual growth of about 10.6% during the period of 1995-96 to 2019-20 as compared to annual growth rate of about 2.2% in production. The export and industrial use of edible oil is stagnant at about 10 lakh tonnes during this period.

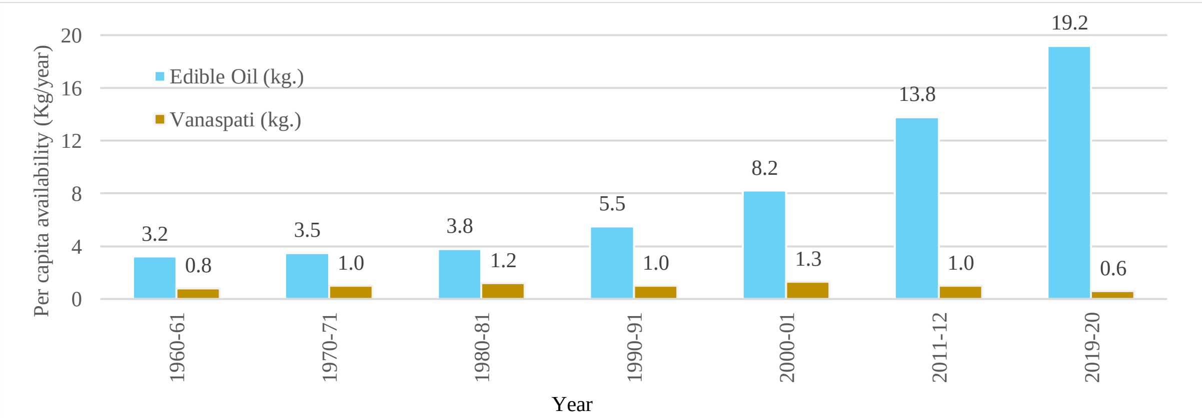
Figure 3. 2: Production and consumption of edible Oil in India (Lakh Tonnes)



Source - Directorate of Vanaspati, Vegetable Oils and Fats

The per capita availability of the edible oils and vanaspati is worked out. The per capita availability of the edible oils increased from 3.2 kg per year in 1960-61 to about 19.2 kg per year in 2019-20 (Figure 3.3). On the other hand, the per capita availability of vanaspati stagnated at 0.6 kg per year in 2019-20, which was at 0.8 kg per year in 1960-61. This reflects, a huge demand for the edible oil over a period of time. The gap between the availability of edible oils and vanaspati has widened over time.

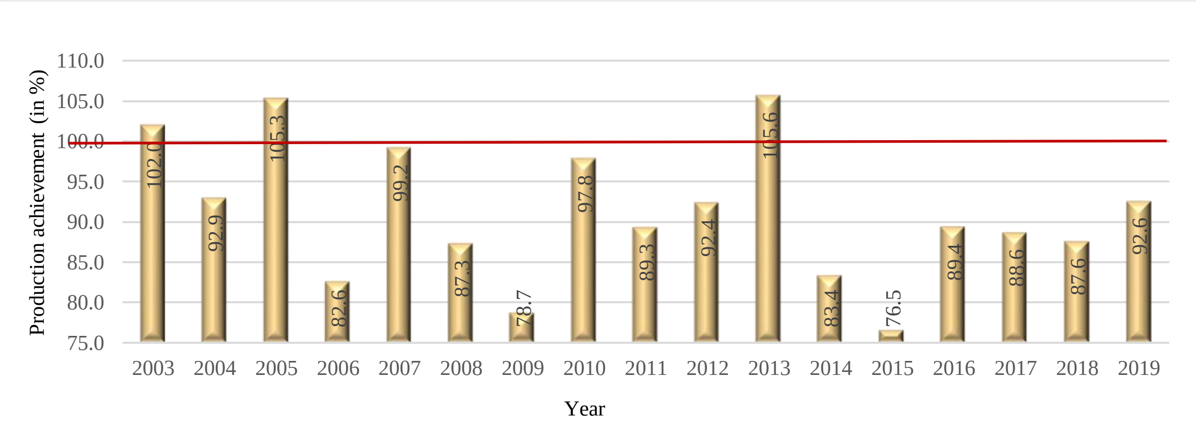
Figure 3. 3: Per capita availability of edible oil & vanaspati (kg/ year)



Source: Economic Survey 2020-21

During the period of past 17 years from 2003 to 2019, in only 2003, 2005 and 2013 (3 out of 17 years) India was able to achieve the production targets of edible oils and oilseeds (Figure 3.4). Only five times the country was able to achieve above 90% of production targets. The number of years, the production was above the target was 12 times for wheat, 11 times for paddy, 9 times for sugarcane, 7 times for cotton and 6 times for coarse cereals and pulses. Since 2002 was a drought year, none of the crops could achieve the production targets in the year. Achievement of targets of oilseed production is given below.

Figure 3. 4: Achievement of oilseed production compared to targets (in %)



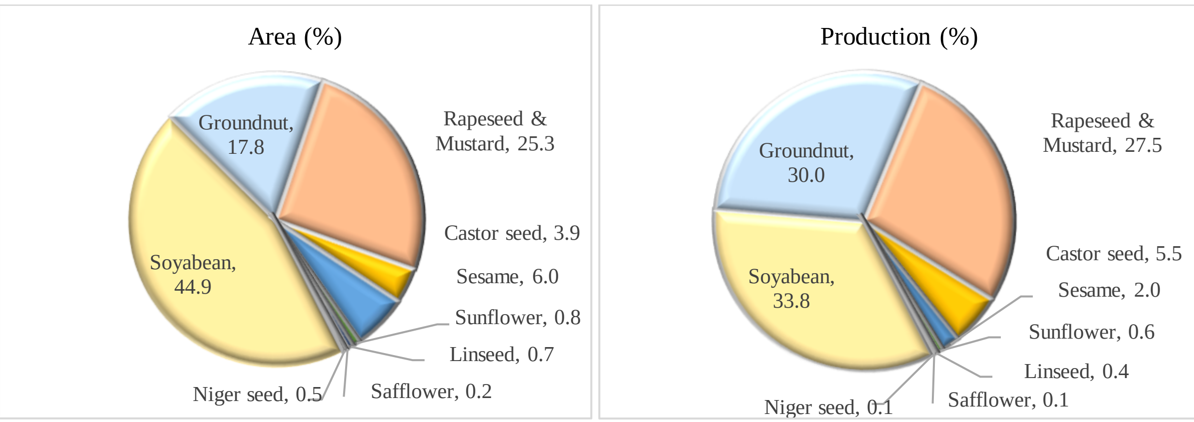
Source - Directorate of Vanaspati, Vegetable Oils and Fats

Major oilseed crops grown in India

Of the total oilseed produced in India, the soybean holds the largest share of about 34% in 2019-20 (Figure 3.5). This is followed by groundnut (30%), rapeseed-mustard (27.5%) and castor seed (5.5%). The share of sesame seeds is about 2%. The other minor oilseeds grown in India are sunflower (0.6%), linseed (0.4%), safflower (0.1%), niger seeds (0.1%) holding less than 1% share in total of these selected major oilseeds' production as of 2019-20.

Of the major oilseeds produced in India, Rajasthan holds the highest production share of about 20.4%. Gujarat (20%), Madhya Pradesh (19.4%) and Maharashtra (15.6%) are other major oilseed producing states in India. In year 2019-20, these four states together had a share of 75% of the total oilseed production in India. The major oilseeds considered are soybean, groundnut, rapeseed and mustard, sesame, sunflower, sunflower, linseed, niger seed and castor seed. Castor seed and the linseed are basically considered non-edible oilseeds, but have been considered in our analysis to obtain the overall picture of the nine oilseeds grown in the country.

Figure 3. 5: Area and production share under major oilseed crops in India (in %)



Source - Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare database. This applies for all the tables and figures include computation on area, production and yield data at the state and district level.

Area under oilseed crops

In 2020-21, the area under major nine-oilseed crops grown was about 16.3% of combined area under food grains, oilseeds, sugarcane, cotton and jute & Mesta. This is the second highest after food grains (73.2%). There is limited scope to increase acreage under oilseed crops.

The state specific shares under each of the major oilseed crops grown in India are worked out for year 2019-20. Madhya Pradesh (43.5%) and Maharashtra (43%) are two major producing states of soybean and contributes more than 86% of the country's soybean production (Figure 3.6). Rajasthan (4.7%), Karnataka (3.4%) and Telangana (2.8%) are the other minor states contributing about 11% of production. Gujarat is the largest producing state of groundnut in India, about 47% of country's groundnut production. Rajasthan (16.3%), Tamil Nadu (10.4%), Andhra Pradesh (8.5%) and Karnataka (5.1%) are the other major groundnut producing states, together producing about 87% of groundnut in India. Rajasthan contributes about 46% of country's rapeseed and mustard production. Haryana (12.6%), Madhya Pradesh (11.4%), Uttar Pradesh (10.5%) and West Bengal (7.8%) are the other major rapeseed and mustard producing states, together contributing more than 88% of rapeseed and mustard production in the country.

The major oilseed states are depicted in Figure 3.7. There is limited acreage under major oilseed crops in eastern India. Rapeseed & mustard is preferred among the major oilseeds in this region.

Some of the other major producing states of the minor oilseed crops in India - Karnataka contributed about 48.6% of the total sunflower production in the country in 2019-20. Karnataka (57.9%) and Maharashtra (34.2%) are the two largest producing states of safflower in India. Gujarat is the single largest producing state of castor seed in India, contributing about 77.7% of country's castor seed production. Madhya Pradesh (37.4%), Jharkhand (19.1%) and Uttar Pradesh (15.4%) are the major producing states of linseed in the country contributing about 72% share. Odisha (47.6%) and Chhattisgarh (23.5%) together contribute to about 71% of the country's niger seed production. West Bengal (20.5%) is the largest producing state of sesame seeds, followed by Madhya Pradesh (19.2%), Gujarat (16.4%), Rajasthan (14%) and Uttar Pradesh (10%), which together contribute about 80% of sesame production in the country.

Figure 3. 6: Production share under major producing state for major oilseed crops (in %) – 2019-20

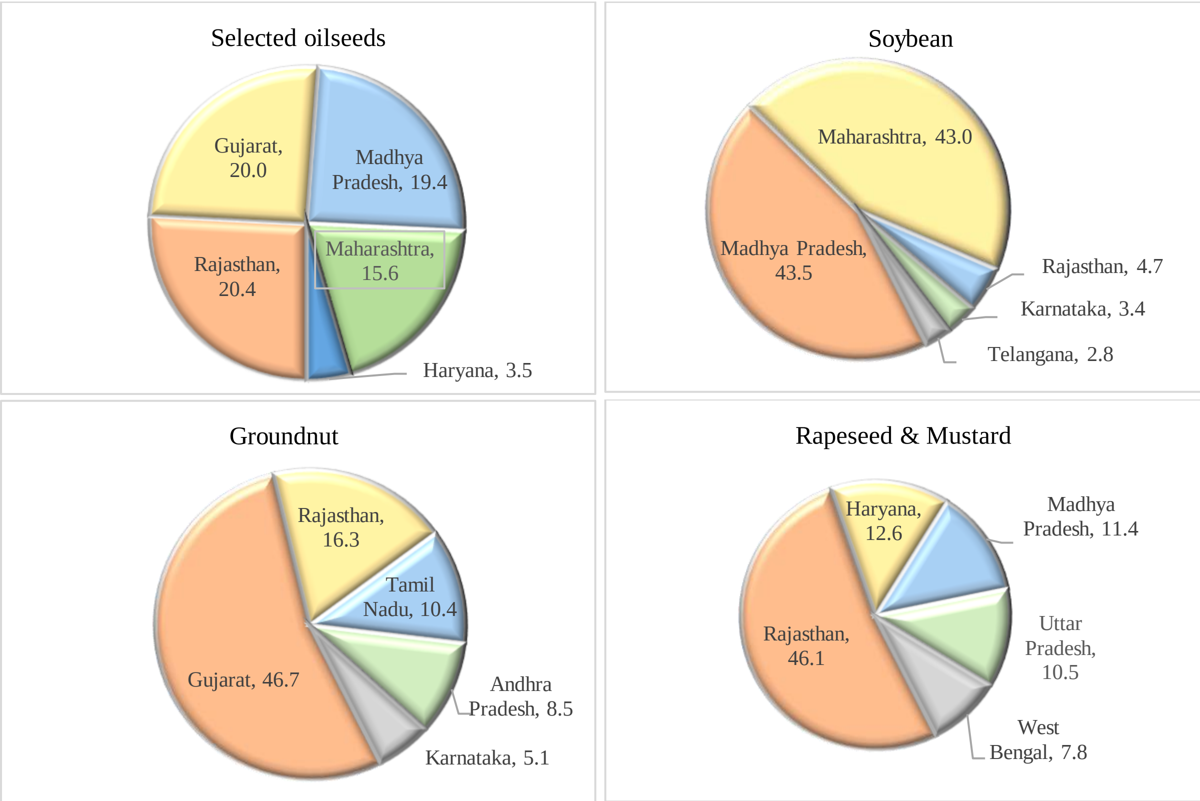
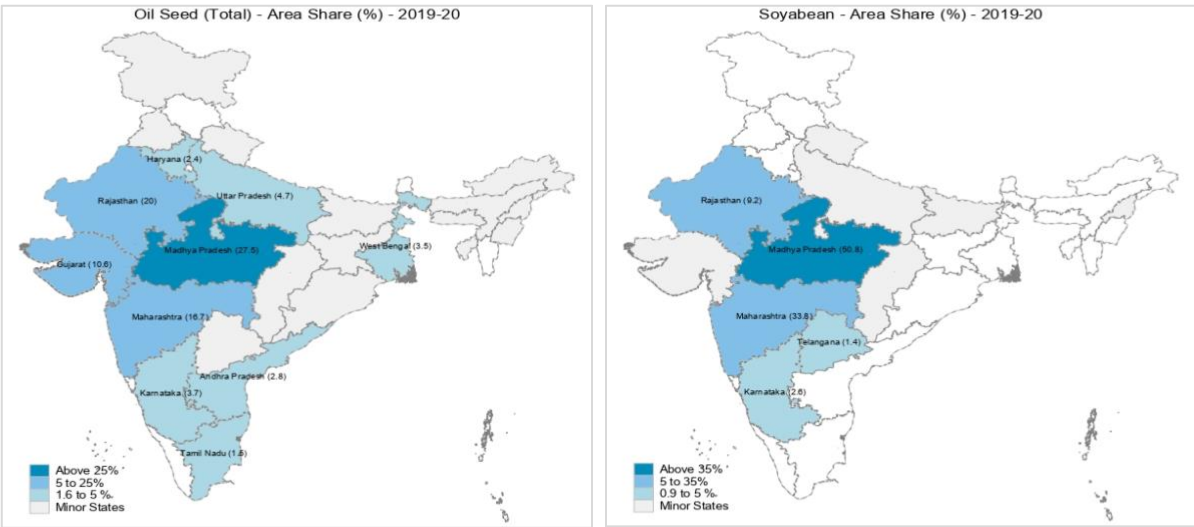
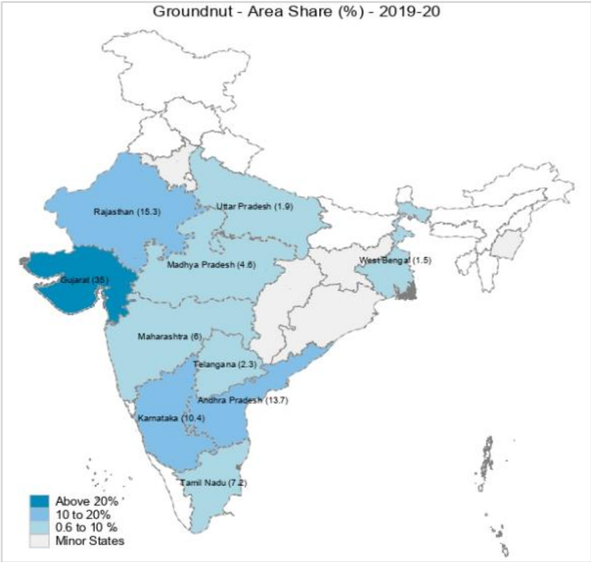
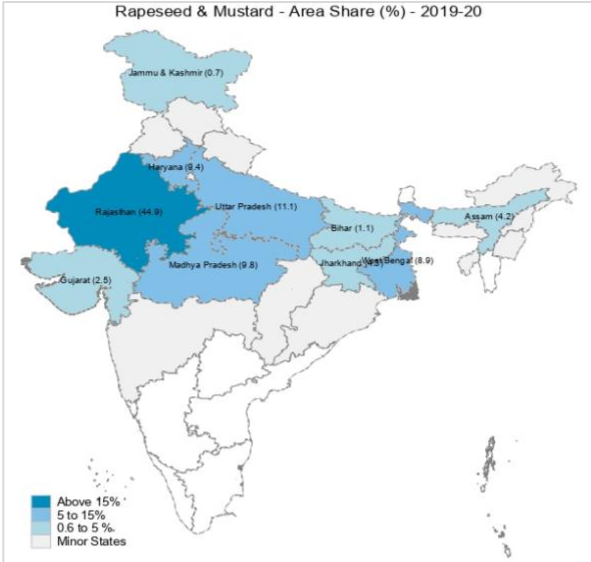


Figure 3. 7: Area share under major producing state for major oilseed crops (in %) – 2019-20







The conversion factor of oil to the oilseeds for some of the primary and secondary sources of oil seeds are reported in the Table 3.3. The extraction rate is about 40% for groundnut and sesame, highest among the major primary oilseed crops. For rapeseed & mustard and linseed the conversion ratio is about 33%. For the largest produced oilseed crops, soybean, this ratio is about 18%. Among the other secondary and tree based edible oil sources, the conversion rate is highest for coconut (about 62%) followed by neem-seed (about 45 to 50%). For cotton seed, the conversion rate is about 14-18%.

Table 3. 3: Oil to oilseed conversion factor for some primary and secondary oilseeds (in %)

Oilseed crop	Conversion Factor (%)
Soybean Seed	18.0
Groundnut	40.0
Rapeseed & Mustard	33.0
Sesamum	40.0
Linseed	33.0
Niger seed	28.0
Castor seed	37.0
Sunflower	31.5
Safflower	25.5
Coconut	62.0
Cotton Seed	14-18
Kardi Seed	40.0
Mahua Seed	36.0
Neem Seed	45-50

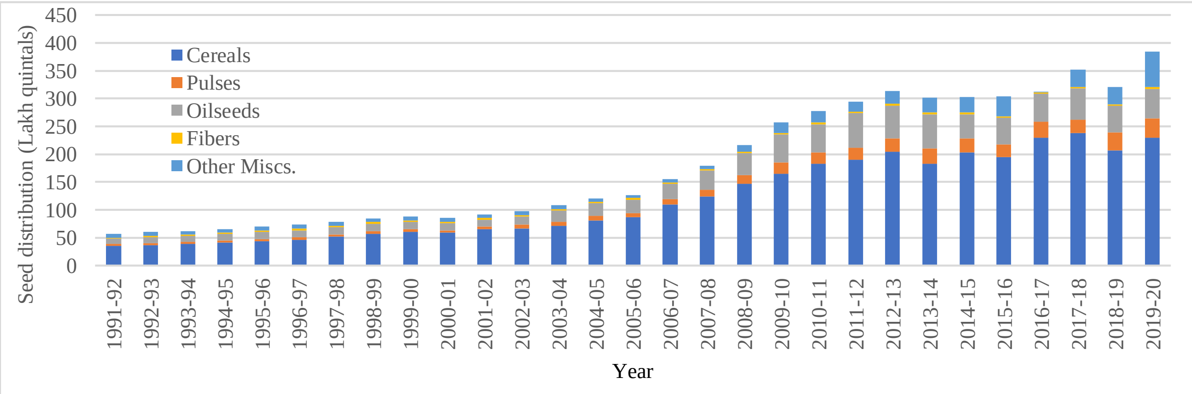
Source: Department of Agriculture, Cooperation & Farmers Welfare, MoA&FW. Note: The extraction rates are based on 'Oil to Kernels crushed' for groundnut and neem, 'Oil to Seed production for 2017-18' for sunflower and safflower, 'Oil to Copra crushed' for coconut, 'Oil to Seed crushed' for all other oilseeds.

Distribution of certified/quality seeds

In India, about 384 lakh quintal certified seeds were distributed in 2019-20 (Figure 3.8). A significant progress has been made in distributing certified quality seeds over time. During 1991-92 only 57.5 lakh quintal seeds where distributed. The cereals hold the largest share in the distribution (about 60% of the total seeds distribution). The share of pulses and oilseeds in

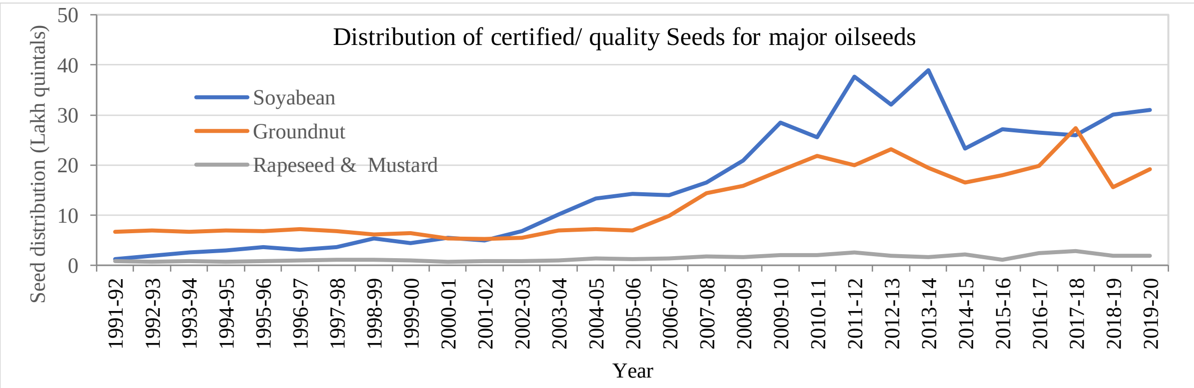
2019-20 is about 8.9% and 13.8%, respectively. Within the oilseeds, the highest share is of soybean (about 58%), followed by groundnut (about 36%) and rapeseed & mustard (3.5%). The distribution of certified and quality seeds for three of the major oilseed crops reported in Figure 3.9. Of the total availability of the certified and quality oilseeds, about 43% is fulfilled by the government and rest 57% by the private sources. In the recent period, since 2013-14, the availability of the certified and quality oilseeds is observed sufficient as compared to the total requirement till 2019-20, except for the year 2014-15 and 2015-16.

Figure 3. 8: Distribution of certified/ quality seeds for major crop groups (Lakh quintals)



Source: Department of Agriculture, Cooperation & Farmers Welfare

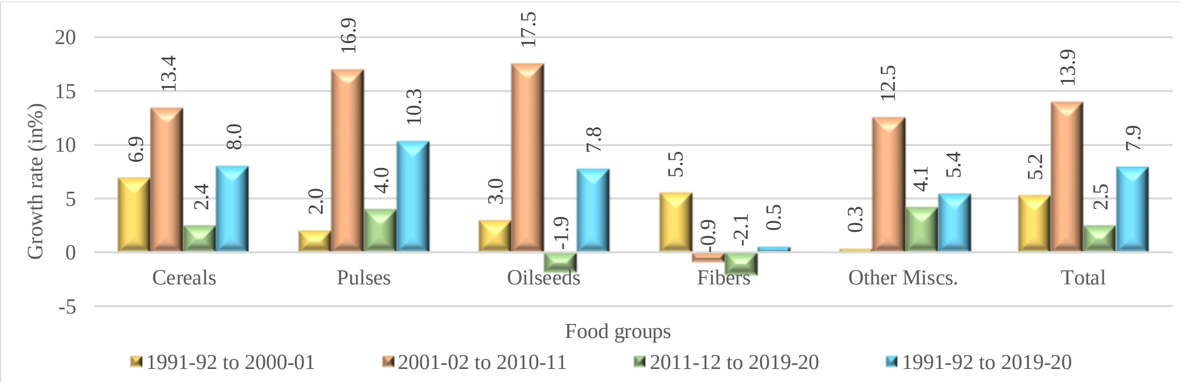
Figure 3. 9: Distribution of certified/ quality seeds for major oilseeds (Lakh quintals)



Source: Department of Agriculture, Cooperation & Farmers Welfare

An annual growth rate of about 14% per annum in distributing the certified seeds was achieved during the decade 2001-02 to 2010-11 but the current decade witnessed stagnation (at just about 2.5% per annum). The growth rate in distribution of certified oilseeds was highest among all the crop groups during the decade 2001-02 to 2010-11 at 17.5% per annum. But during the current decade the growth is -2% per annum, stands lowest along with the fibers. The growth rates of the last three decades are reported in Figure 3.10.

Figure 3. 10: Decadal growth in distribution of certified/ quality seeds (in %)



Source: Calculation on data from Department of Agriculture, Cooperation & Farmers Welfare

Yield of major oilseeds grown in India

India is lagging behind in terms of productivity of oilseed crops compared to other major oilseed producing countries. Measures to enhance the productivity are needed because of limited options to increase area under these crops. The yield of the major oilseeds is analysed at the national as well as state level. The three-year moving average yield of these oilseed crops at three different point of time – 1985-86, 2004-05 and 2019-20 for a reported in Figure 3.11. This suggests, the yield of most of the oilseed crops is improved over time, especially during the recent period (2019-20) compared to previous periods of time. The trend in yield of three of the major oilseed crops is reported in Figure 3.12, indicating stagnation in soybean yield over past two decades mainly contributed by stagnating yield in major producing states of soybean. On the other hand, the groundnut yield increased with a higher acceleration during this phase. The yield of some of the minor oilseed crops is still very low and has not witnessed the expected growth. The state-level yield of major oilseed crops has been analysed below.

Figure 3. 11: Yield of major oilseeds in India (3 YMA) (in Tonnes/Hectare)

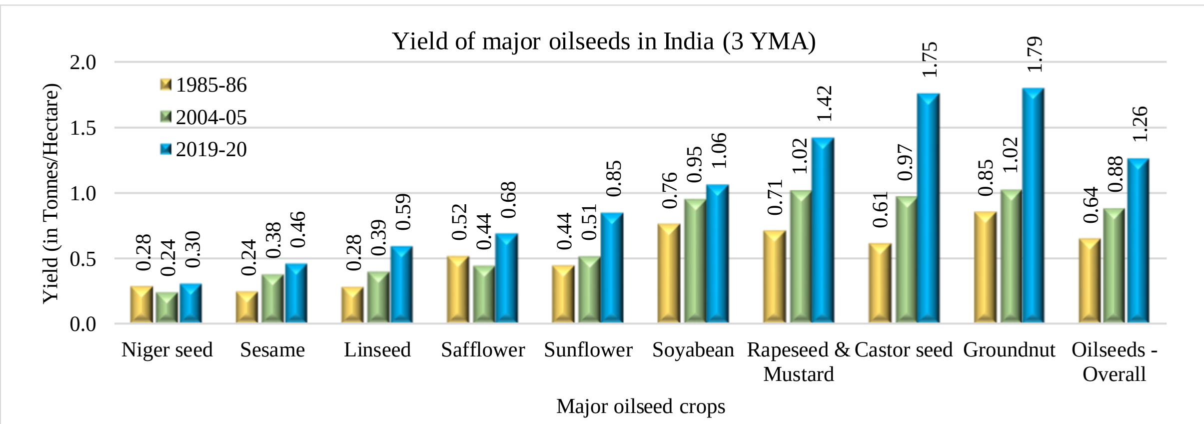
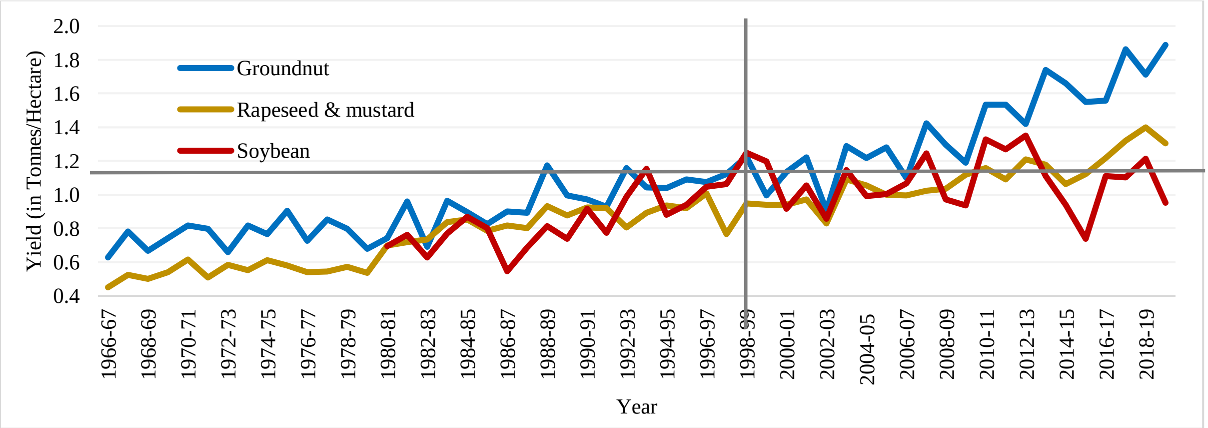


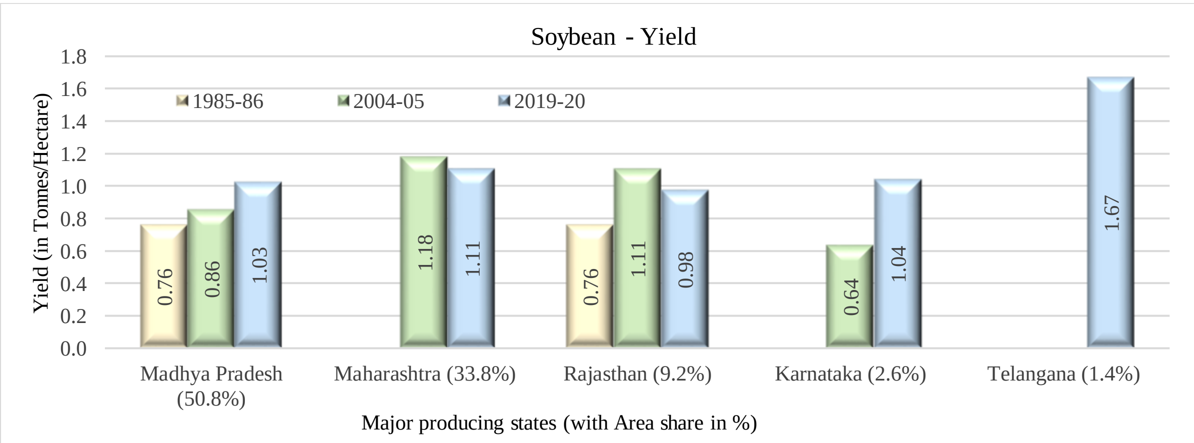
Figure 3. 12: Trend in yield of major three oilseed crops grown in India



Soybean

The yield of soybean is highest in Telangana which was 1.7 tonnes per hectare in 2019-20 (Figure 3.13). The state holds slightly more than 1% of the area under soybean in the country. Telangana is followed by Maharashtra, Karnataka and Madhya Pradesh in which the crop yield is just more than 1 tonne per hectare. The soybean yield in major producing states like Maharashtra and Rajasthan witnessed a decline in 2019-20 as compared to 2004-05. In all these states and the largest producing state - Madhya Pradesh, the yield has not shown much growth and stagnated in the range of 0.8 to 1.2 tonnes per hectare.

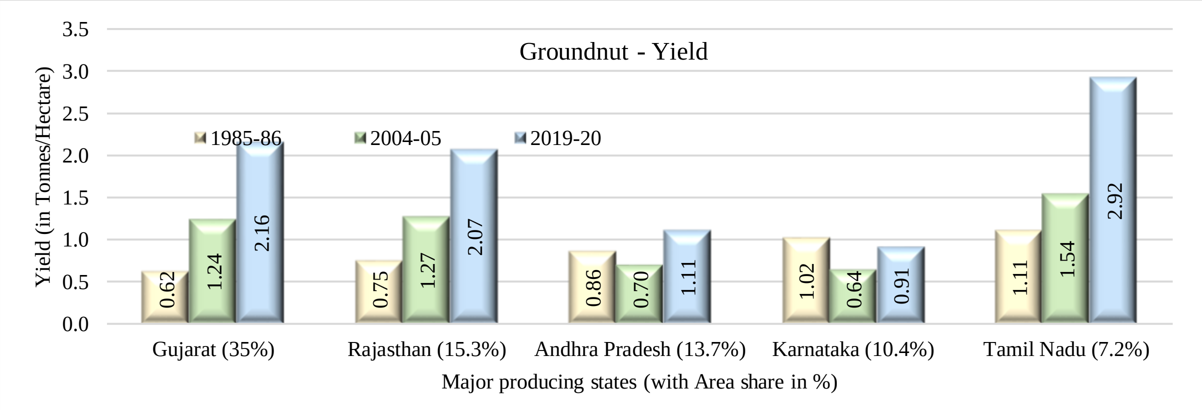
Figure 3. 13: Yield of soybean in major producing states (in Tonnes/Hectare)



Groundnut

The yield of groundnut is highest in Tamil Nadu at 2.9 tonnes per hectare (Figure 3.14). The largest producing state Gujarat stands second in terms of yield at 2.2 tonnes per hectare, followed by Rajasthan at 2.1 tonne per hectare. In the other two major producing states - Andhra Pradesh and Karnataka, holding about 24% of country's area share, the yield is much lower, around 1 tonne per hectare, nearly 2.5 times to 3 times lower than Tamil Nadu. The yield in these two states witnessed stagnation around 1 tonne per hectare since 1985-86.

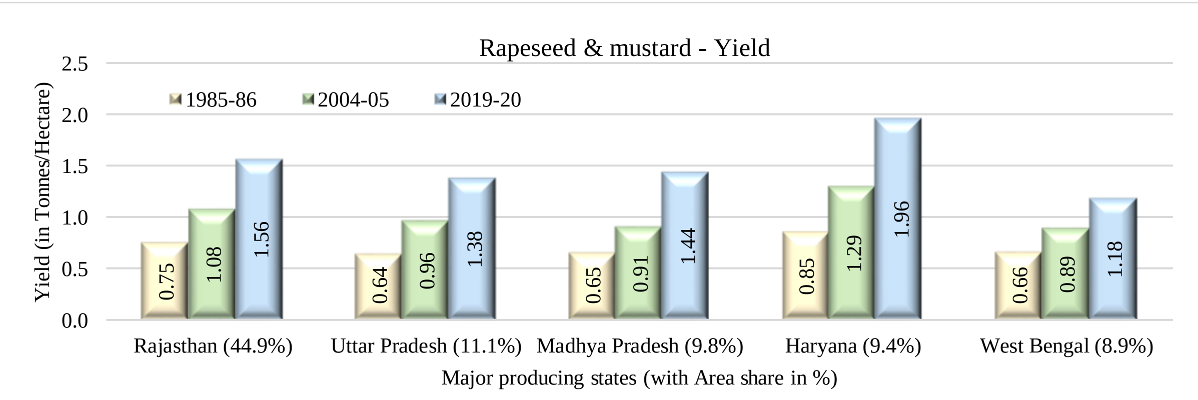
Figure 3. 14: Yield of groundnut in major producing states (in Tonnes/Hectare)



Rapeseed & mustard

The yield of rapeseed and mustard is highest in Haryana about 2 tonnes per hectare. This is followed by Rajasthan, Madhya Pradesh and Uttar Pradesh at about 1.5 tonnes per hectare (Figure 3.15). In all the major producing states the yield has nearly doubled in 2019 as compared to 1985 level. West Bengal holding about 9% of area share witnessed a comparatively slower growth in yield than other major states.

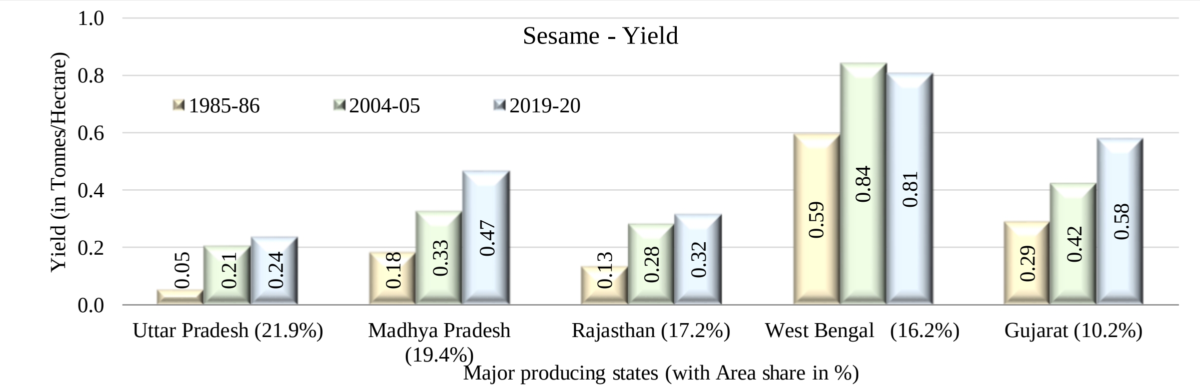
Figure 3. 15: Yield of rapeseed & mustard in major producing states (in Tonnes/Hectare)



Sesame seed

Sesame seed is locally known as 'til'. The productivity of sesame is highest in West Bengal at 0.8 tonne per hectare (Figure 3.16). This is followed by Gujarat at 0.6 tonne per hectare and Madhya Pradesh at 0.5 tonnes per hectare. The yield of sesame in Uttar Pradesh and Rajasthan is much lower, around 0.3 tonnes per hectare, holding about 39% of the area share in 2019-20. None of the major producing state is still able to reach the threshold of 1 tonne per hectare yield.

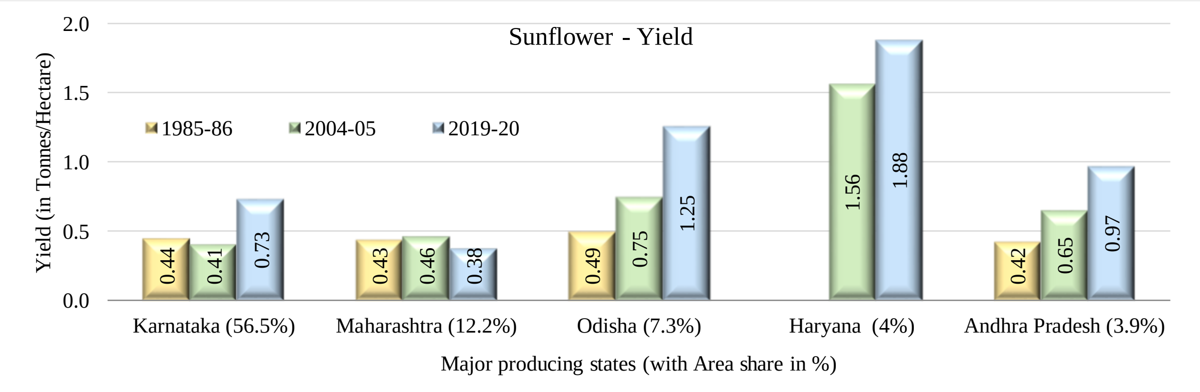
Figure 3. 16: Yield of sesame seed in major producing states (in Tonnes/Hectare)



Sunflower seed

Sunflower is majorly grown in Karnataka, which has more than 56% area share. But the productivity of sunflower in Karnataka is very low, about 0.7 tonne per hectare in 2019-20, which is slightly more than the yield in Maharashtra (Figure 3.17). Maharashtra reported the lowest yield of 0.4 tonne per hectare and has stagnated at this level since 1985-86. Haryana holding just 4% of country's areas share, reported the highest yield at 1.9 tonnes per hectare in 2019-20. This is followed by Odisha, (1.25 tonnes per hectare) and Andhra Pradesh (one tonne per hectare).

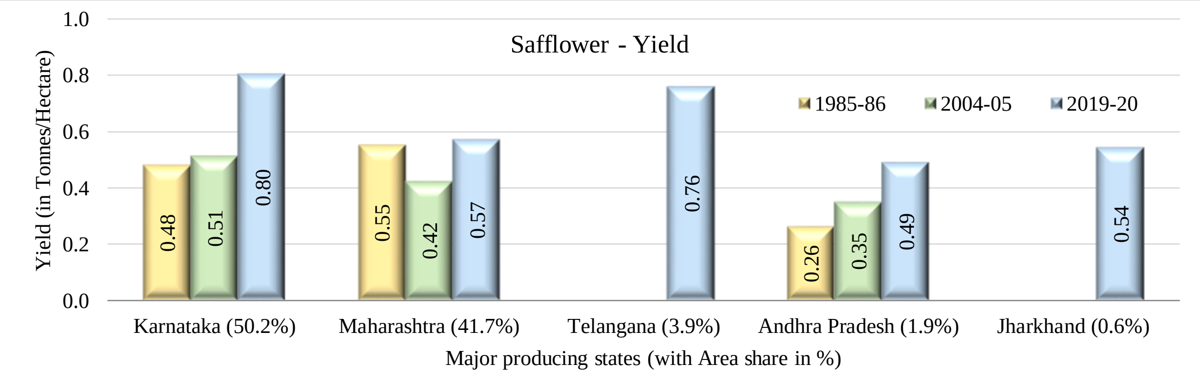
Figure 3. 17: Yield of sunflower seed in major producing states (in Tonnes/Hectare)



Safflower seed

Karnataka (50%) and Maharashtra (42%) are the major safflower producing states in India, together holding nearly 92% area share. The productivity of safflower is also highest in Karnataka at 0.8 tonnes per hectare in 2019-20 (Figure 3.18). This is followed by Telangana at 0.76 tonnes per hectare and Maharashtra at 0.57 tonnes per hectare.

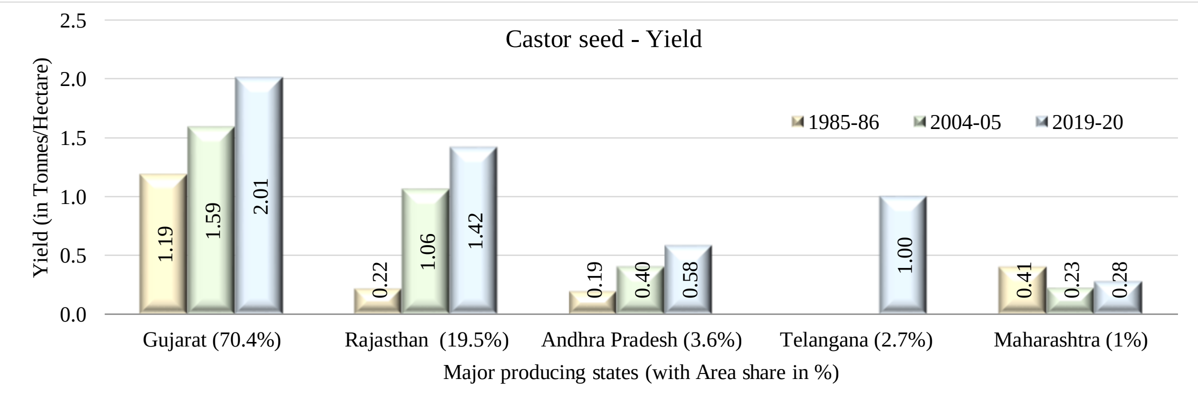
Figure 3. 18: Yield of safflower seed in major producing states (in Tonnes/Hectare)



Castor seed

Gujarat is the largest castor seed producing state holding with more than 70% of the share in the total area under the crop in the country. Gujarat is followed by Rajasthan with 19.5% area share. The yield of castor seed is also highest in Gujarat at 2 tonnes per hectare and in Rajasthan it is 1.4 tonnes per hectare (Figure 3.19). The yield of castor seed in other producing states such as Andhra Pradesh (0.6 tonnes per hectare) and Maharashtra (0.3 tonnes per hectare) is very low compared to the two largest producing states.

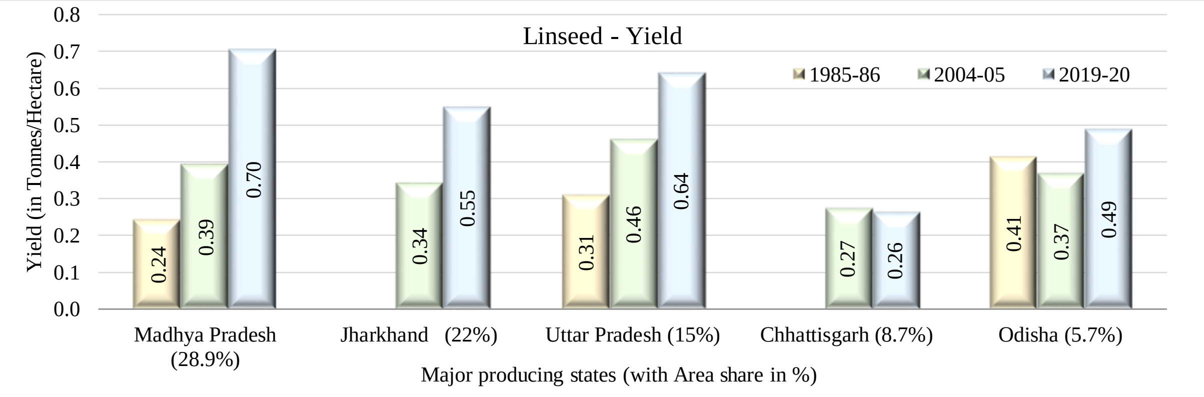
Figure 3. 19: Yield of castor seed in major producing states (in Tonnes/Hectare)



Linseed

Yield of linseed is also ranging between 0.5 tonnes per hectare to 0.7 tonnes per hectare and in 4 out of 5 major producing states except Chhattisgarh (Figure 3.20). The linseed yield in Chhattisgarh in just 0.26 tonnes per hectare. All three-major producing state - Madhya Pradesh (area share - 29%), Jharkhand (22%) and Uttar Pradesh (15%) - together have a two-thirds share of country’s total area under the crop. The yield of linseed has improved over time.

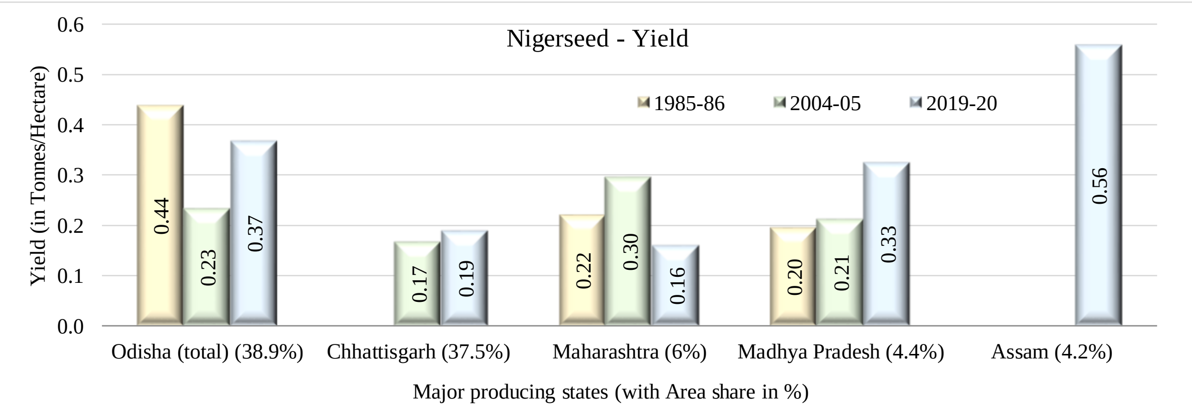
Figure 3. 20: Yield of linseed in major producing states (in Tonnes/Hectare)



Niger seed

Niger seed is mainly grown in Odisha and Chhattisgarh but the yield is very low, around 0.4 tonnes per hectare in Odisha and less than 0.2 tonnes per hectare in Chhattisgarh and Maharashtra (Figure 3.21). Assam holding just 4% area share reported the highest yield of 0.56 tonnes per hectare.

Figure 3. 21: Yield of Niger seed in major producing states (in Tonnes/Hectare)

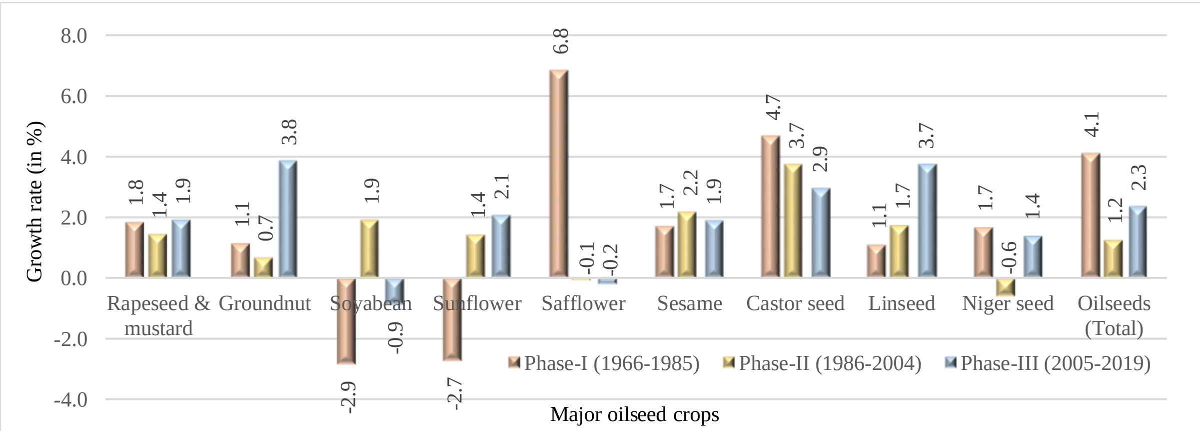


Growth rates of yield for major oilseeds by states

In the past it has been observed that the rapeseed & mustard yield improved during 1984-85 to 1996-97 due to high-yielding seeds and improvements in irrigation facilities. The growth has become almost stagnant in the last one decade in some of the major oilseed producing states due to intermittent drought conditions and changes in cropping pattern. In this section, the yield growth rates are calculated and analyzed for the major and minor oilseed crops in India. The growth rates are analyzed for three phases - phase I (from 1966 to 1985), phase II (from 1986 to 2004) and phase III (from 2005 to 2019). The phase I represents the historical period of limited exposure to technological advancement but limited use of inputs such as fertilizer; phase II includes the period of launching of Oilseed Mission Programs and the yield performance thereafter; and the final phase (phase III) represents the recent oilseed yield performance during the recent times.

In India, the oilseed crops on combined basis, witnessed positive growth in all the three phases (Figure 3.22). The initial phase witnessed the highest overall growth of +4.1% on annual basis, which declined to +1.2% during the phase II and increase again to about +2.3% in the third phase. For most of the oilseed crops the growth during the three phases witnessed positive growth except in a few cases – soybean and safflower during phase I & III, sunflower during phase I and niger seed during phase II. At the crop specific level, groundnut, sunflower and linseed witnessed a positive momentum over the phases in yield growth, while safflower and castor seed reflected a positive but declining rate over the periods due to high initial phase growth. Rapeseed & mustard and sesame witnessed stagnating growth and soybean and niger seed reflected no clear direction of growth over the study phases.

Figure 3. 22: Phase-wise growth rates of yield for major oilseed crops – India



Gujarat is a major oilseed producing state performed better than other major oilseed producing states over the three phases. The state continues gaining growth momentum in overall oilseed yield from 1.85% per annum during phase I to 2.8% during phase II and 3.6% in phase III.

For Soybean, the highest growth in the crop yield was during phase I, especially in the states of Gujarat and Rajasthan with a growth rate of nearly 10.7% per annum and 8.3% per annum, respectively (Table 3.4). During phase II, all the major producing states of soybean witnessed positive growth with the highest growth rate in Maharashtra at (+5.7% per annum), followed by Karnataka (+3.3%) and Gujarat (+2.2%). But during phase III, the growth momentum is carried forward only by Gujarat (+4.2%) and Karnataka (+3.3%). Three of the largest producing states - Madhya Pradesh (-0.8%), Maharashtra (-1%) and Rajasthan (-3%) recorded the negative growth during the recent phase.

Contrary to this, two of the largest producing states of groundnut - Gujarat and Rajasthan are continuing the growth momentum since the phase I. These states performed better during the phase II and phase III as compared to the phase I, with a growth rate of nearly 4% and 4.1% per annum respectively in these phases in Gujarat and 3% and 3.1% per annum in Rajasthan during phase II and phase III, respectively. The growth acceleration was highest in phase II compared to phase I but the acceleration stagnated during the phase III. Also, for the other major producing states - Andhra Pradesh, Karnataka and Tamil Nadu, growth during phase III is better than the previous two phases.

Similar to soybean, in most of the major producing states of rapeseed and mustard, phase I witnessed the highest growth in crop yield in the range of 3% to 4.2% per (except Uttar Pradesh). These states, however stagnated and were able to hold on to growth rate of 0.7% to 1.7% per annum during phase II but the growth momentum picked once again in the recent phase with 2 to 3% per annum in these states excepting Uttar Pradesh.

Odisha witnessed the highest annual growth rate in sunflower yield among the major producing states during phase II and phase III, followed by Andhra Pradesh, Karnataka and Haryana. However, Maharashtra witnessed a negative growth of nearly -4.6% per annum during the recent phase III. This reflects that the sunflower yield in Maharashtra has been flat during the last three decades in spite of the oilseed mission programs launched by the government.

The safflower yield performance in the major producing states is worsening over time. During phase I, Karnataka (8.1% per annum), Maharashtra (6.7%) and Andhra Pradesh (3.2%) reported the best yield growth rates but these states recorded only 1% growth rate during phase II and showed a negative growth rate of 1.6% during the phase III.

Being a minor oilseed crop, the sesame yield was not in the focus during the phase I but performed much better during phase II witnessing the yield growth of +3.2% up to +9% per annum in most of the states. These states were also able to hold the growth momentum further in range +1.6% to +4.6% per annum during the phase III, except West Bengal. As for other minor oilseed, in the recent period - Rajasthan and Andhra Pradesh performed better for castor seed; Madhya Pradesh and Uttar Pradesh for linseed; and Madhya Pradesh for niger seed. On the contrary, states like Maharashtra and Gujarat for Castor seed; Odisha for linseed; and Maharashtra for niger seed lost the growth momentum over phases, or were not able to pick up the growth momentum at all. Figure 3.23 also represents the yield growth rates of major oilseeds in some major as well as minor producing states.

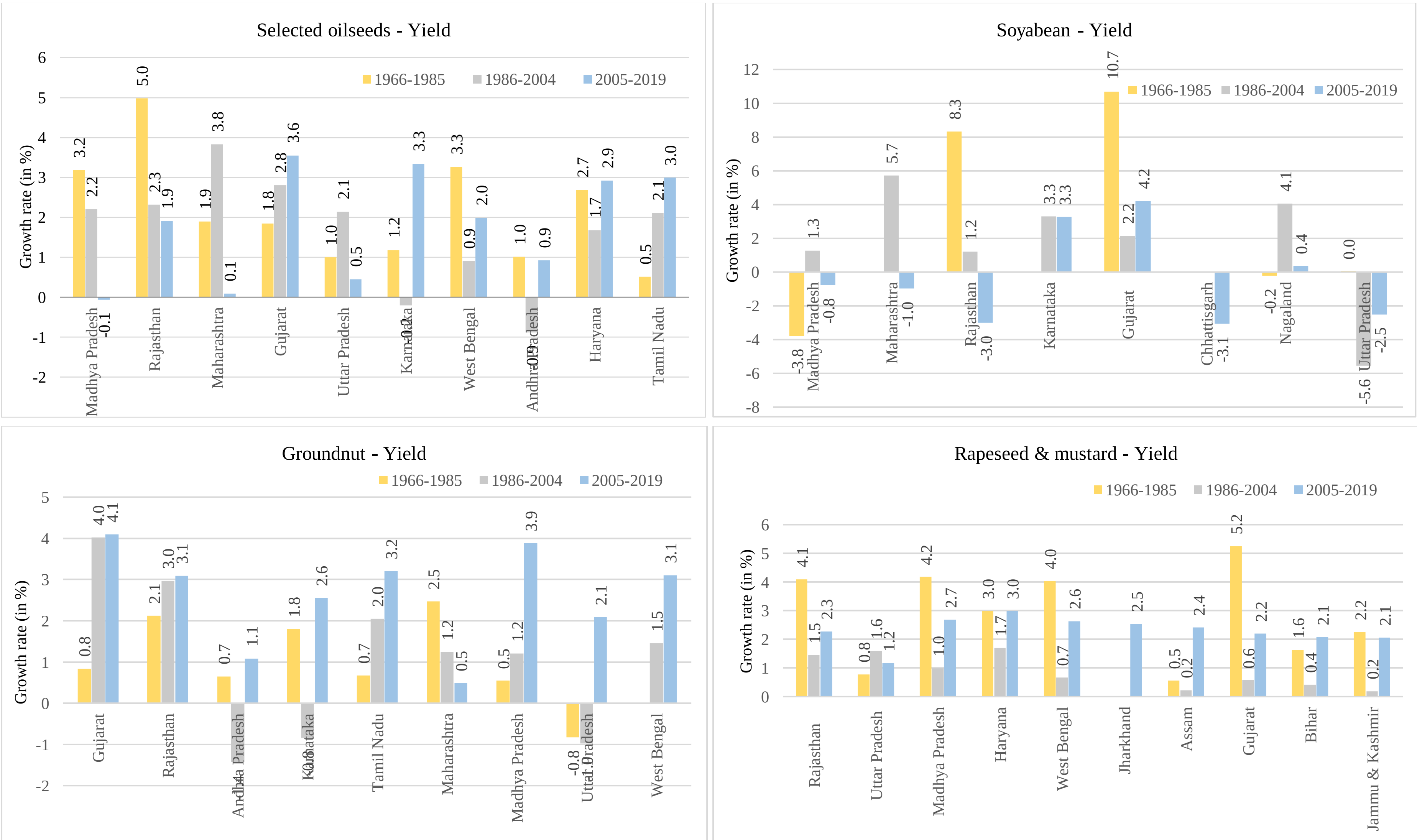
Table 3. 4: Phase-wise growth rates of yield for major oilseed crops in major producing states (in %)

Crop	Top 5 states	Phase-I	Phase-II	Phase-III
Soybean	Madhya P.	-3.8	1.3	-0.8
	Maharashtra		5.7	-1.0
	Rajasthan	8.3	1.2	-3.0
	Karnataka		3.3	3.3
	Gujarat	10.7	2.2	4.2
	India	-2.9	1.9	-0.9
Groundnut	Gujarat	0.8	4.0	4.1
	Rajasthan	2.1	3.0	3.1
	Andhra P.	0.7	-1.4	1.1
	Karnataka	1.8	-0.8	2.6
	Tamil Nadu	0.7	2.0	3.2
	India	1.1	0.7	3.8
Rapeseed & mustard	Rajasthan	4.1	1.5	2.3
	Uttar Pradesh	0.8	1.6	1.2
	Madhya P.	4.2	1.0	2.7
	Haryana	3.0	1.7	3.0
	West Bengal	4.0	0.7	2.6
	India	1.8	1.4	1.9
Sunflower	Karnataka	-11.4	0.5	2.5
	Maharashtra	5.3	0.7	-4.6
	Odisha	0.7	3.2	2.9
	Haryana		0.7	1.3
	Andhra P.	3.8	2.0	1.7
	India	-2.7	1.4	2.1
Safflower	Karnataka	8.1	1.3	-0.2
	Maharashtra	6.7	-0.6	-1.5
	Telangana			2.9
	Andhra P.	3.2	0.4	6.3
	Jharkhand			4.1
	India	6.8	-0.1	-0.2

Crop	Top 5 states	Phase-I	Phase-II	Phase-III
Sesame	Uttar Pradesh	-3.9	9.0	2.4
	Madhya P.	0.4	3.2	1.6
	Rajasthan	1.1	4.8	2.1
	West Bengal	0.6	0.6	-0.4
	Gujarat	0.8	8.6	4.6
	India	1.7	2.2	1.9
Castor seed	Gujarat	6.7	2.4	0.3
	Rajasthan	-2.2	5.8	1.2
	Andhra P.	-0.9	3.1	1.7
	Telangana			10.6
	Maharashtra	4.2	-2.8	-1.8
	India	4.7	3.7	2.9
Linseed	Madhya P.	-0.04	1.8	4.9
	Jharkhand		-20.5	3.6
	Uttar Pradesh	2.0	2.2	4.5
	Chhattisgarh		2.1	0.7
	Odisha	0.2	-1.1	1.1
	India	1.1	1.7	3.7
Niger seed	Odisha	0.3	-3.7	0.7
	Chhattisgarh		-2.0	0.7
	Maharashtra	1.6	2.9	-4.1
	Madhya P.	0.8	1.4	4.1
	Assam		-0.2	1.5
	India	1.7	-0.6	1.4
Oilseeds - Total	Madhya P.	3.18	2.20	-0.06
	Rajasthan	4.98	2.32	1.91
	Maharashtra	1.89	3.83	0.09
	Gujarat	1.85	2.81	3.55
	Uttar Pradesh	1.00	2.14	0.45
	India	4.1	1.2	2.3

Note: Phase-I (1966-1985), Phase-II (1986-2004) and Phase-III (2005-2019). Growth rate for soybean and sunflower crop in phase-I are from 1976-1985. For Jharkhand and Chhattisgarh, latest data is available after year 2000 for Phase-II. Source: Author's computation from data of yield from MoA&FW database.

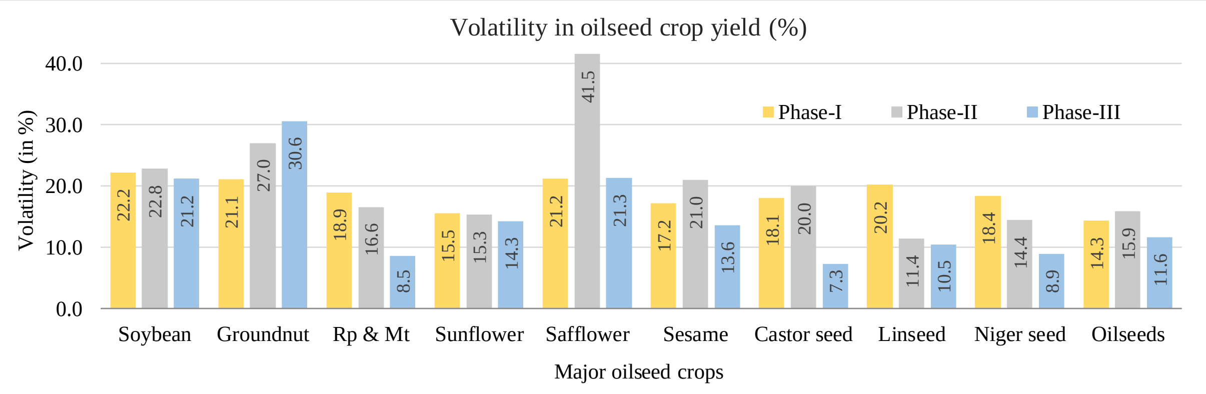
Figure 3. 23: Growth rate of yield of major oilseeds in major producing states (in %)



Volatility in oilseed crop yield

The volatility in yield is analysed here for major oilseeds. The crop, state and time specific volatility analyses is discussed to measure the extent of variation in yield of oilseed crops. The standard deviation of the growth rates is considered to measure the volatility. In general, for most of the oilseed crops, the volatility in crop yield is ranging from 10% to 22% range except few cases of high volatility in groundnut during phase II and phase III and in safflower during phase II (Figure 3.24). The higher volatility reflects higher variation in crop yield over the phases, reflective of unstable yield due to various underlying factors.

Figure 3. 24: Volatility in yield of oilseed crops (in %)



Phase-wise volatility in oilseed yield in major producing states based on the spatial-temporal analysis is reported in the Table 3.5. The states like - Maharashtra and Gujarat reflected higher volatility of above 20% during all the three phases for most of the oilseed crops, except few cases for Gujarat in recent phase. The crop and state specific incidences of higher yield volatility were observed during phase I and phase II. The volatility in yield of most of the crops reduced to a lower level for most of the major producing states. At the crop specific level, the higher yield volatility is observed for most of the states producing soybean, whereas, most of the states producing rapeseed & mustard reported comparatively lower yield volatility.

At the crop and state specific level, for Soybean coefficient volatility is high for Maharashtra, Rajasthan and Karnataka during recent two phases. For groundnut, the volatility in yield in most of the southern states growing groundnut such as Karnataka, Tamil Nadu and Telangana are less as compare to the major produce in the states of Gujarat and Rajasthan except for the outlier Andhra Pradesh during the most recent phase. In fact, in Andhra Pradesh the volatility has increased over the period but in Rajasthan it reduced to the half over time. Being the largest producing state of the groundnut, Gujarat reported surprisingly very high volatility in yield. The rapeseed and mustard crop reflected a perfect example of yield volatility stabilization in all the major producing states to nearly under 17%. In Rajasthan it reduced to just 13% from a higher level of above 50% observed during the initial phase. But the yield volatility is still high for Haryana, the largest yield delivering states. The stable price mechanism, availability of inputs on time, better irrigation, mechanization and technological advancement might have contributed to stable crop yield over time.

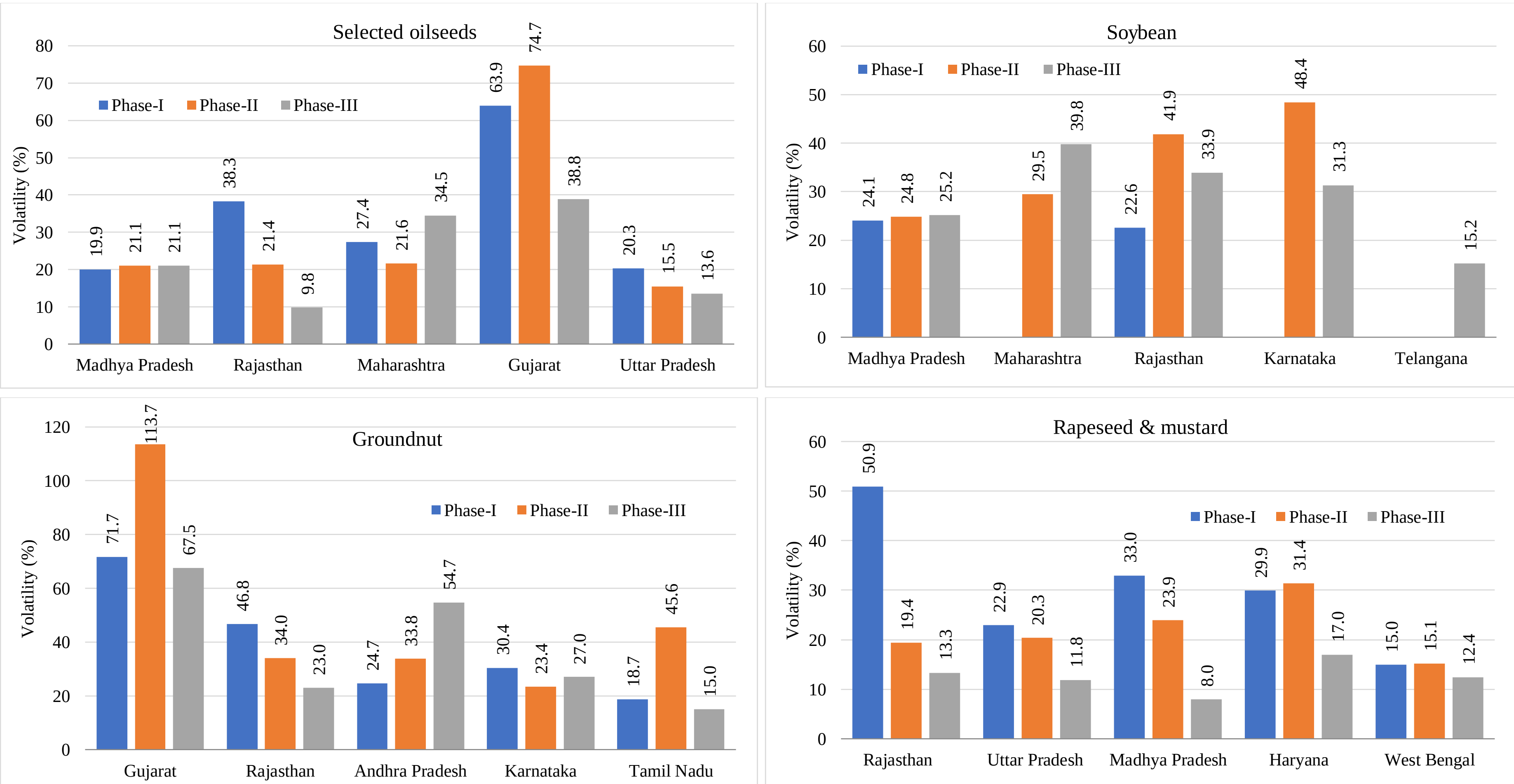
For the other minor oilseed crops sunflower, linseed and nigerseed the volatility in yield during the phase I was on the higher end in many of the major producing states but stabilized to a lower range in most of the cases in phase III. While for safflower, sesame and castor seed, the middle phase recorded the higher yield volatility. In specific, the states reported the lower volatility during the phase III are - Karnataka, Odisha and Haryana for sunflower; Karnataka for safflower; Madhya Pradesh and West Bengal for sesame; Gujarat, Maharashtra and Rajasthan for castor seed; Odisha, Madhya Pradesh and Jharkhand for Linseed; and Odisha, Assam and Chhattisgarh for nigerseed. Figure 3.25 represents yield volatility for major produced oilseed crops and for selected oilseeds.

Table 3. 5: Phase-wise volatility in oilseed crop yield in major oilseed producing states (in %)

Crop	Top 5 states	Phase-I	Phase-II	Phase-III	Crop	Top 5 states	Phase-I	Phase-II	Phase-III
Soyabean	Madhya P.	24.1	24.8	25.2	Sesame	Uttar Pradesh	64.5	33.6	33.0
	Maharashtra		29.5	39.8		Madhya P.	38.1	34.6	13.3
	Rajasthan	22.6	41.9	33.9		Rajasthan	82.8	93.2	48.2
	Karnataka		48.4	31.3		West Bengal	11.9	16.8	20.1
	Gujarat			15.2		Gujarat	47.0	123.7	42.4
	India	22.2	22.8	21.2		India	17.2	21.0	13.6
Groundnut	Gujarat	71.7	113.7	67.5	Castor seed	Gujarat	26.5	22.9	8.2
	Rajasthan	46.8	34.0	23.0		Rajasthan	47.7	61.3	25.9
	Andhra P.	24.7	33.8	54.7		Andhra P.	39.0	16.4	46.3
	Karnataka	30.4	23.4	27.0		Telangana			42.5
	Tamil Nadu	18.7	45.6	15.0		Maharashtra	18.8	21.0	24.4
	India	21.1	27.0	30.6		India	18.1	20.0	7.3
Rapeseed & mustard	Rajasthan	50.9	19.4	13.3	Linseed	Madhya P.	31.3	18.4	17.6
	Uttar Pradesh	22.9	20.3	11.8		Jharkhand		26.3	16.5
	Madhya P.	33.0	23.9	8.0		Uttar Pradesh	39.9	18.6	24.2
	Haryana	29.9	31.4	17.0		Chhattisgarh		24.0	22.3
	West Bengal	15.0	15.1	12.4		Odisha	14.0	11.4	2.7
	India	18.9	16.6	8.5		India	20.2	11.4	10.5
Sunflower	Karnataka	27.8	23.1	23.5	Niger seed	Odisha	17.3	18.7	9.1
	Maharashtra	131.8	34.6	50.9		Chhattisgarh		13.2	6.3
	Odisha	43.4	23.7	6.2		Maharashtra	43.1	28.6	24.9
	Haryana		19.8	18.3		Madhya P.	31.0	26.2	21.6
	Andhra P.	54.4	25.1	25.6		Assam		6.2	6.7
	India	15.5	15.3	14.3		India	18.4	14.4	8.9
Safflower	Karnataka	27.0	28.7	24.4	Oilseeds - Total	Madhya P.	19.9	21.1	21.1
	Maharashtra	24.8	57.5	37.4		Rajasthan	38.3	21.4	9.8
	Telangana			32.2		Maharashtra	27.4	21.6	34.5
	Andhra P.	34.7	34.1	26.8		Gujarat	63.9	74.7	38.8
	Jharkhand			20.6		Uttar Pradesh	20.3	15.5	13.6
	India	21.2	41.5	21.3		India	14.3	15.9	11.6

Note: Phase-I (1966-1985), Phase-II (1986-2004) and Phase-III (2005-2019). Growth rate for soybean and sunflower crop in phase-I are from 1976-1985. For Jharkhand and Chhattisgarh, latest data is available after year 2000 for Phase-II.

Figure 3. 25: Volatility in yield of few of the oilseeds in major producing states



Decomposition of oilseed production- national and state level

To measure the relative contribution of area and yield to the total production change the decomposition analyses is performed at the national and state level for major oilseed crops. Due to easy interpretation of results, the additive approach of decomposition is widely preferred. The simple additive decomposition approach is preferred utilising three factors – area, yield and interaction effect to measure the effect of such components in total output of major oilseed crops. The three-time period have been considered for the analysis – 1966 to 1985, 1986 to 2004 and 2005 to 2019. The coverage includes all the major oilseed producing states by oilseed crops along with national level analysis.

The results at the national level suggest that on the overall basis, the change in production of oilseed crops during phase I and phase III is mainly contributed due to increase in yield of different oilseed crops (Table 3.6). In the phase II, the role of both, change in area and yield, equally contributed the production increase, which is also supplemented and reflected through the combined interaction effect.

For the oilseed crop soybean, the change in production is mainly driven due to the area effect in all the three phases. The proportionate contribution of the change in area to the change in production is observed large for phase I and phase III. Contrary to this, for groundnut, the change in production is driven mainly by the change in yield. The share of interaction increased over the phases. For rapeseed & mustard, there is no clear trend but the production change is mainly driven by yield effect (in phases I & III) and area effect (in phase II).

Among the minor oilseed crops, for sesame seed production is mainly driven by the yield effects in all the three study phases. Similar but not so strong yield effect is witnessed for the castor seed. For sunflower, the effect of area change is strong in all the three phases. The same is the case with safflower seed, linseed and niger seed crops for phase II and phase III. In all these three crops, the change in production in the phase I was driven by area effect.

The decomposition analysis is also performed at state level for three of the major oilseed crops grown in India. For Soybean, the exercise is restricted to only phase II and phase III due to limitations of data. Among the major producing states, the change in production during the phase II is mainly contributed by increase in acreage, especially in Andhra Pradesh and the largest producing state Madhya Pradesh (Table 3.7). In other three major states, Maharashtra, Karnataka and Rajasthan, the interaction effect also played important role along with the area effect. In phase III, Andhra Pradesh is replaced by Telangana. Madhya Pradesh and Maharashtra continue with the acreage increases, while in Rajasthan and Telangana, yield played the dominant role in production change. In Karnataka, a combined effect is observed.

For groundnut, in the largest producing state of Gujarat, the increase in crop yield majorly contributed to the production change in all the three phases, while in Andhra Pradesh, the production change is mainly due to the area effect in all the three phases. In other major producing states, in Tamil Nadu – yield effect in phase I and area effect in phase II &III; in Karnataka –yield effect in phase II and area effect in phase I &III; in Maharashtra –yield effect in phase II and area effect in phase I. Rajasthan became the second largest producing state of groundnut during phase III dominantly due to increase in area.

For rapeseed and mustard, area is the major contributor to production change in Rajasthan in all the three phases. In Uttar Pradesh, the increase in crop yield mainly contributed to the production during the recent two phases (phase II & III) and area effect drove the production increase in phase I. No clear effect is visible in other major producing states like Haryana, Madhya Pradesh and West Bengal but broadly the production change is driven by yield increase in phase III, and is driven by area increase in phase II in these states except West Bengal.

Table 3. 6: Decomposition analysis of output for oilseed crops – National level

Major crops	Phase-I (1966-1985)			Phase-II (1986-2004)			Phase-III (2005-2019)		
	Yield	Area	Interaction	Yield	Area	Interaction	Yield	Area	Interaction
Soybean	-3.1	133.3	-30.2	8.3	59.0	32.8	-39.9	163.1	-23.2
Groundnut	117.8	-14.9	-2.8	138.8	-32.0	-6.8	301.2	-115.8	-85.4
Rapeseed & mustard	54.8	27.4	17.8	25.1	50.5	24.3	156.3	-47.3	-9.0
Sunflower	-29.6	187.6	-57.9	18.5	61.0	20.6	-60.3	105.9	54.4
Safflower	39.9	23.8	36.3	-37.5	115.5	22.0	-42.6	106.1	36.6
Sesame	253.1	-100.9	-52.2	151.6	-29.2	-22.4	348.6	-228.2	-20.4
Castor seed	42.5	32.5	25.0	68.6	11.7	19.7	62.3	24.5	13.1
Linseed	116.3	-10.7	-5.6	-81.9	131.8	50.1	-232.4	195.7	136.7
Niger seed	57.0	23.6	19.4	-115.7	184.7	30.9	-26.5	108.7	17.8
Oilseeds (Total)	58.9	29.8	11.3	39.8	41.1	19.0	116.9	-13.9	-3.0

Note: Phase-I (1966-1985), Phase-II (1986-2004) and Phase-III (2005-2019). For soybean and sunflower, the Phase-I period is from 1976 to 1985.

Table 3. 7: Decomposition analysis of output for three major oilseed crops – State level

Major states	Phase-I (1966-1985)			Major states	Phase-II (1986-2004)			Major states	Phase-III (2005-2019)		
	Yield	Area	Interaction		Yield	Area	Interaction		Yield	Area	Interaction
Soybean											
				Madhya Pradesh	10.9	59.8	29.4	Madhya Pradesh	-295.9	530.7	-134.8
				Maharashtra	1.6	39.7	58.8	Maharashtra	9.5	83.3	7.2
				Rajasthan	4.1	50.7	45.2	Rajasthan	152.9	-129.8	76.9
				Karnataka	4.2	48.8	47.0	Karnataka	28.1	32.5	39.5
				Andhra Pradesh	0.1	85.0	14.9	Telangana	358.4	-154.7	-103.7
Groundnut											
Gujarat	89.6	19.3	-8.9	Gujarat	72.1	20.9	7	Gujarat	158.1	-36.6	-21.5
Andhra Pradesh	25	65	10	Andhra Pradesh	27.2	68.1	4.7	Rajasthan	18	57.9	24
Karnataka	39	49.3	11.7	Karnataka	1374.3	-1188	-86.3	Andhra Pradesh	-201.7	171.1	130.6
Tamil Nadu	90.5	7.4	2.1	Tamil Nadu	-425.6	392.2	133.4	Karnataka	-217.9	205.6	112.3
Maharashtra	-16338.3	10335.6	6102.7	Maharashtra	447.7	-206.1	-141.6	Tamil Nadu	-1143.8	740.7	503
Rapeseed & mustard											
Uttar Pradesh	-203.2	214.7	88.5	Rajasthan	6.9	70.0	23.0	Rajasthan	-275.1	330.9	44.2
Rajasthan	18.1	27.0	54.9	Uttar Pradesh	173.3	-45.7	-27.6	Uttar Pradesh	179.6	-72.6	-7.0
Haryana	40.5	30.0	29.5	Haryana	17.8	54.7	27.5	Madhya Pradesh	208.4	-73.8	-34.6
Madhya Pradesh	20.1	30.2	49.7	Madhya Pradesh	25.7	47.2	27.2	Haryana	133.9	-21.1	-12.8
Assam	3.3	92.7	4.0	West Bengal	39.4	38.9	21.7	West Bengal	33.1	52.1	14.8

Note: Phase-I (1966-1985), Phase-II (1986-2004) and Phase-III (2005-2019). For soybean and sunflower, the Phase-I period is from 1976 to 1985. For soybean, analysis not performed due to data limitations

Chapter 4: Yield Gaps and factors impacting yield of oilseeds

Yield gaps of oilseeds across major producing states

Within the country, there are huge yield gaps across the producing states of oilseed crop. In some cases, the yield of the major producing states is way below as compared to minor producing states' yield. The yield gaps for the major producing states for important oilseed crops are analysed in this section. Improvement in the yield of important oilseeds will be beneficial to farmers and will also strengthen trade through export of oil meals and help to reduce the import dependency.

On the basis of overall oil seeds produced in India, Tamil Nadu recorded the highest three-year average yield at 2.59 tonnes per hectare as of 2019-20, although the share of Tamil Nadu in country's oilseed area is just 1.5% (Table 4.1). Madhya Pradesh which has the highest area share (27.5%), recorded 59.4% lower yield than that of Tamil Nadu. Maharashtra with about below 17% of country's area share also reported yield 58% below that of Tamil Nadu. Similarly, Rajasthan with an area share of 20% of country's area recorded a yield that is 44.5% less. Improving oilseeds yield in these three major states – Madhya Pradesh, Maharashtra and Rajasthan, covering close to two-thirds of country's oilseed area, can improve oilseed production in India substantially. At the aggregate level, India reported nearly -51% less average oilseed yield as compared to the highest yield state Tamil Nadu. The crop specific yield gaps in the major producing states are reported in detail in Table 4.1.

Soybean

Soybean is the largest produced oilseed crop in India. The South Indian state Telangana recorded the highest three-year average yield at 1.67 tonnes per hectare in 2019-20. Among the largest producing states of soybean, Maharashtra (holding about 34% of country's area under soybean) and Madhya Pradesh (51% country's area share) reported 33.6% to 38.6% less yield than Telangana. Overall, the average yield of soybean at the all-India level is nearly 37% below Telangana.

Groundnut

Tamil Nadu reported the highest three year moving average yield at 2.92 tonnes per hectare in 2019-20. The states with highest area share of groundnut, Gujarat (35%) and Rajasthan (15%), reported the average groundnut yield for the same year at -26% to -29%

below, respectively, as compare to Tamil Nadu. Four of the major states namely Andhra Pradesh (area share 13.7%), Karnataka (10.4%), Maharashtra (6%) and Uttar Pradesh (1.9%) holding one-third of area share in the country, are severely lacking in delivering crop-yield in range of -62% to -69% below as compare to Tamil Nadu.

Rapeseed and mustard

Haryana reported the highest yield in India in 2019-20 at nearly 2 tonnes per hectare. The largest rapeseed and mustard producing state of Rajasthan, with nearly 45% country's area share, witnessed 20% lesser yield than Haryana. Some of the other major producing states such as Madhya Pradesh (-26.5%), Uttar Pradesh (-29.5%), West Bengal (-39.4%) and Jharkhand (-62.4%) recorded lower yields than Haryana.

Sesame seed

The yield of sesame seed in India is very less as compared to other oilseed crops. West Bengal with more than 16% area share under sesame seed reported the highest average yield of a mere 0.8 tonnes per hectare. The state with the highest area share in the country - Uttar Pradesh (22%) reported 71% lower yield in 2019-20 than that of West Bengal. Rajasthan, Madhya Pradesh and Gujarat, the other major states holding nearly to 47% share of country's area, recorded 61%, 42% and 28% lower yield than West Bengal.

Sunflower seed

Karnataka, the single largest producing state of sunflower and holding nearly 57% of country's area reported 65.3% lower yield in 2019-20 as compared to the Telangana, the state that recorded the highest yield at 2.1 tonnes per hectare. Doubling the crop yield in Karnataka can contribute significantly to reduction in the import burden of the country. Maharashtra, another major producing state with more than 12% area share reported 82.2% lower yield than Telangana, implying that the state could attain just about 20% of the yield in Telangana.

Safflower

Karnataka, holding half of the country's area share under safflower, also reported the highest yield at 0.8 tonnes per hectare. Maharashtra with nearly 42% area share reported 29% lower yield than Karnataka.

Castor seed

Similar to safflower crop, Gujarat with highest area share under the castor seed in the country (70.4%), also has the highest yield at 2 tonnes per hectare. Rajasthan with nearly 19.5% area share reported 29.5% lower yield than Gujarat. Average yield of castor seed in India is 13% lower than Gujarat. But some of the southern states like Andhra Pradesh and Telangana, which together hold 6.5% area share, recorded yield nearly 71% and 50% lower respectively than Gujarat.

Linseed

The state with the highest linseed yield is Rajasthan with a yield of 1 tonne per hectare in 2019-20. Linseed is largely grown in Madhya Pradesh (area share 29%), Jharkhand (22%), Uttar Pradesh (15%) and Chhattisgarh (9%). These states have reported, respectively, 29%, 45%, 36% and 74% lower yield than Rajasthan.

Niger seed

Assam reported the highest yield of niger seed at 0.56 tonnes per hectare. Two of the major states - Odisha (area share 39%) and Chhattisgarh (37.5%) - together holding nearly three-fourth of area under niger seed in the country, witnessed 34% and 66% lower yield than Assam, respectively.

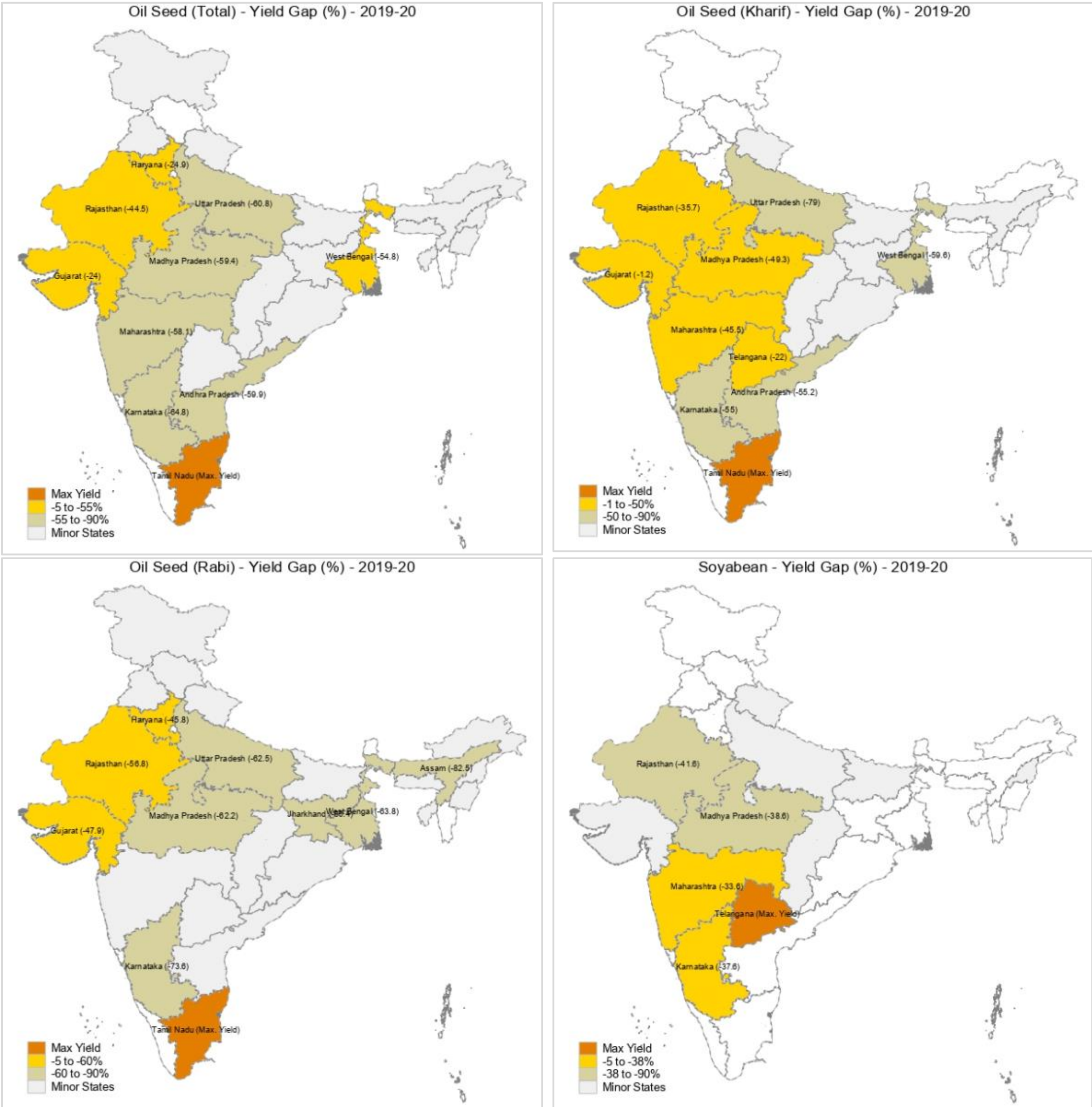
Table 4. 1: Yield gaps (%) for major oilseeds produced in India – State-wise (2019-20)

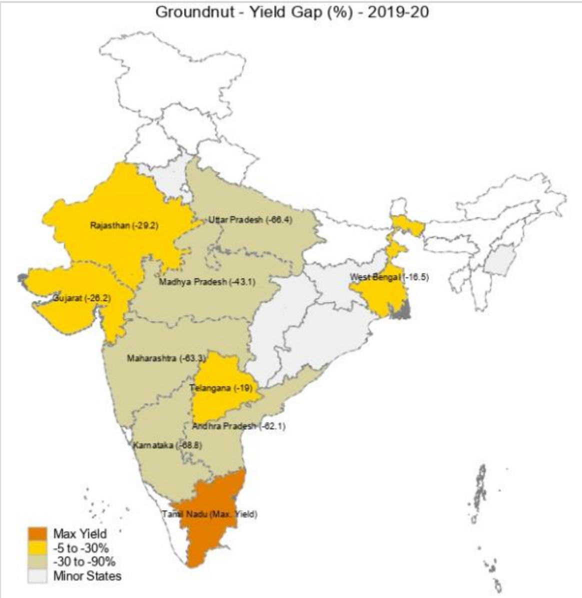
State (Area share %)	Yield gap (%)	State (Area share %)	Yield gap (%)	State (Area share %)	Yield gap (%)	State (Area share %)	Yield gap (%)	State (Area share %)	Yield gap (%)
Oilseed total		Soybean		Groundnut		Rapeseed & mustard		Sesame seed	
Tamil Nadu (1.5%)	2.59	Telangana (1.4%)	1.67	Tamil Nadu (7.2%)	2.92	Haryana (9.4%)	1.96	West Bengal (16.2%)	0.81
Gujarat (10.6%)	-24.0	Maharashtra (33.8%)	-33.6	West Bengal (1.5%)	-16.5	Gujarat (2.5%)	-5.9	Karnataka (1.8%)	-9.6
Haryana (2.4%)	-24.9	Average yield - India	-36.8	Telangana (2.3%)	-19.0	Rajasthan (44.9%)	-20.3	Telangana (1.3%)	-23.2
Rajasthan (20%)	-44.5	Karnataka (2.6%)	-37.6	Gujarat (35%)	-26.2	Madhya Pradesh (9.8%)	-26.5	Tamil Nadu (3.3%)	-26.0
Average yield - India	-51.3	Madhya Pradesh (50.8%)	-38.6	Rajasthan (15.3%)	-29.2	Average yield - India	-27.5	Gujarat (10.2%)	-28.2
West Bengal (3.5%)	-54.8	Rajasthan (9.2%)	-41.6	Average yield - India	-38.7	Uttar Pradesh (11.1%)	-29.5	Madhya Pradesh (19.4%)	-42.2
Maharashtra (16.7%)	-58.1			Madhya Pradesh (4.6%)	-43.1	Bihar (1.1%)	-36.6	Average yield - India	-43.5
Madhya Pradesh (27.5%)	-59.4			Andhra Pradesh (13.7%)	-62.1	West Bengal (8.9%)	-39.4	Rajasthan (17.2%)	-61.0
Andhra Pradesh (2.8%)	-59.9			Maharashtra (6%)	-63.3	Jammu & Kashmir (0.7%)	-51.6	Andhra Pradesh (2.4%)	-63.4
Uttar Pradesh (4.7%)	-60.8			Uttar Pradesh (1.9%)	-66.4	Jharkhand (4.3%)	-62.4	Uttar Pradesh (21.9%)	-70.9
Karnataka (3.7%)	-64.8			Karnataka (10.4%)	-68.8	Assam (4.2%)	-67.6	Maharashtra (1.6%)	-76.1
Sunflower		Safflower		Castor seed		Linseed		Niger seed	
Telangana (1.8%)	2.11	Karnataka (50.2%)	0.80	Gujarat (70.4%)	2.01	Rajasthan (2.7%)	1.00	Assam (4.2%)	0.56
Haryana (4%)	-10.8	Telangana (3.9%)	-5.4	Average yield - India	-12.9	Bihar (4.6%)	-14.7	Odisha (total) (38.9%)	-33.9
Punjab (1.9%)	-10.9	Average yield - India	-14.7	Rajasthan (19.5%)	-29.5	Nagaland (3.3%)	-18.2	Madhya Pradesh (4.4%)	-41.6
Bihar (3.5%)	-32.3	Maharashtra (41.7%)	-28.8	Telangana (2.7%)	-50.1	Madhya Pradesh (28.9%)	-29.3	Average yield - India	-45.3
Odisha (7.3%)	-40.5	Jharkhand (0.6%)	-32.4	Haryana (0.4%)	-53.8	Uttar Pradesh (15%)	-35.6	Chhattisgarh (37.5%)	-65.9
West Bengal (3.4%)	-43.5	Andhra Pradesh (1.9%)	-38.9	Karnataka (0.4%)	-62.7	Assam (2.7%)	-38.5	Maharashtra (6%)	-71.2
Andhra Pradesh (3.9%)	-54.0			Odisha (0.6%)	-68.7	Average yield - India	-40.5		
Average yield - India	-59.8			Andhra Pradesh (3.6%)	-70.9	Jharkhand (22%)	-44.9		
Tamil Nadu (1.9%)	-60.8			Madhya Pradesh (0.7%)	-78.1	Odisha (5.7%)	-51.0		
Karnataka (56.5%)	-65.3			Tamil Nadu (0.5%)	-84.5	Maharashtra (3.1%)	-65.6		
Maharashtra (12.2%)	-82.2			Maharashtra (1%)	-86.2	Chhattisgarh (8.7%)	-73.5		

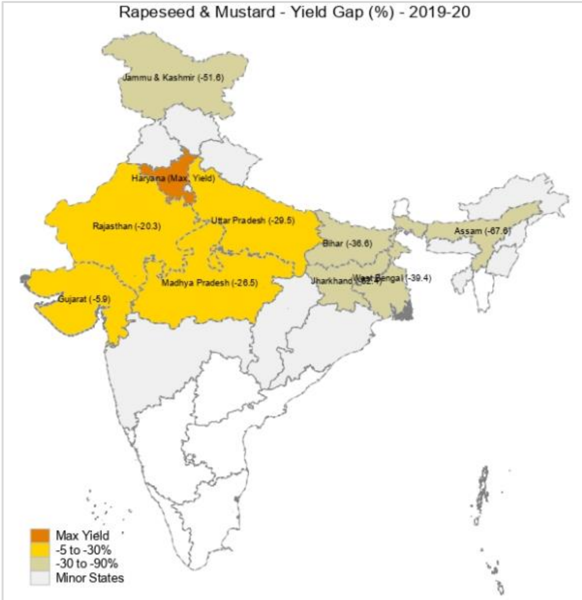
Note: Three year moving average (3YMA) yield is considered to measure yield gaps, The values for top most state for each crop in "yield gap (%)" column represents the 3YMA yield (the highest yield in tonnes per hectare) of the state for a particular oilseed crop.

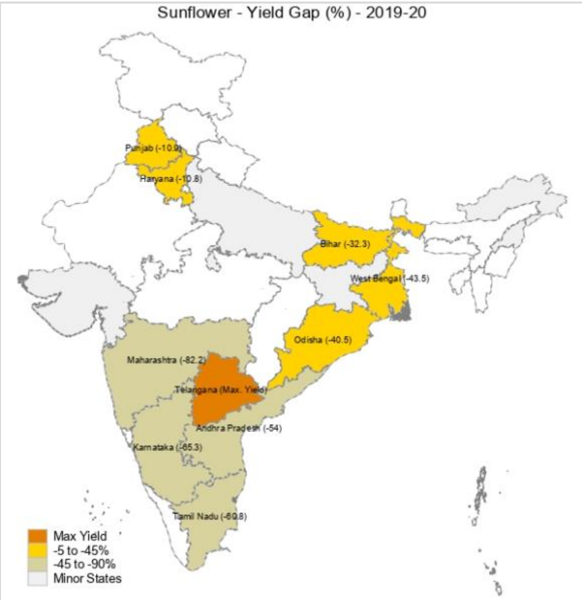
Considering the yield of all the oilseeds, most of the states in the central and south western part on India witnessed the huge yield gaps as compared to the highest yield state. This is mainly due to Madhya Pradesh (for soybean), Uttar Pradesh, Maharashtra, Karnataka (for groundnut). For rapeseed & mustard, all the eastern Indian states witnessed highest yield gaps. Figure 4.1 represents an overview of the yield gap levels in major producing states for three major oilseeds grown in India.

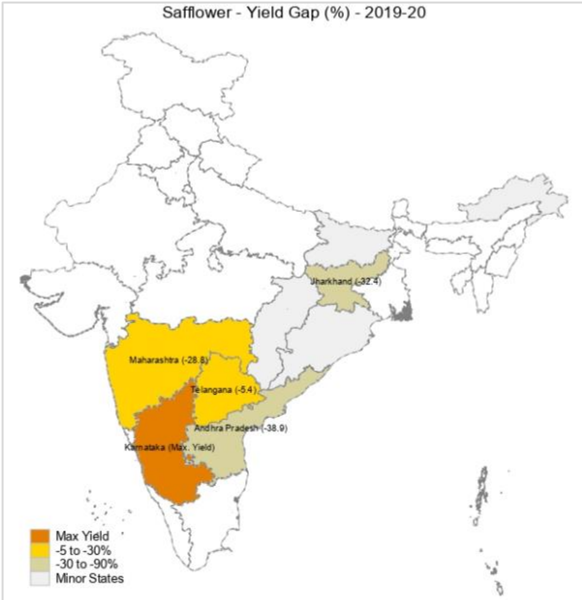
Figure 4. 1: Major oil-seed crops – Yield gaps (%) by states

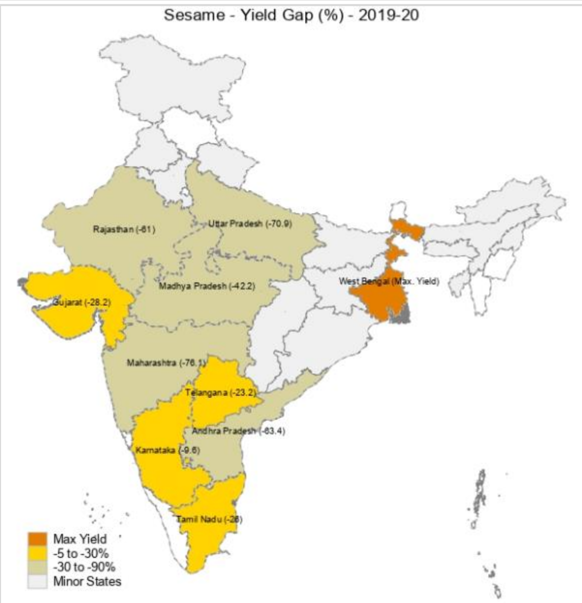


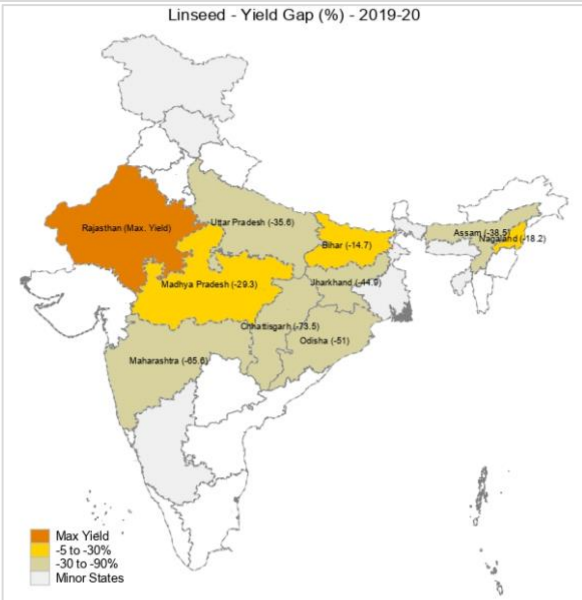

Groundnut - Yield Gap (%) - 2019-20
Rajasthan (-29.2)
Uttar Pradesh (-66.4)
West Bengal (-16.5)
Madhya Pradesh (-43.1)
Gujarat (-26.2)
Maharashtra (-63.3)
Telangana (-19)
Andhra Pradesh (-62.1)
Karnataka (-68.8)
Tamil Nadu (Max. Yield)
Max Yield
-5 to -30%
-30 to -90%
Minor States

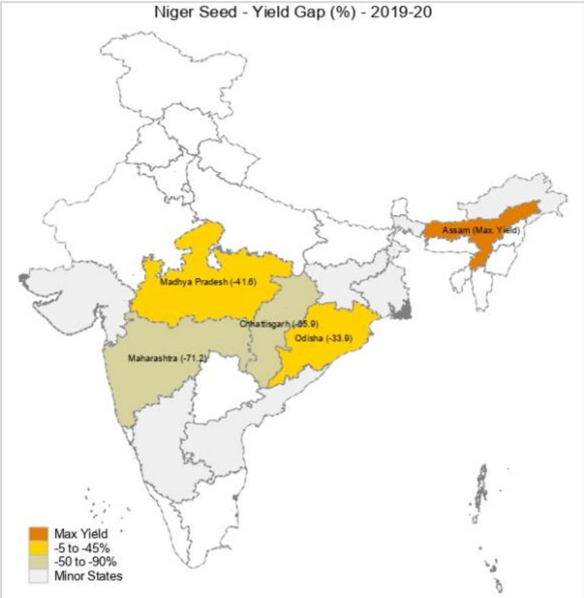

Rapeseed & Mustard - Yield Gap (%) - 2019-20
Jammu & Kashmir (-51.6)
Haryana (Max. Yield)
Rajasthan (-20.3)
Uttar Pradesh (-29.5)
Assam (-67.6)
Bihar (-36.6)
Gujarat (-5.9)
Madhya Pradesh (-26.5)
Max Yield
-5 to -30%
-30 to -90%
Minor States

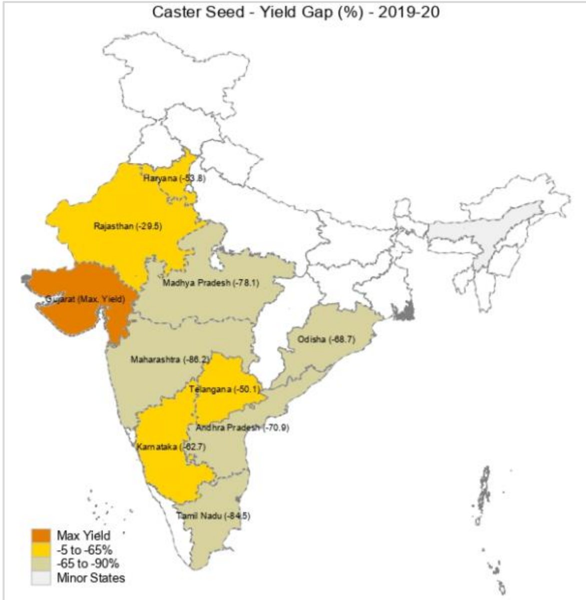

Sunflower - Yield Gap (%) - 2019-20
Punjab (-10.9)
Haryana (-10.8)
Bihar (-32.3)
West Bengal (-43.5)
Odisha (-40.5)
Maharashtra (-82.2)
Telangana (Max. Yield)
Andhra Pradesh (-54)
Karnataka (-65.3)
Tamil Nadu (-60.8)
Max Yield
-5 to -45%
-45 to -90%
Minor States


Safflower - Yield Gap (%) - 2019-20
Jharkhand (-32.4)
Maharashtra (-28.8)
Telangana (-5.4)
Andhra Pradesh (-38.9)
Karnataka (Max. Yield)
Max Yield
-5 to -30%
-30 to -90%
Minor States


Sesame - Yield Gap (%) - 2019-20
Rajasthan (-61)
Uttar Pradesh (-70.9)
West Bengal (Max. Yield)
Madhya Pradesh (-42.2)
Gujarat (-28.2)
Maharashtra (-76.1)
Telangana (-23.2)
Andhra Pradesh (-63.4)
Karnataka (-9.6)
Tamil Nadu (-26)
Max Yield
-5 to -30%
-30 to -90%
Minor States


Linseed - Yield Gap (%) - 2019-20
Rajasthan (Max. Yield)
Uttar Pradesh (-35.6)
Assam (-38.5)
Nagaland (-18.2)
Bihar (-14.7)
Madhya Pradesh (-29.3)
Jharkhand (-44.9)
Chhattisgarh (-73.5)
Odisha (-51)
Maharashtra (-65.6)
Max Yield
-5 to -30%
-30 to -90%
Minor States





An attempt has been made to report the yield and the yield gaps by the state clusters for some major oilseed crops. The state clusters are categorized in a set of three states based on high to low yield gaps and then sorted on the cumulative area share under the oilseed crop. A particular cluster thus including major as well as minor states with similar average yield and average yield gaps.

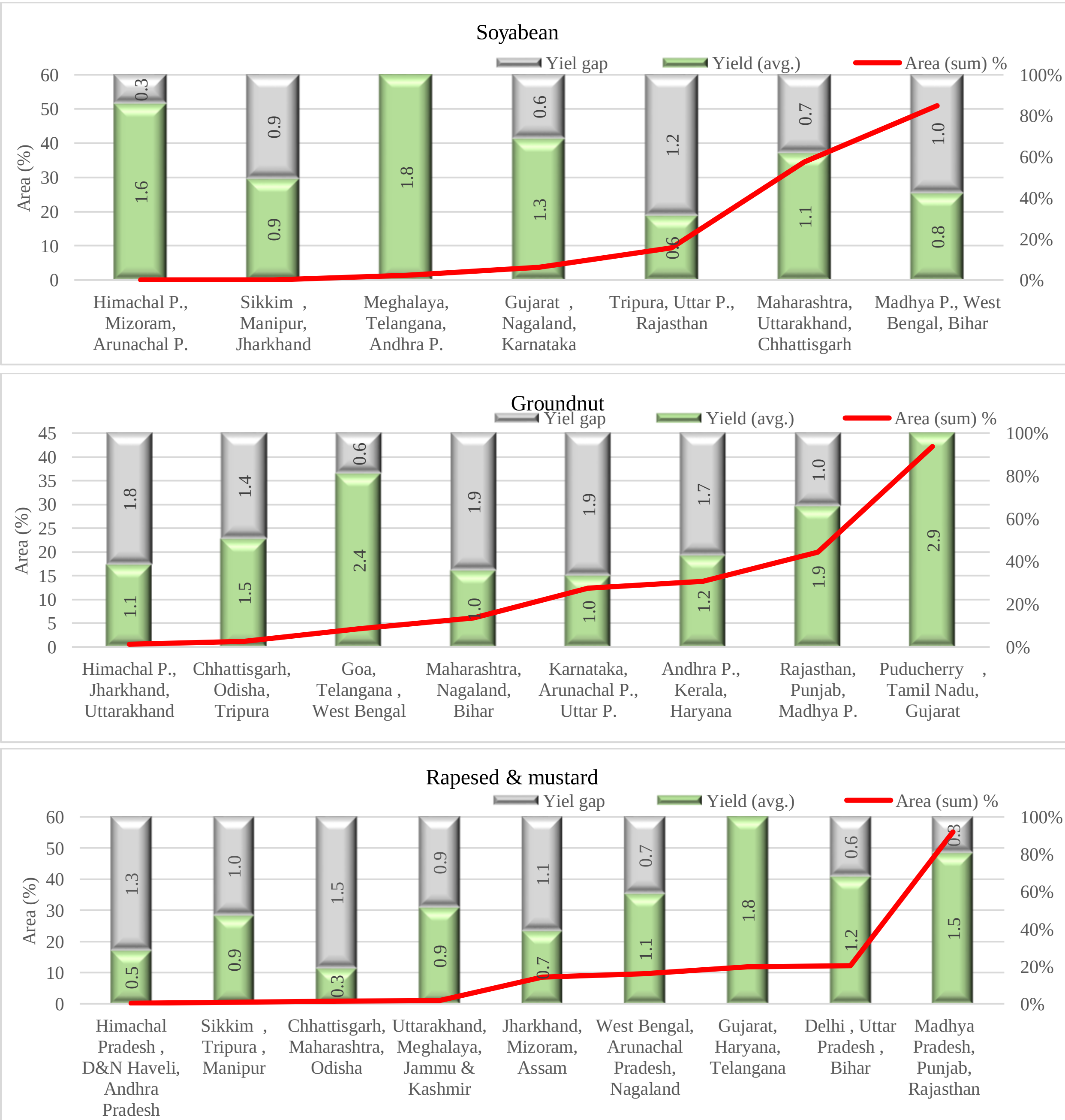
For soybean, the state cluster including highest producing state of Madhya Pradesh along with Bihar and West Bengal majorly contribute to high cumulative area. This is followed by the state cluster of Maharashtra (also including Uttarakhand and Chhattisgarh) and the state cluster of Uttar Pradesh (also including Rajasthan and Tripura). All the three clusters together contribute nearly 80% acreage under soybean but performed worst in terms of yield as 2 out of these 3 clusters reported the highest yield gaps (Figure 4.2). On the contrary, 2 out of 3 state clusters holding minimal acreage perform well in terms of crop yield.

Similarly, for Groundnut, the top two state clusters of Gujarat (including Tamil Nadu and Puducherry) and Rajasthan (including Madhya Pradesh and Punjab) performed well in terms of crop yield (Figure 4.2). These two state clusters together hold nearly 60% of acreage under groundnut. The state clusters of Andhra Pradesh (including Haryana and Kerala), Uttar Pradesh (including Karnataka and Arunachal Pradesh) and of Maharashtra (including Bihar and Nagaland), despite being the follow-up major area clusters, have not performed up to the mark as the yield gaps are very high. The state cluster with minimum area share, which perform well in terms of groundnut yield, is of West Bengal, Telangana and Goa.

For rapeseed and mustard, the single largest state cluster of Rajasthan (including Madhya Pradesh and Punjab) covers nearly 80% of country's acreage under the crop, performed satisfactory as the yield gaps are low (Figure 4.2). The state cluster with the highest yield is of Gujarat (also includes Haryana and Telangana). The worst performing state cluster are the clusters holding small area share in the country.

In case of soybean the top-area clusters are performing poorly as it includes Madhya Pradesh which holds about half of the country's area under soyabean but lagging in crop yield by nearly 39% less than the highest yield state. On the other side, in the case of groundnut and rapeseed & mustard, it is the reverse as the top-area clusters includes the states which have high area share under respective crops and delivering higher crop yield.

Figure 4. 2: Average yield and yield gaps by 'state clusters' in India – Major oilseed crops (2019-20)



Yield gaps of oilseeds across the districts in major producing states

The district level yield gaps are analyzed for the major producing states of oilseed crops. As mentioned before, the yield gaps for each of the state (or district) are calculated with respect to the highest-yield state (or district). The yield gaps are calculated for the year 2018-19 except in few cases for which 2017–18 year is considered due to unavailability of data for the recent year.

Soybean

Madhya Pradesh holds nearly 51% area share under soybean in the country (Table 4.2, Figure 4.3 to Figure 4.5). The highest yield of soybean in the state is recorded in the districts of Indore, Ashok Nagar and Dhar at 1.5 tonnes per hectare among the major producing districts in the state. The yield gaps are ranging up-to -57%, for the lowest yield district – Betul. The Mandsaur, Agar Malwa and Khandwa districts reported yield gaps in the range from -41% to -50%. Similarly, the district – Ratlam, Sagar, Vidisha and Rayagada witnessed -32% to -37% less yield as compare to the top yield delivering district.

In Maharashtra, Osmanabad and Beed districts (contributes nearly 11% area under soybean in the state) reported 61% to 83% lower yield compared to Akola district (1.4 tonnes per hectare yield) which is among the top districts covering 80% of the area under soybean in the state. Gadchiroli is a minor district in terms of area coverage but the largest yield- district in Maharashtra at 2.3 tonnes/hectare. With this district as the benchmark, the yield gaps low-yield districts are even worse as depicted in the state map.

There are five major producing districts of soybean in Rajasthan with an aggregate share of more than 82% of soybean area in the state – Pratapgarh, Chittorgarh, Baran, Jhalawar and Kota. The yield of soybean in these districts ranges from 1.4 tonnes per hectare (highest in Pratapgarh) to 1.2 tonnes per hectare (lowest in Kota), with up to -15% yield gaps at most.

In Karnataka, there are three major producing districts of soybean – Belgaum (highest yield at 1.26 tonnes per hectare, 27.5% area share), Bidar (Area share 48%, yield gap -35%) and Dharwad (Area share 13%, yield gap -38%).

Groundnut

Gujarat is the largest producing state of groundnut. 'Banas Kantha' district in Gujarat reported the highest yield of groundnut at 2.7 tonnes per hectare, followed by District 'Gir

Somnath' (Table 4.3, Figure 4.6 to Figure 4.8). These two districts share nearly 15% of area under groundnut in the state. The rest of the seven major producing districts reported yield gap ranging from -34% to -86%, The lowest yield is in the district 'Devbhumi Dwarka' at just 0.4 tonnes per hectare. Morbi and Amreli districts recorded more than -72% yield gaps as compared to the top-yield district.

Rajasthan is the second largest producing state of groundnut. The Churu district in Rajasthan, holding nearly 11% area share, reported the highest yield at 2.5 tonnes per hectare. One of the major producing districts – Jodhpur recorded -22% yield less than the Churu district. Another major district - Jaisalmer recorded the least yield at 1.6 tonnes per hectare (-34% yield gap). Jodhpur (16.6%) and Jaisalmer (5.1%) together hold close to 22% area share.

In Andhra Pradesh, the Chittoor district has nearly 15% area share under groundnut and reported the highest yield at 1.1 tonne per hectare. The largest district under groundnut is Anantapur (holding 66% area share in the state) and recorded the crop yield of just 0.36 tonnes per hectare which is only one-third of yield of the Chittoor district.

Similarly, in other major producing states, many of the districts holding large area share under the groundnut crop are lagging behind in terms of yield. Among these states, the 'Cuddalore' district in Tamil Nadu and 'Midnapore East' district in West Bengal reported the highest yield under groundnut at 6.15 tonnes per hectare and 4.53 tonnes per hectare, respectively.

The districts which were lagging behind in crop yield by at least -50% as compared to the respective top yield district in the particular state are – Chitradurga and Gadag (in Karnataka); Tiruvannamalai, Vellore, Pudukkottai, Erode, Dharmapuri, Salem and Namakkal (in Tamil Nadu); Dhule, Ahmednagar and Aurangabad (in Maharashtra); Lalitpur and Deoria (in Uttar Pradesh); Jhargram, Nadia and Jalpaiguri (in West Bengal). Datia and Neemuch (in Madhya Pradesh) and Suryapet and Mahabubabad (in Telangana) which reported yield gaps in the range of -40% to -50%.

Rapeseed & mustard

Rajasthan (45%) holds the largest area share under the rapeseed mustard in the country, followed by Uttar Pradesh (11%), Madhya Pradesh (10%), Haryana and West Bengal (9%, each) (Table 4.4, Figure 4.9 to Figure 4.10). In all these major producing states, the districts within the state with highest yield under rapeseed & mustard recorded the yield close to 2.1

tonnes per hectare to 2.3 tonnes per hectare, except in West Bengal, which recorded a maximum yield of 1.8 tonnes per hectare. In the other minor producing states of Gujarat, Jharkhand, Assam, Bihar and Jammu and Kashmir, the yield is in range of 1.5 tonnes per hectare to 2 tonnes per hectare in the top-yield district (except Assam).

In these major and minor mustard producing states, a number of districts reported a yield much lower than (-85% or less) the largest producing district in the state. Some of the districts with highest yield gaps are – Bikaner (-43.6%) and Churu (-41.3%) in Rajasthan; Kushi Nagar (-74.7%), Balrampur (-64.7%), Sitapur (-63.5%) and Barabanki (-63.2%) in Uttar Pradesh; Chhatarpur (-75%), Shivpuri (74.5%), Mandsaur (-71.5%) and Neemuch (-70.8%) in Madhya Pradesh; Birbhum (-49.3%) Purba Bardhaman (-41%) in West Bengal; Palamu (-60.5%) and Sahebghani (-59.2%) in Jharkhand; Jamui (-67.6%) and Darbhanga (-69.4%) in Bihar; Chirang (-41%) in Assam and Udhampur (-85.1%) in Jammu and Kashmir.

More focus should be on these laggard districts to improve yield. Gujarat and Haryana performed better as the maximum yield gaps are within the range of -20% for the districts with the least crop yield. In many of these states the sowing of oilseed crops is concentrated in a limited number of districts. For example, only two districts in Gujarat, seven districts in Haryana and eight districts in West Bengal are covering most of the acreage under mustard.

Table 4. 2: Yield gaps (%) for Soybean in major producing states -District-wise (2018-19)

Madhya Pradesh (50.8%)	Yield (T/H)	Yield gaps (%)	Maharashtra (33.8%)	Yield (T/H)	Yield gaps (%)	Rajasthan (9.2%)	Yield (T/H)	Yield gaps (%)	Karnataka (2.6%)	Yield (T/H)	Yield gaps (%)
Indore (4.5%)	1.49	0.0	Akola (5.2%)	1.40	0.0	Pratapgarh (13.9%)	1.39	0.0	Belgaum (27.5%)	1.26	0.0
Ashoknagar (3.3%)	1.49	0.0	Hingoli (5.3%)	1.39	-0.7	Chittorgarh (11.4%)	1.31	-5.3	Bidar (47.8%)	0.82	-34.8
Dhar (5.7%)	1.49	-0.4	Nanded (8.7%)	1.39	-1.0	Baran (19.9%)	1.24	-11.0	Dharwad (13.2%)	0.79	-37.7
Shajapur (5.2%)	1.34	-10.1	Washim (7.4%)	1.37	-2.5	Jhalawar (23.6%)	1.24	-11.0			
Ujjain (9.3%)	1.29	-13.7	Amravati (7.2%)	1.21	-14.1	Kota (13.7%)	1.18	-15.2			
Dewas (7.1%)	1.23	-17.5	Yavatmal (6.8%)	1.18	-16.0						
Sehore (6.1%)	1.17	-21.8	Parbhani (6%)	1.11	-20.9						
Guna (3.8%)	1.10	-26.4	Buldhana (9.9%)	1.11	-21.0						
Sagar (4.8%)	1.02	-31.9	Latur (10.7%)	1.02	-27.2						
Ratlam (5.2%)	0.96	-35.6	Jalna (3.3%)	0.90	-35.9						
Vidisha (5.4%)	0.95	-36.2	Osmanabad (5.3%)	0.55	-60.8						
Rajgarh (7.1%)	0.93	-37.3	Beed (5.3%)	0.24	-82.7						
Mandsaur (5%)	0.88	-41.3									
Agar Malwa (3.1%)	0.84	-43.8									
Khandwa (3.6%)	0.75	-49.4									
Betul (2.7%)	0.64	-57.0									

Table 4. 3: Yield gaps (%) for Groundnut in major producing states -District-wise (2018-19)

Gujarat (35.0%)	Yield (T/H)	Yield gaps (%)	Rajasthan (15.3%)	Yield (T/H)	Yield gaps (%)	Andhra Pradesh (13.7%)	Yield (T/H)	Yield gaps (%)	Karnataka (10.4%)	Yield (T/H)	Yield gaps (%)	Tamil Nadu (7.2%)	Yield (T/H)	Yield gaps (%)
Banas Kanth (8.8%)	2.70		Churu (10.8%)	2.45		Chittoor (14.7%)	1.11	0.0	Bellary (11.2%)	1.11		Cuddalore (2.9%)	6.15	
Gir Somnath (6.1%)	2.62	-3.0	Sikar (3.7%)	2.29	-6.4	Anantapur (66%)	0.36	-67.7	Belgaum (5.7%)	1.04	-5.8	Kanchipuram (4.2%)	4.25	-31.0
Bhavnagar (6%)	1.78	-34.1	Bikaner (35.5%)	2.22	-9.3				Bagalkot (5.7%)	0.99	-10.9	Krishnagiri (3.4%)	3.42	-44.4
Junagadh (14.5%)	1.25	-53.9	Jaipur (4.6%)	2.10	-14.3				Yadgir (6.4%)	0.81	-27.2	Villupuram (10.9%)	3.13	-49.2
Jamnagar (8.2%)	1.18	-56.3	Chittorgarh (3.8%)	1.98	-19.2				Raichur (6.4%)	0.80	-28.1	Tiruvannamalai (21.9%)	2.72	-55.8
Rajkot (15%)	1.06	-60.9	Jodhpur (16.6%)	1.92	-21.7				Dharwad (5.7%)	0.77	-30.8	Vellore (9.7%)	2.57	-58.2
Morbi (8.4%)	0.77	-71.6	Jaisalmer (5.1%)	1.60	-34.6				Koppal (5.7%)	0.69	-37.3	Pudukkottai (3.1%)	2.21	-64.0
Amreli (6.7%)	0.71	-73.7							Tumkur (11.9%)	0.58	-48.0	Erode (5.6%)	2.02	-67.2
Dev. Dwarka (11%)	0.39	-85.5							Chitradurga (14%)	0.41	-63.1	Dharmapuri (2.9%)	1.98	-67.7
									Gadag (7.4%)	0.39	-64.8	Salem (6%)	1.76	-71.4
												Namakkal (9.6%)	1.47	-76.1
Maharashtra (6.0%)	**Yield (T/H)**	**Yield gaps (%)**	**Madhya Pradesh (4.6%)**	**Yield (T/H)**	**Yield gaps (%)**	**Telangana (2.3%)**	**Yield (T/H)**	**Yield gaps (%)**	**Uttar Pradesh (1.9%)**	**Yield (T/H)**	**Yield gaps (%)**	**West Bengal (1.5%)**	**Yield (T/H)**	**Yield gaps (%)**
Kolhapur (17.6%)	1.45		Shivpuri (49.8%)	2.22		Warangal (5.2%)	3.17	0.0	Mahoba (9.7%)	1.51		Medinipur East (23.6%)	4.53	
Satara (16.8%)	1.12	-23.2	Alirajpur (4.8%)	1.73	-22.2	Wanaparthy (18%)	3.07	-3.0	Unnao (2.6%)	1.27	-16.0	Medinipur West (10.5%)	2.66	-41.3
Sangli (11.3%)	1.05	-27.8	Tikamgarh (8.3%)	1.51	-31.9	Jogulamba (12%)	2.48	-21.7	Shahjahanpur (4%)	1.15	-23.6	Hooghly (22.6%)	2.43	-46.3
Nashik (10.5%)	0.94	-35.1	Chhatarpur (6.9%)	1.34	-39.7	Nagarkurnool (36%)	2.46	-22.5	Hardoi (8.1%)	1.13	-25.4	Jhargram (8.4%)	2.22	-51.0
Pune (10%)	0.93	-36.1	Datia (5.1%)	1.27	-42.9	Narayanapet (4.5%)	2.25	-29.0	Saharanpur (2.7%)	1.06	-29.9	Nadia (8.7%)	2.08	-53.9
Dhule (7.6%)	0.52	-63.9	Neemuch (5.2%)	1.16	-48.0	Suryapet (3.6%)	1.79	-43.5	Gorakhpur (3.3%)	0.97	-35.9	Jalpaiguri (6.4%)	1.98	-56.3
Ahmednagar (4.4%)	0.52	-64.3				Mahabubabad (5%)	1.62	-48.8	Jhansi (29.9%)	0.85	-43.3			
Aurangabad (3.6%)	0.41	-71.7							Kheri (6.6%)	0.83	-44.8			
									Sitapur (2.9%)	0.80	-46.9			
									Lalitpur (9.4%)	0.70	-53.5			
									Deoria (2%)	0.48	-68.2			

Table 4. 4: Yield gaps (%) for Rapeseed & Mustard in major producing states -District-wise (2018-19)

Uttar Pradesh (11.1%)	Yield (T/H)	Yield gaps (%)
Budaun (4.9%)	2.31	0.0
Etawah (2%)	2.30	-0.3
Agra (8.1%)	2.21	-4.4
Mathura (7%)	2.18	-5.7
Etah (1.9%)	2.07	-10.5
Kasganj (1.3%)	2.03	-12.0
Kanpur Dehat (3.3%)	1.98	-14.3
Auraiya (2.1%)	1.90	-17.6
Firozabad (1.8%)	1.86	-19.4
Bulandshahr (2%)	1.86	-19.6
Shahjahanpur (1.9%)	1.80	-22.2
Bareilly (2.5%)	1.73	-25.0
Aligarh (3.1%)	1.70	-26.5
Hathras (1.6%)	1.67	-27.6
Kannauj (1.1%)	1.64	-28.9
Sambhal (1.8%)	1.47	-36.6
Kanpur Nagar (2%)	1.41	-38.9
Hardoi (1.7%)	1.24	-46.4
Jalaun (3.2%)	1.23	-46.7
Unnao (2.2%)	1.20	-48.2
Fatehpur (2.2%)	1.11	-51.8
Hamirpur (2.3%)	1.01	-56.4
Gonda (1.4%)	1.00	-56.7
Kheri (3.8%)	1.00	-56.9
Jhansi (1.8%)	0.92	-60.2
Pilibhit (1.3%)	0.91	-60.6
Bahraich (1.3%)	0.90	-61.2
Barabanki (3%)	0.85	-63.2
Sitapur (3.8%)	0.84	-63.5
Balrampur (2.4%)	0.82	-64.7
Kushi Nagar (1.3%)	0.58	-74.7

Rajasthan (44.9%)	Yield (T/H)	Yield gaps (%)
Bharatpur (7.9%)	2.22	0.0
Dholpur (2.5%)	2.20	-1.0
Alwar (9%)	2.14	-4.0
Baran (4%)	2.12	-4.8
Karauli (3%)	1.99	-10.4
Sawai Madhop. (6%)	1.89	-14.9
Ganganagar (9%)	1.87	-15.9
Hanumangarh (4.7%)	1.77	-20.6
Jhunjhunu (2.5%)	1.67	-25.0
Tonk (9.8%)	1.65	-25.9
Jhalawar (2.5%)	1.65	-26.0
Jaipur (3.1%)	1.43	-35.7
Jalore (2.7%)	1.36	-38.7
Jodhpur (6.2%)	1.36	-38.8
Churu (3.3%)	1.31	-41.3
Bikaner (5.8%)	1.25	-43.6
Gujarat (2.5%)	**Yield**	**Gaps**
Banas Kantha (72%)	1.83	0.0
Patan (12.4%)	1.55	-15.2
J&K (0.7%)	**Yield**	**Gaps**
Kulgam (15%)	1.55	0.0
Pulwama (20.4%)	1.42	-8.2
Badgam (9.7%)	1.08	-30.0
Anantnag (27.6%)	1.00	-35.2
Kathua (5.7%)	0.68	-56.0
Udhampur (4.3%)	0.23	-85.1

Madhya Pradesh (9.8%)	Yield (T/H)	Yield gaps (%)
Bhind (32.9%)	2.12	0.0
Morena (20.6%)	2.09	-1.5
Sheopur (6.1%)	1.33	-37.2
Gwalior (7.3%)	0.90	-57.6
Neemuch (2.1%)	0.62	-70.8
Mandsaur (4.2%)	0.61	-71.5
Shivpuri (5.6%)	0.54	-74.5
Chhatarpur (2.6%)	0.53	-75.0
Jharkhand (4.3%)	**Yield**	**Gaps**
Saraikela Kh. (4.5%)	1.30	0.0
Pakur (3.8%)	0.95	-26.9
Gumla (3.8%)	0.93	-28.3
Hazaribagh (4.8%)	0.90	-30.8
Latehar (4.9%)	0.88	-32.4
Lohardaga (3.9%)	0.87	-32.8
Deoghar (3.7%)	0.80	-38.5
East Singhb. (3.6%)	0.75	-42.3
Ranchi (4.3%)	0.70	-46.2
Dumka (5.9%)	0.65	-50.0
Simdega (4.3%)	0.63	-51.9
Khunti (4.2%)	0.60	-53.8
West Singhb. (4.1%)	0.59	-54.6
Chatra (4.5%)	0.58	-55.4
Garhwa (5.7%)	0.56	-56.9
Sahebganj (4.6%)	0.53	-59.2
Palamu (5.5%)	0.51	-60.5

Haryana (9.4%)	Yield (T/H)	Yield gaps (%)
Rewari (12.1%)	2.30	0.0
Hisar (12.4%)	2.20	-4.3
Jhajjar (5.3%)	2.12	-7.5
Sirsa (8.7%)	1.99	-13.2
Charki Dadri (9.6%)	1.90	-17.3
Mahendragarh (15%)	1.88	-17.9
Bhiwani (21.9%)	1.85	-19.4
Assam (4.2%)	**Yield**	**Gaps**
Jorhat (3.5%)	0.82	0.0
Dhubri (5.6%)	0.78	-4.4
Kokrajhar (7.9%)	0.73	-10.2
Nagaon (5.8%)	0.73	-10.7
Sonitpur (7%)	0.71	-13.5
Lakhimpur (8.5%)	0.64	-21.4
Barpeta (6.6%)	0.64	-21.6
Darrang (4.7%)	0.64	-21.6
Baksa (3.9%)	0.63	-22.9
Marigaon (3.5%)	0.58	-29.4
Karbi Anglong (8.3%)	0.58	-29.6
Dhemaji (5.7%)	0.56	-31.7
Kamrup (4.1%)	0.56	-31.9
Chirang (5%)	0.48	-40.9

West Bengal (8.9%)	Yield (T/H)	Yield gaps (%)
Dinajpur Dakshin (12%)	1.79	0.0
Maldah (7.5%)	1.57	-12.4
24 Paraganas N. (6%)	1.39	-22.5
Dinajpur Uttar (11.9%)	1.21	-32.5
Murshidabad (21%)	1.18	-34.0
Nadia (14.5%)	1.13	-36.6
Purba Bardhaman (5%)	1.06	-41.0
Birbhum (6.1%)	0.91	-49.3
Bihar (1.1%)	**Yield**	**Gaps**
Katihar (7%)	1.97	0.0
Vaishali (3.6%)	1.82	-7.9
Rohtas (2.9%)	1.62	-17.6
Khagaria (3.7%)	1.58	-20.0
Nalanda (5.1%)	1.54	-21.8
Siwan (2.5%)	1.52	-22.9
Saran (4.1%)	1.43	-27.6
Lakhisarai (3.2%)	1.43	-27.7
Purbi Champa. (2.6%)	1.32	-33.2
Pashchim Champa (4%)	1.32	-33.3
Muzaffarpur (6%)	1.26	-36.2
Samastipur (9.6%)	1.26	-36.4
Bhojpur (2.6%)	1.24	-37.1
Begusarai (9.6%)	1.18	-40.2
Gopalganj (2.9%)	1.05	-46.6
Patna (3.1%)	1.05	-46.8
Aurangabad (2.8%)	0.96	-51.1
Jamui (2.8%)	0.64	-67.6
Darbhanga (2.5%)	0.60	-69.4

Figure 4. 3: District-wise yield gaps (%) for Soybean - Madhya Pradesh (2018-19)

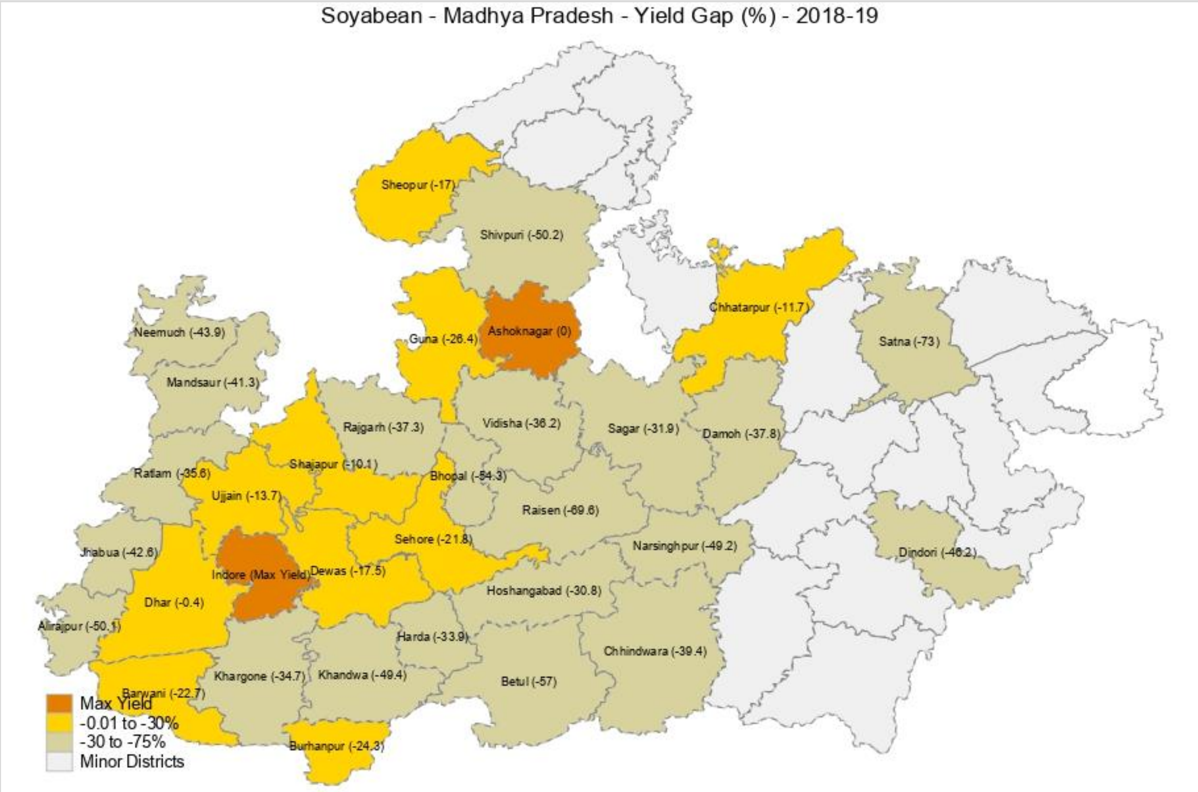


Figure 4. 4: District-wise yield gaps (%) for Soybean - Maharashtra (2018-19)

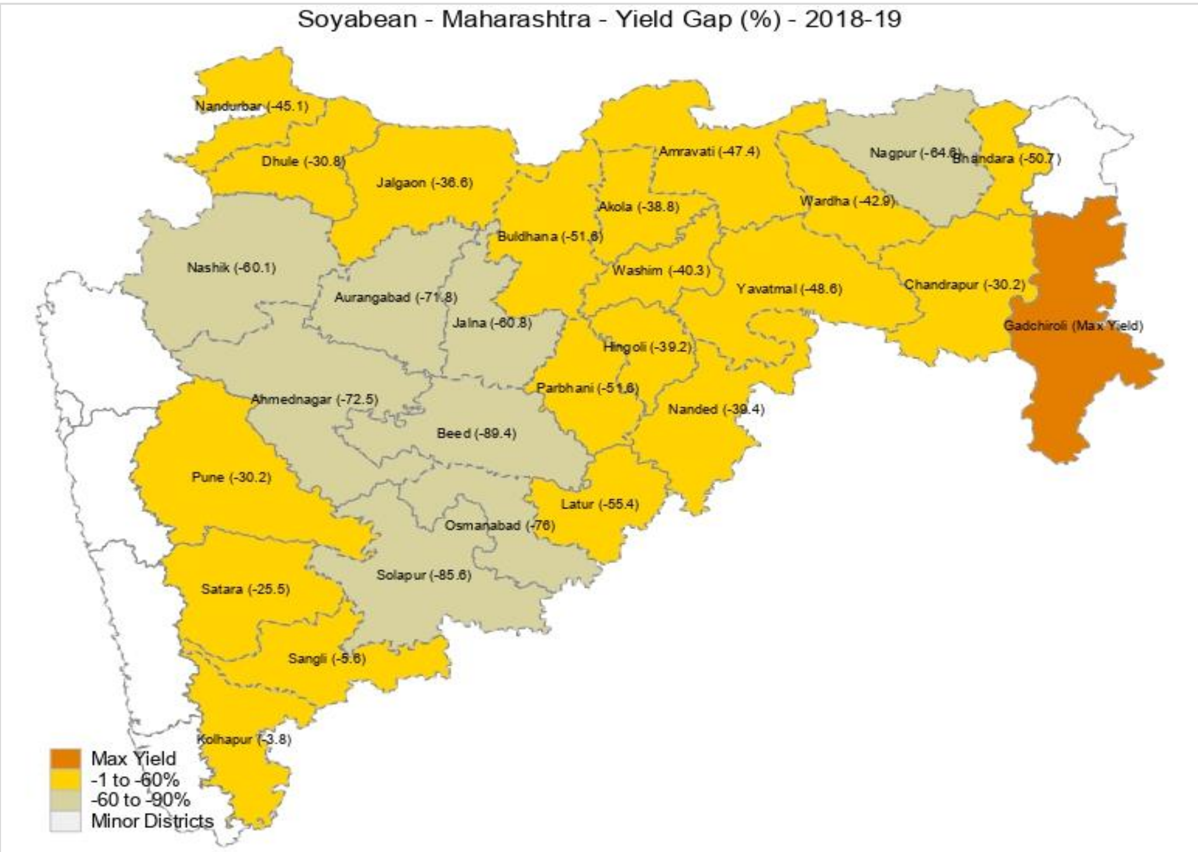


Figure 4. 5: District-wise yield gaps (%) for Soybean - Rajasthan (2018-19)

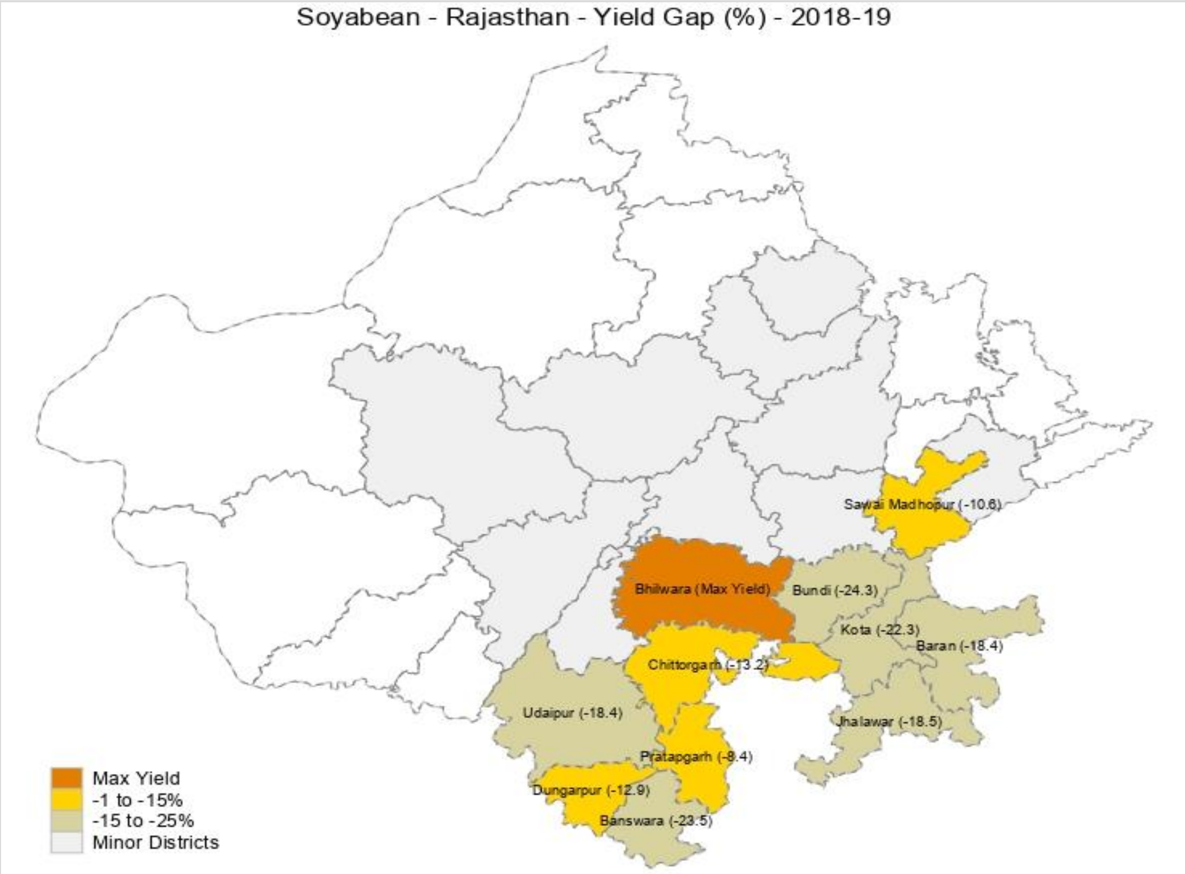


Figure 4. 6: District-wise yield gaps (%) for Groundnut - Gujarat (2018-19)

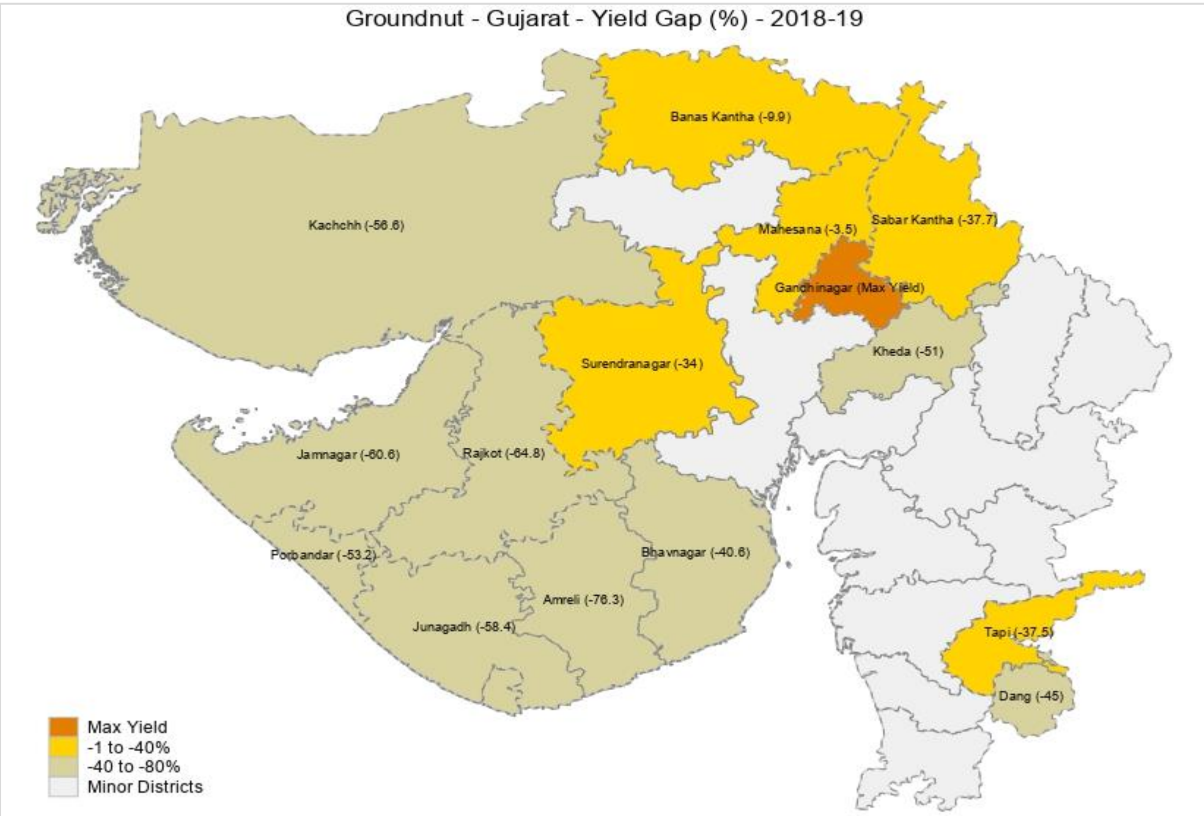


Figure 4. 7: District-wise yield gaps (%) for Groundnut - Rajasthan (2018-19)

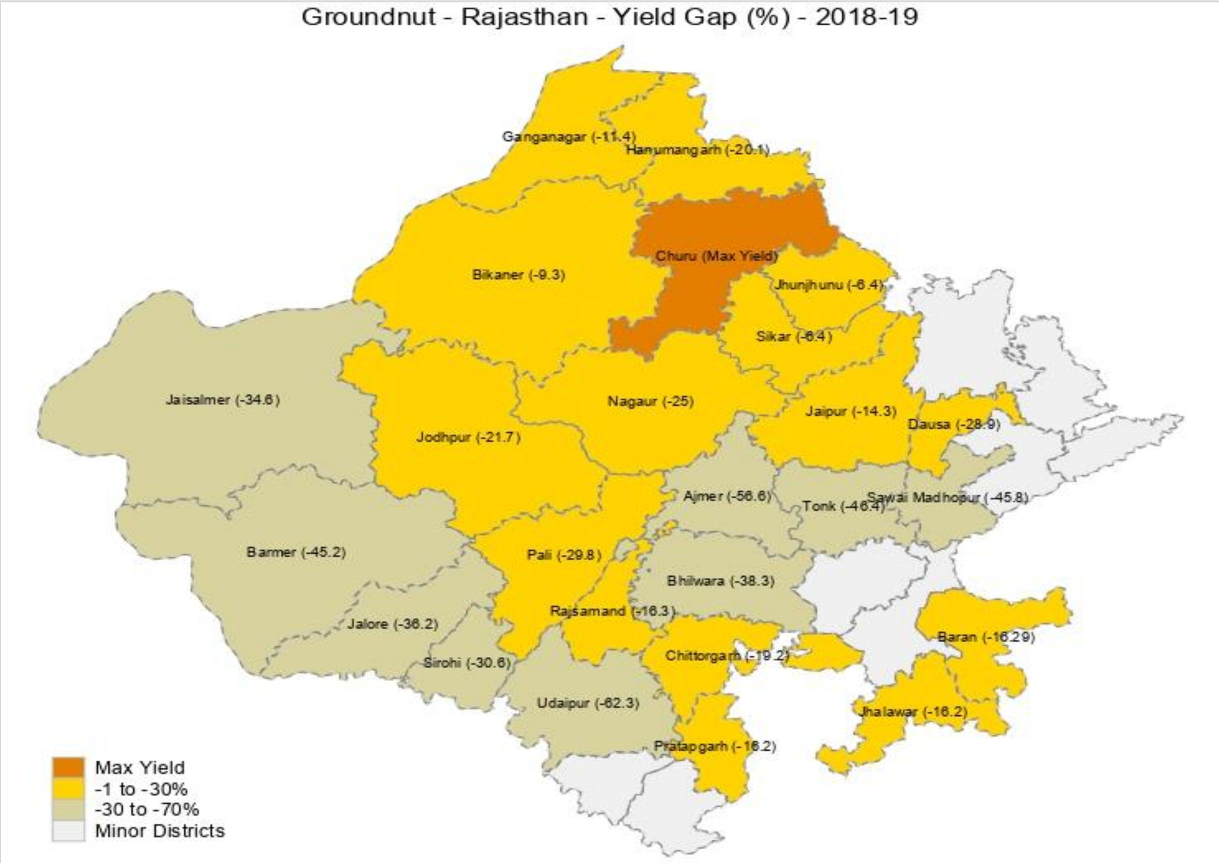


Figure 4. 8: District-wise yield gaps (%) for Groundnut – Andhra Pradesh (2018-19)

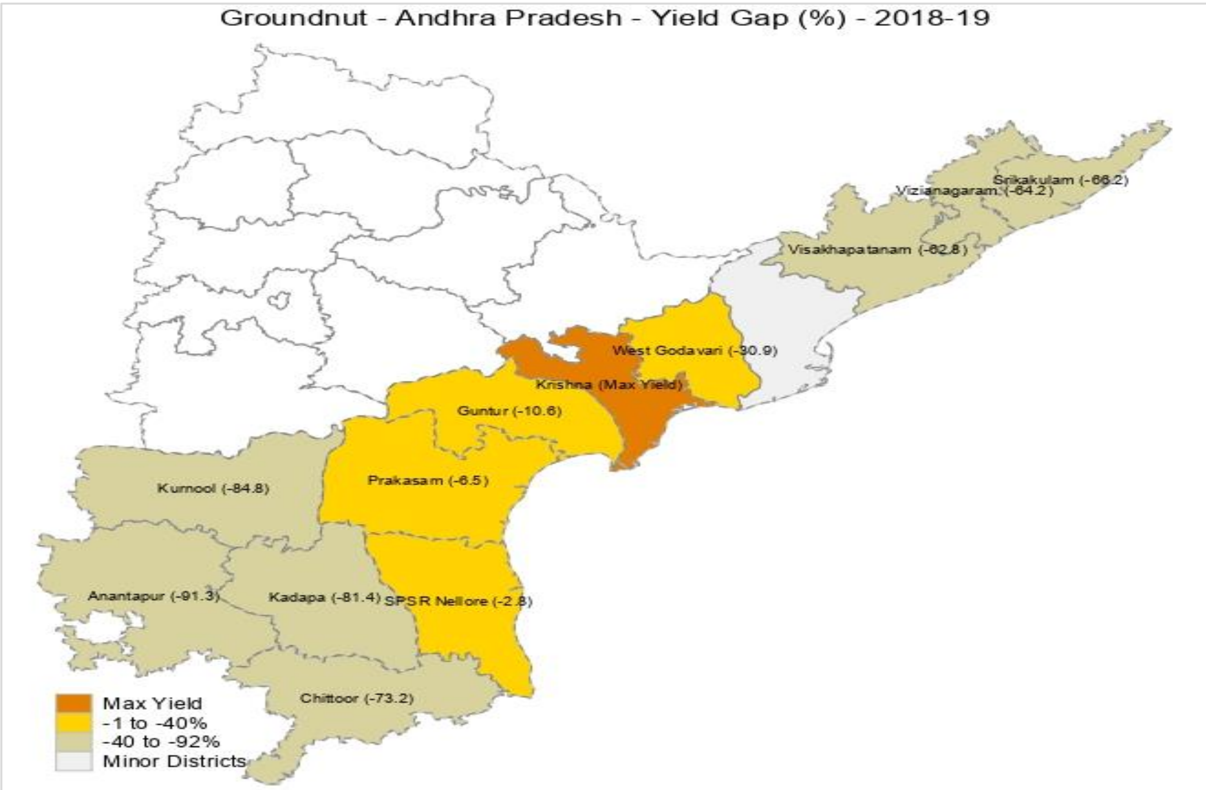


Figure 4. 9: District-wise yield gaps (%) for Rapeseed & Mustard - Rajasthan (2018-19)

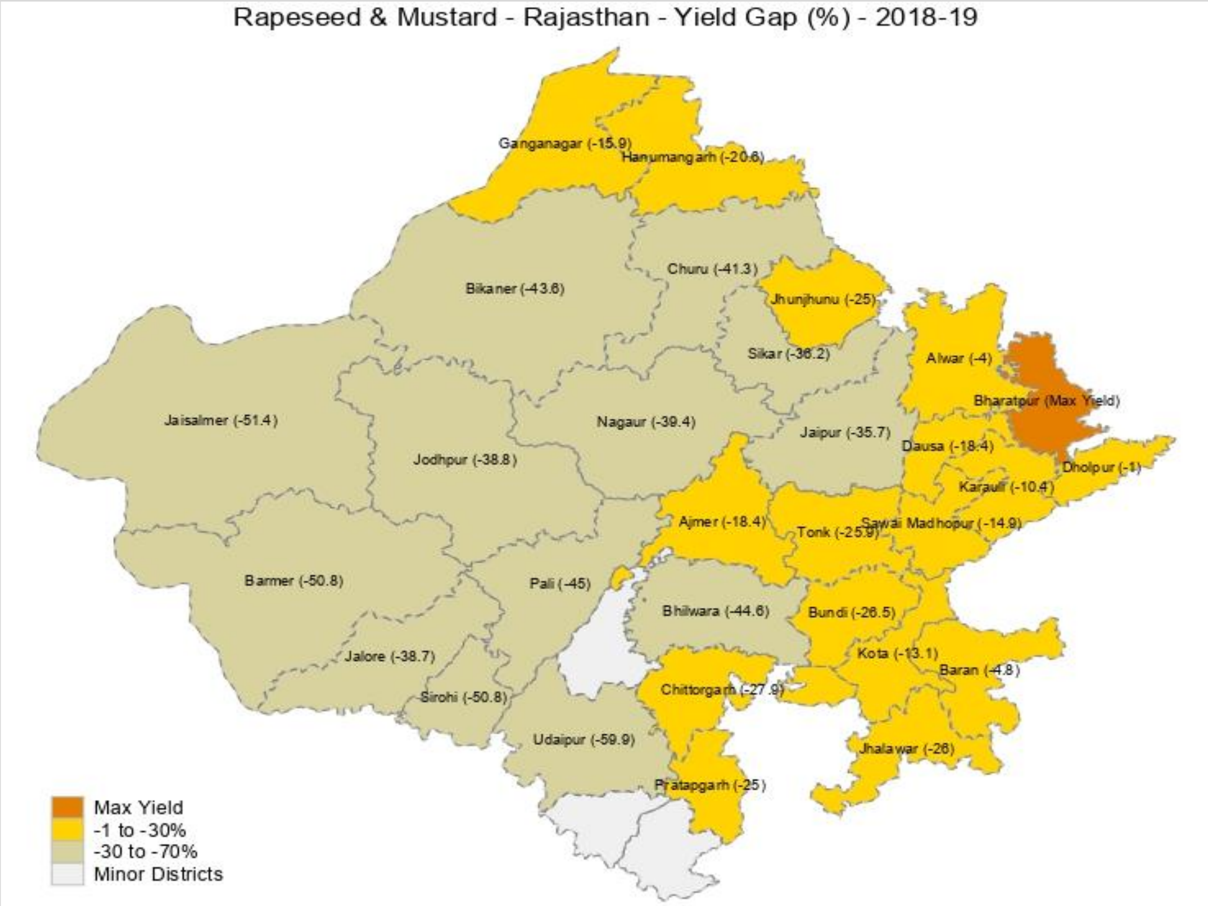
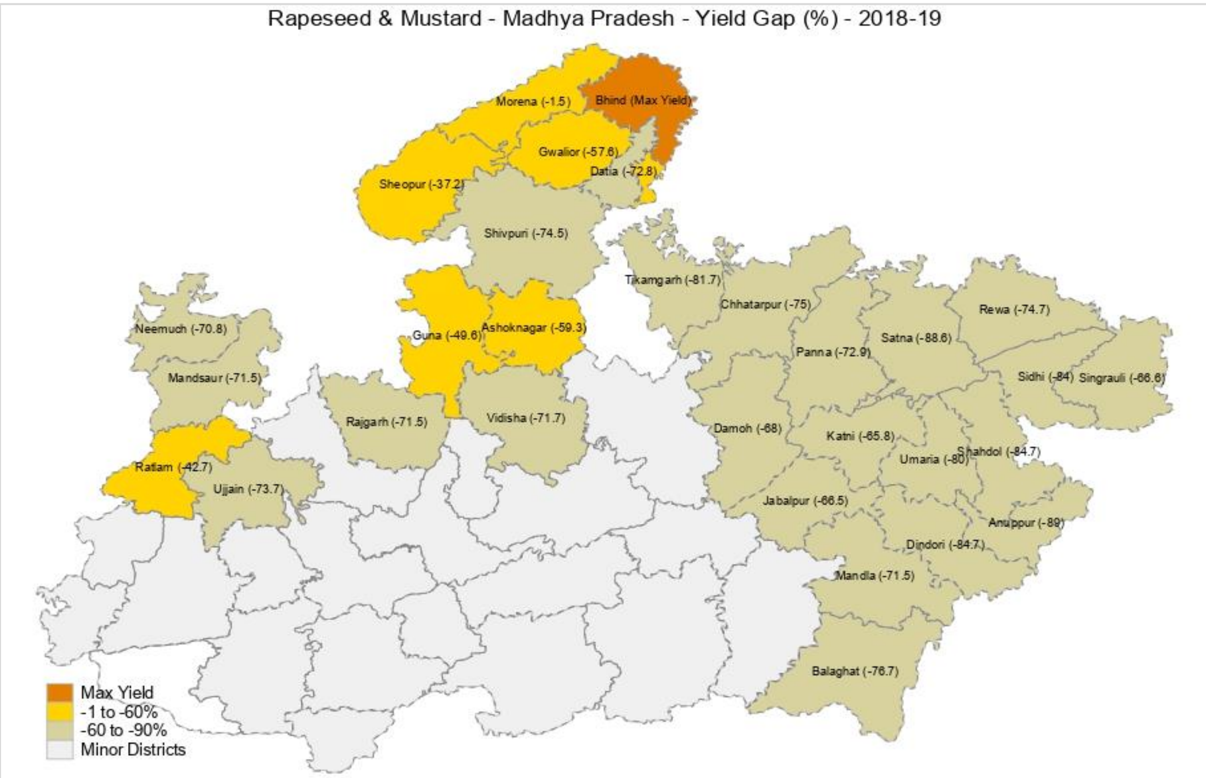


Figure 4. 10: District-wise yield gaps (%) for Rapeseed & Mustard – Madhya Pradesh (2018-19)



Many of the oilseeds such as sesame seed, sunflower seed, sunflower seed, castor seed, linseed and niger seed are considered as minor oilseeds. The production of these oilseeds is limited in India and concentrated in a few states and districts. The yield gap across the districts in the major producing states is analyzed below.

Sesame is mainly grown in Uttar Pradesh, Madhya Pradesh, Rajasthan, West Bengal and Gujarat (Table 4.5, Figure 4.11). High yield gaps across districts were observed in Uttar Pradesh, Rajasthan and Gujarat in many of the districts as compared to the highest-yield district in the respective state. In Uttar Pradesh, 8 out of 10 districts reported a yield gap of more than 50% and in half of such districts the gap is more than 78% and close to 90%. Similarly, in Rajasthan 4 out of 11 districts and in Gujarat 3 out of 8 districts witnessed yield gaps of at least by -50% for sesame. In Madhya Pradesh and West Bengal, the yield gaps are in the range of -30% to -36%.

Sunflower and safflower seed are mainly grown in Karnataka, which has more than 56% and 50% of the all-India area share under these two oilseed crops, respectively (Table 4.5, Figure 4.15). In this state, three out of six districts for sunflower are with yield gaps in the range of -46.5% and -65%) and four out of six districts for safflower are with yield gaps in the range of -44.5% and -73%). Maharashtra is the second largest producing state of sunflower (holding close to 42% acreage share) and safflower (holding above 12% acreage share). Solapur district covered nearly 83% of the state's area under sunflower, but reported a very low yield of just 0.2 tonnes per hectare.

For safflower, Latur district covering nearly 23% of state's area share, reported -55% yield gaps, followed by Parbhani (-33% yield gap with nearly 11% area share) and Osmanabad (-13%, 31%). Anantapur (-55%), Kurnool (-25%) in Andhra Pradesh for sunflower; and Sangareddy (-40%) and Kamareddy (-37%) in Telangana for safflower, are some other districts which showed large yield gaps.

In general, Kurukshetra and Ambala districts in Haryana reported the highest yield for sunflower at nearly 1.8 tonnes per hectare which is close to double compared to the districts in Karnataka (the largest producing state) and Andhra Pradesh and, nearly 7 to 8 times compared to Solapur district in Maharashtra. The yield of safflower is comparatively better in the districts of Karnataka compared to other states.

Castor seed is mainly grown in Gujarat, which has more than 70% share of the country's total area (Table 4.6, Figure 4.12). Most of the districts in Gujarat, except Kutch (-75% yield gap) and Surendranagar (-86% yield gap), reported better yield of above 1.85 tonnes per hectare compared to other major producing states like Rajasthan, Andhra Pradesh and Telangana. In other states, Jodhpur in Rajasthan (-75% yield gap); Kurnool in Andhra Pradesh (-28%); and Mahbubnagar and Narayanpet in Telengana (-21.6% each) are the districts with large yield gaps. At the state level, Andhra Pradesh and Telangana are lagging in yield compared to Gujarat and Rajasthan.

Yield of niger seed is very low compared to other oilseed crops. Odisha holds nearly 39% of country's total area under nigerseed, followed by Chhattisgarh (37.5%) (Table 4.6, Figure 4.13). The highest yield gaps are reported from Malkangiri in Orissa (-33%); Balrampur in Chhattisgarh (-21%); Osmanabad (-69%), Latur (-47%) and Nasik (-22%) in Maharashtra; and Chhindwara in Madhya Pradesh (-48%).

Turning to linseed, Ratlam district in Madhya Pradesh reported the highest yield of 1.7 tonnes per hectare, which is nearly double the yield of other districts in the state and the districts in Uttar Pradesh and Bihar (Table 4.6, Figure 4.14). Hence, the other eight districts in Madhya Pradesh are lagging by -50% to -78% compared to Ratlam. The yield gaps in Uttar Pradesh in four out of six major producing districts are in range of -38% up to -54%. Overall, Chhattisgarh reported lowest yield of linseed, of 0.3 tonnes per hectare, in five of the major producing districts.

Table 4. 5: Sesame, Sunflower and Safflower

Sesame

Uttar Pradesh (21.9%)	Yield	Yield gaps (%)	Madhya Pradesh (19.4%)	Yield	Yield gaps (%)	Rajasthan (17.2%)	Yield	Yield gaps (%)	West Bengal (16.2%)	Yield	Yield gaps (%)	Gujarat (10.2%)	Yield	Yield gaps (%)
Mahoba (9.6%)	0.59	0.0	Datia (9.4%)	0.68	0.0	Tonk (4.2%)	0.50	0.0	Hooghly (16.7%)	1.14	0.0	Bhavnagar (10.2%)	0.93	0.0
Hardoi (5.6%)	0.50	-14.8	Panna (5.7%)	0.60	-10.8	Karauli (7.3%)	0.44	-12.6	Nadia (12.4%)	1.12	-1.6	Botad (5.5%)	0.69	-25.1
Jalaun (14.1%)	0.27	-53.7	Gwalior (14.2%)	0.60	-11.1	Dausa (3%)	0.42	-15.6	Purba Bardhaman (7.7%)	0.99	-13.1	Junagadh (5.8%)	0.60	-35.1
Banda (3.5%)	0.26	-55.0	Chhatarpur (36.9%)	0.59	-12.6	Pali (20.8%)	0.42	-16.0	Murshidabad (8.7%)	0.90	-21.0	Morbi (10.8%)	0.50	-46.5
Fatehpur (3.4%)	0.23	-61.7	Sheopur (8%)	0.49	-27.2	Sawai Madhopur (11.8%)	0.40	-20.4	Medinipur West (30.8%)	0.83	-27.7	Amreli (4.7%)	0.49	-46.9
Hamirpur (12.8%)	0.22	-62.5	Morena (3.9%)	0.48	-28.5	Jodhpur (9.7%)	0.39	-22.6	Bankura (10.4%)	0.73	-35.7	Surendranagar (21.8%)	0.44	-52.7
Unnao (3.5%)	0.13	-78.7	Tikamgarh (3.6%)	0.48	-29.2	Bhilwara (3.7%)	0.31	-38.5				Banas Kantha (6.7%)	0.28	-69.9
Jhansi (24.5%)	0.08	-87.1				Sirohi (7.3%)	0.23	-53.5				Kachchh (17.2%)	0.26	-71.5
Sitapur (2.9%)	0.07	-87.7				Jaisalmer (3%)	0.23	-53.9						
Shahjahanpur (2.6%)	0.06	-89.3				Bikaner (6%)	0.17	-66.7						
						Jalore (4%)	0.13	-74.8						

Sunflower

Karnataka (56.5%)	Yield	Yield gaps (%)	Maharashtra (12.2%)	Yield	Yield gaps (%)	Haryana (4%)	Yield	Yield gaps (%)	Andhra Pradesh (4%)	Yield	Yield gaps (%)
Belgaum (8.4%)	0.99	0.0	Solapur (83.4%)	0.17	0.0	Kurukshetra (63.3%)	1.84	0.0	Kadapa (42%)	0.92	0.0
Bagalkot (27.6%)	0.94	-5.1				Ambala (34.7%)	1.82	-0.8	Chittoor (4.9%)	0.83	-9.7
Bellary (9.5%)	0.85	-14.3							Kurnool (13.6%)	0.69	-25.3
Bijapur (6.2%)	0.53	-46.5							Anantapur (22.7%)	0.42	-54.9
Koppal (19.2%)	0.45	-54.2									
Gadag (10.2%)	0.35	-64.8									

Safflower

Karnataka (50.2%)	Yield	Yield gaps (%)	Maharashtra (41.7%)	Yield	Yield gaps (%)	Telangana (3.9%)	Yield	Yield gaps (%)	Andhra Pradesh (1.9%)	Yield	Yield gaps (%)
Bidar (28.2%)	0.95	0.0	Hingoli (21.7%)	0.65	0.0	Vikarabad (9.6%)	0.60	0.0	Kadapa (54.8%)	0.16	0.0
Belgaum (6.8%)	0.77	-19.3	Osmanabad (31.2%)	0.56	-13.3	Kamareddy (29%)	0.38	-36.7	Kurnool (16.9%)	0.15	-3.7
Chitradurga (6.6%)	0.53	-44.5	Parbhani (10.9%)	0.44	-32.6	Sangareddy (42.9%)	0.36	-40.1	Anantapur (21.7%)	0.15	-4.4
Bijapur (10%)	0.41	-57.1	Latur (23%)	0.29	-54.6						
Dharwad (20.2%)	0.40	-57.5									
Gadag (10.8%)	0.26	-72.8									

Table 4. 6: Castor seed, Linseed and Niger seed

Castor seed											
Gujarat (70.4%)	Yield	Yield gaps (%)	Rajasthan (19.5%)	Yield	Yield gaps (%)	Andhra Pradesh (3.6%)	Yield	Yield gaps (%)	Telangana (2.7%)	Yield	Yield gaps (%)
Banas Kantha (11.5%)	2.87	0.0	Jalore (29.8%)	1.98	0.0	Anantapur (33%)	0.51	0.0	Wanaparthy (22.2%)	0.92	0.0
Gandhinagar (4.8%)	2.47	-14.1	Sirohi (30.8%)	1.45	-26.9	Kurnool (54.7%)	0.37	-27.6	Jogulamba (15.3%)	0.77	-17.0
Mahesana (16.7%)	2.21	-22.9	Barmer (15.8%)	1.30	-34.4				Mahbubnagar (21.2%)	0.73	-21.6
Vadodara (9.3%)	2.04	-29.0	Jodhpur (12.9%)	0.50	-74.8				Narayanapet (33.8%)	0.72	-21.6
Patan (11.3%)	1.92	-33.2									
Ahmadabad (10.5%)	1.85	-35.4									
Kachchh (7.9%)	0.73	-74.7									
Surendranagar (11.1%)	0.40	-85.9									
Linseed											
Madhya Pradesh (28.9%)	Yield	Yield gaps (%)	Uttar Pradesh (15%)	Yield	Yield gaps (%)	Chhattisgarh (8.7%)	Yield	Yield gaps (%)	Bihar	Yield	Yield gaps (%)
Ratlam (5.6%)	1.69	0.0	Mahoba (24%)	0.84	0.0	Surajpur (8.7%)	0.30	0.0	Pashchim Champaran (2.3%)	0.862	0.0
Mandsaur (23.6%)	0.85	-49.6	Banda (8.3%)	0.83	-1.2	Rajnandgaon (22%)	0.28	-5.6	Kaimur (Bhabua) (15.1%)	0.851	-1.3
Chhatarpur (6%)	0.71	-57.8	Mirzapur (16.5%)	0.52	-38.1	Balrampur (25.1%)	0.28	-6.1	Rohtas (6.3%)	0.851	-1.3
Neemuch (5.9%)	0.70	-58.5	Sonbhadra (19.4%)	0.48	-43.3	Surguja (20.5%)	0.26	-14.0	Bhojpur (2.3%)	0.849	-1.5
Balaghat (13.1%)	0.59	-65.0	Hamirpur (7.6%)	0.45	-46.3	Korea (5.4%)	0.18	-39.6	Kishanganj (19%)	0.848	-1.6
Rewa (5.3%)	0.56	-66.9	Chandauli (6%)	0.39	-53.9				Bhagalpur (8.8%)	0.848	-1.6
Anuppur (8.2%)	0.43	-74.8							Katihar (2.4%)	0.847	-1.7
Seoni (8.3%)	0.41	-75.6							Supaul (4.4%)	0.846	-1.9
Dindori (6%)	0.38	-77.6							Aurangabad (20.8%)	0.844	-2.1
Niger seed											
Odisha (38.9%)	Yield	Yield gaps (%)	Chhattisgarh (37.5%)	Yield	Yield gaps (%)	Maharashtra (6.0%)	Yield	Yield gaps (%)	Madhya Pradesh (4.4%)	Yield	Yield gaps (%)
Koraput (60.3%)	0.29	0.0	Bastar (11.3%)	0.21	0.0	Pune (15.8%)	0.18	0.0	Anuppur (16.4%)	0.33	0.0
Rayagada (12%)	0.29	-1.7	Jashpur (36.6%)	0.19	-8.6	Satara (14%)	0.18	-2.0	Dindori (61%)	0.30	-10.2
Malkangiri (10.7%)	0.19	-33.2	Surguja (13.5%)	0.19	-8.8	Nashik (19.5%)	0.14	-21.6	Chhindwara (8.8%)	0.17	-47.8
			Balrampur (20.6%)	0.17	-21.1	Latur (7%)	0.10	-47.0			
						Osmanabad (30%)	0.06	-69.0			

Figure 4. 11: District-wise yield gaps (%) for Sesame seed – Madhya Pradesh (2018-19)

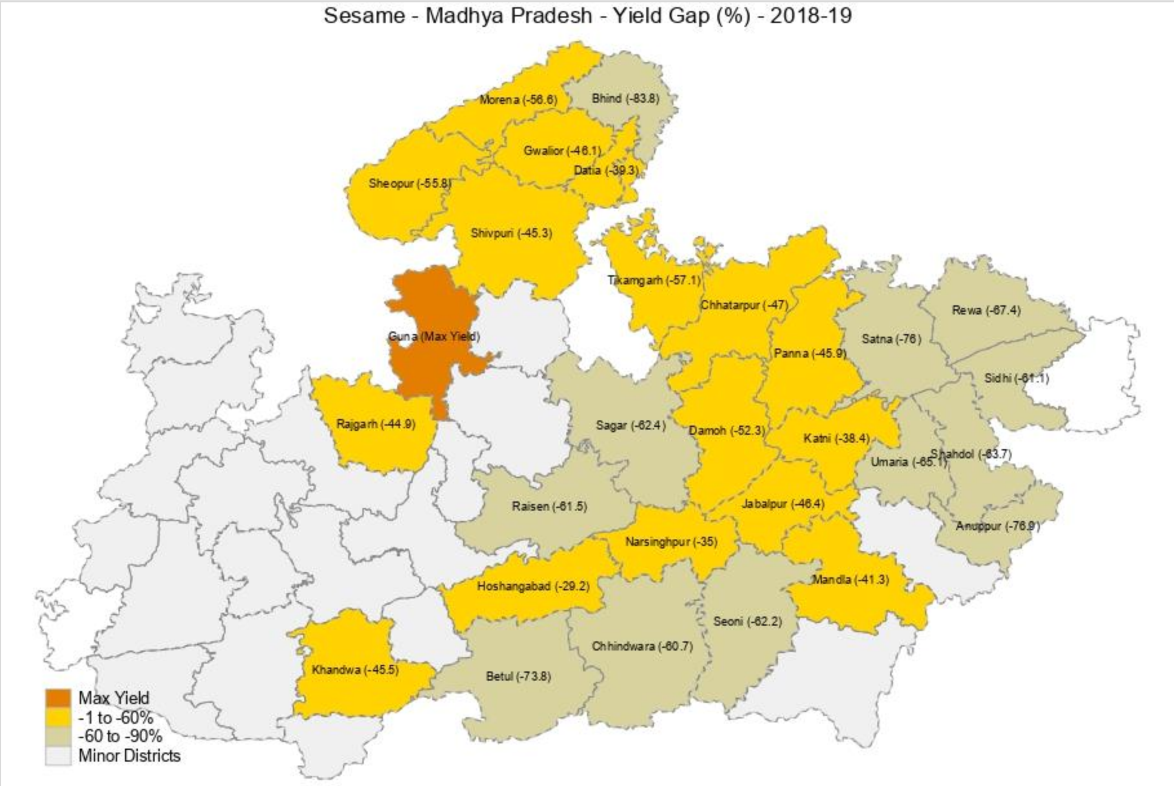


Figure 4. 12: District-wise yield gaps (%) for Castor seed – Gujarat (2018-19)

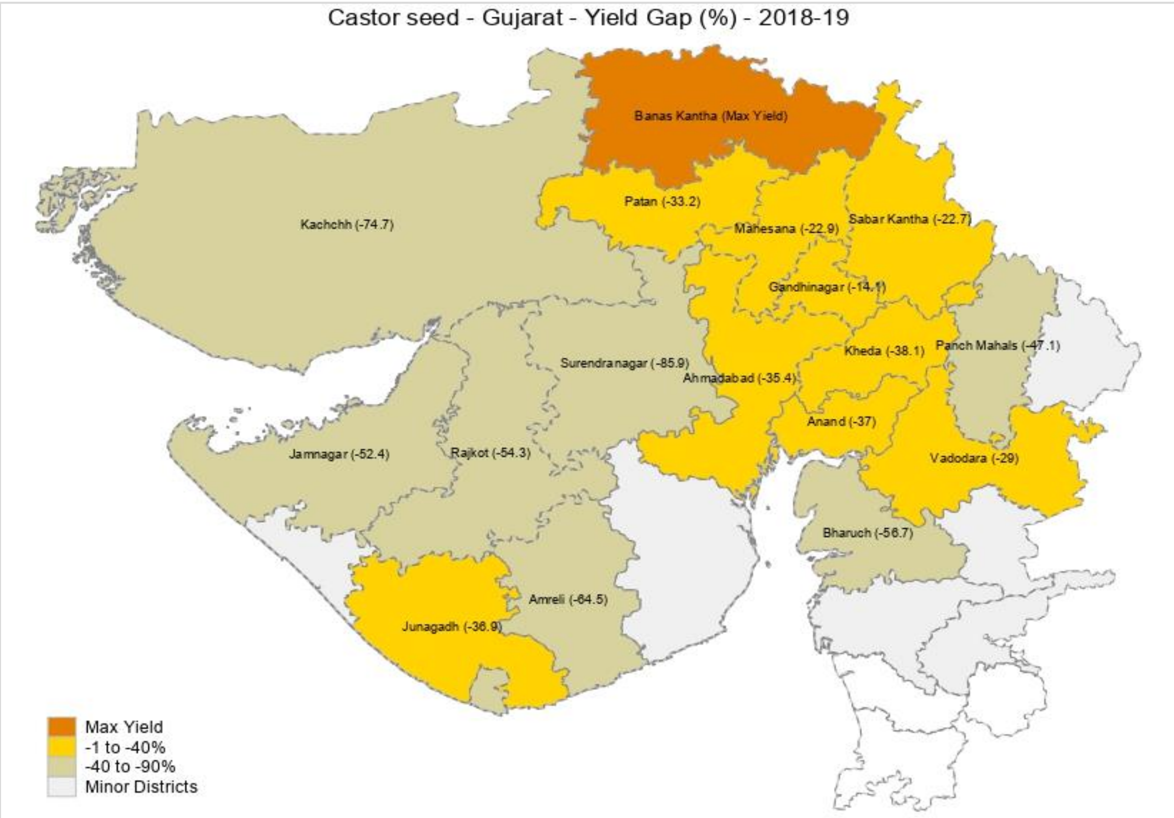


Figure 4. 13: District-wise yield gaps (%) for Niger seed – Odisha (2018-19)

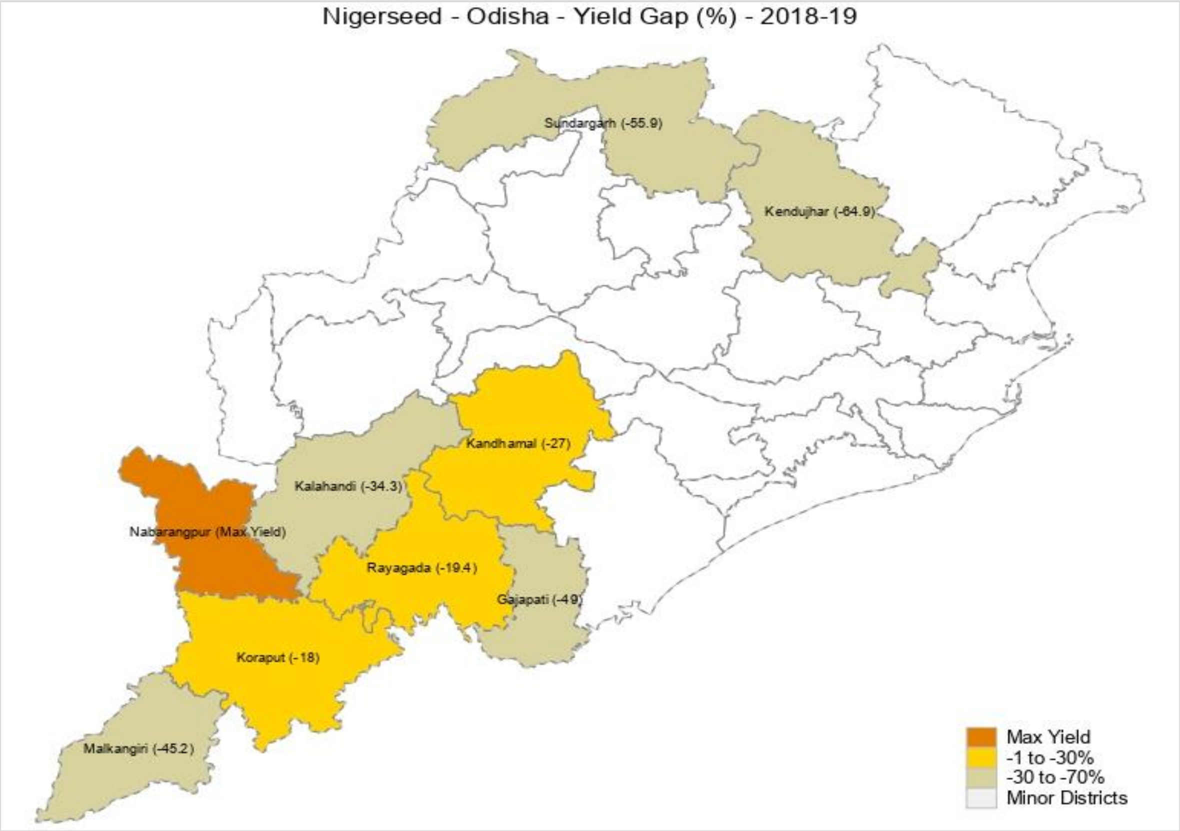


Figure 4. 14: District-wise yield gaps (%) for Linseed – Madhya Pradesh (2018-19)

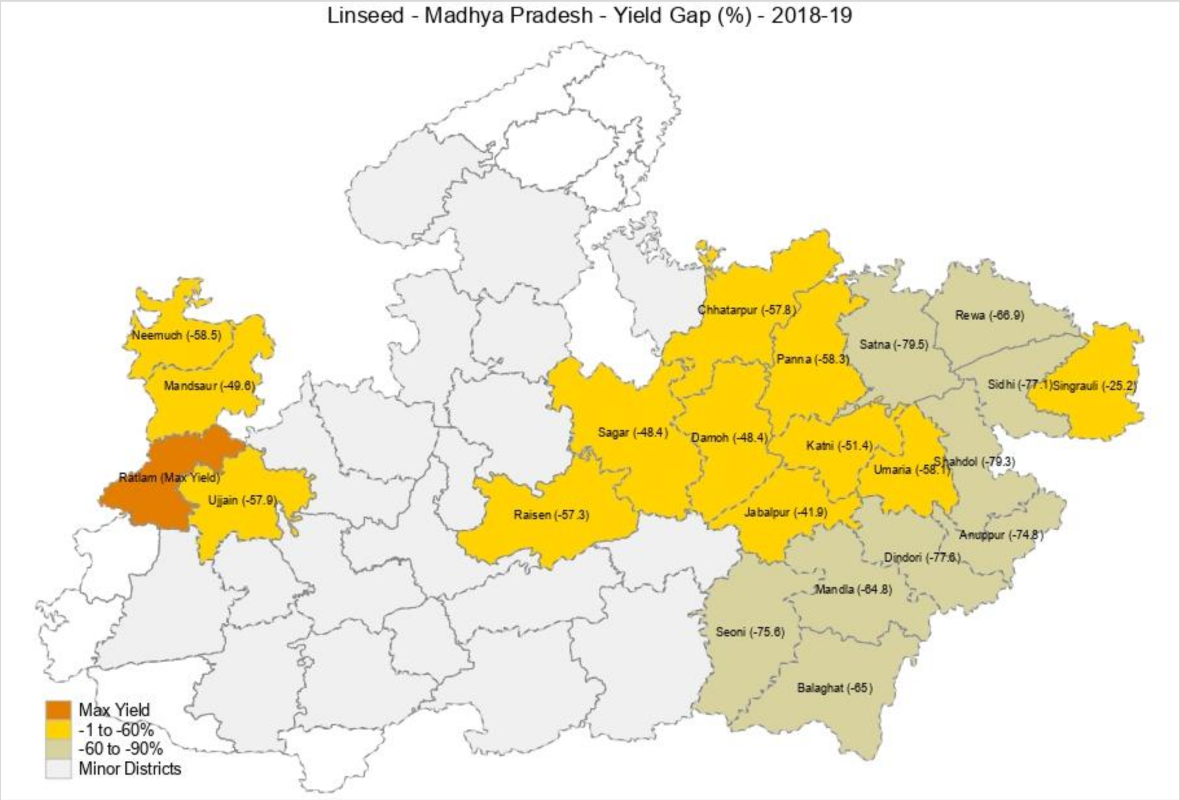
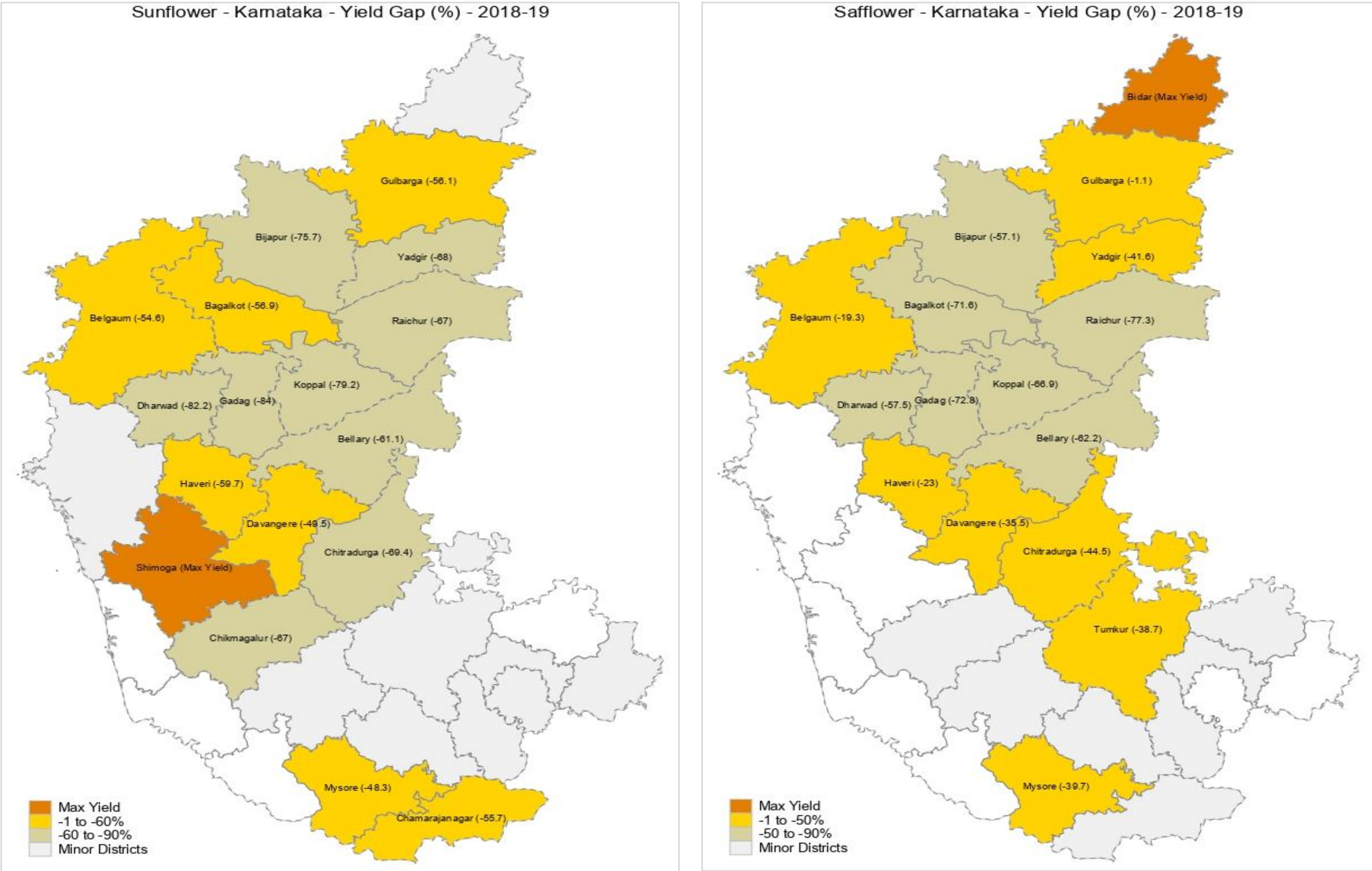


Figure 4. 15: District-wise yield gaps (%) for Sunflower and Safflower – Karnataka (2018-19)



Yield gaps for major oilseeds from KVK stations - state level

The yield gaps for some of the major oilseed crops are analyzed using the data reported at the district level by the various 'Krishi Vikas Kendras (KVKs)' located in various district. The crop yields at the 'farmer's plot' and at the 'demonstration' stage is reported for major oilseed crops across such KVKs. The 'yield gap' reported here is the gap between the yields at the demonstration level with respect to yield reported at the farmer's plot.

Soybean

Among the major producing states of Soybean, Madhya Pradesh reported the highest yield gap (above 37%) between the demonstration level and at the farmer's plot (Table 4.7). This gap is about 29% for Maharashtra and 26% for Rajasthan. The highest demonstration yield is observed in Maharashtra at 19.3 quintals per hectare whereas this is close to 15 quintals per hectare in Madhya Pradesh and Rajasthan. The benefit cost ratios (B:C ratios) during the demonstration and at the farmer's plot were also compared. Among the major producing states, the highest B:C ratio is nearly 2.3 times during the demonstration in Madhya Pradesh, and observed lowest at the farmer's plot in Maharashtra at 1.8 times. Among the minor producing states, the gaps between the yield at the demonstration level and at the farmer's plot are ranging from 42% (highest in Chhattisgarh) to 17% (lowest in Bihar) due to base effect of yield at the farmer's plot in respective states. The highest B:C ratio during demonstration is reported in Karnataka.

Table 4. 7: Yield gaps during demonstration stage and at farmer's plot - Soybean

State		Yield gap (%)	B:C ratio (Farmer's plot)	B:C ratio (Demonstration)	Yield (Farmer's plot) (q/ha)	Yield (Demonstration) (q/ha)
Major	Madhya Pradesh	37.22	1.93	2.29	11.22	15.40
	Maharashtra	28.52	1.79	2.06	15.04	19.33
	Rajasthan	25.72	1.99	2.23	11.70	14.71
Minor	Karnataka	30.78	2.54	3.29	13.19	17.25
	Gujarat	22.48	2.20	2.63	13.96	17.10
	Chhattisgarh	41.58	2.27	2.47	8.91	12.62
	Nagaland	22.97	1.45	1.79	7.27	8.94
	Bihar	16.67	1.88	2.19	18.60	21.70

Groundnut

Rajasthan and Tamil Nadu witnessed high yield in range of 23 to 25 quintiles per hectare during the demonstration stage, whereas the other three major producing states Gujarat, Andhra Pradesh and Karnataka reported the yield up-to 21 quintiles per hectare during demonstration (Table 4.8). But at the farmer's plot the yield decreases in range from 13 to 21 quintiles per hectare, reported highest in Rajasthan. The highest yield gap between the demonstration level and at the farmer's plot is reported in Karnataka (44%) followed by Tamil

Nadu (32%). Though, this gap is observed least in Rajasthan (below 18%) but the BC ratio is in Rajasthan during the demonstration stage is comparatively very less at 1.3 times as compare to all other states in which this ratio is at reported least 2.3 times. Among the minor producing states, the yield gaps between the demonstration level and at the farmer's plot are ranging from 72.3% (highest in Chhattisgarh) to 16.5% (lowest in Telangana) due to base effect of yield at the farmer's plot in respective states. The B:C ratio, of above three times, during demonstration is reported in three of the minor states of groundnut – Telengana, Uttar Pradesh and Chhattisgarh but only Telangana was able to hold this ratio at the farmer's plot.

Table 4. 8: Yield gaps during demonstration stage and at farmer's plot - Groundnut

	State	Yield gap (%)	B:C ratio (Farmer's plot)	B:C ratio (Demonstration)	Yield (Farmer's plot) (q/ha)	Yield (Demonstration) (q/ha)
Major	Gujarat	24.75	1.94	2.34	15.38	19.19
	Rajasthan	17.84	2.65	1.31	20.87	24.59
	Andhra Pradesh	23.81	2.43	2.46	16.89	20.91
	Karnataka	43.80	2.44	2.87	13.09	18.83
	Tamil Nadu	31.77	1.91	2.52	17.96	23.67
Minor	Maharashtra	44.43	2.46	2.32	14.81	21.39
	Madhya Pradesh	26.74	2.24	2.68	12.23	15.50
	Telangana	16.54	3.84	3.17	19.35	22.55
	Uttar Pradesh	31.24	2.68	3.32	20.93	27.46
	West Bengal	28.94	1.88	2.18	17.96	23.16
	Odisha	32.29	1.92	2.27	15.14	20.03
	Chhattisgarh	72.34	2.58	3.58	9.40	16.20
	Jharkhand	41.72	1.99	2.47	9.53	13.51

Mustard

Haryana is the only major producing state of mustard who witnessed the highest yield during the demonstration stage at 23.3 quintal per hectare and able to record 19.5 quintal per hectare yield at the farmer's plot (Table 4.9). None among the other major producing states – Rajasthan, Uttar Pradesh, Madhya Pradesh and West Bengal, were able to reach at the yield level of 19 quintiles per hectare even during the demonstration stage. At the farmer's plot, the highest achieved yield is just 14.4 quintiles per hectare for these states. The BC ratio is above 2.3 times during the demonstration stage for all major states, least in Haryana due to base effect. All the major states are able to hold this ratio at above two times except West Bengal at the farmer's plot. The wide level of variation in yield is observed across the minor states of mustard. At the demonstration stage, on the one side, states like Punjab, Bihar, Gujarat and Jharkhand witnessed yield above 11 quintals per hectare, highest being in Punjab (close to 20 quintiles per hectare), but on the other side, is states like Assam, Jammu and Kashmir; and Chhattisgarh witnessed low yield, only up to 9.5 quintiles per hectare during demonstration stage. Similar pattern in yield is observed at the farmer's plot. The highest yield gap between these two levels is reported in Chhattisgarh (45.5%) and in Assam and Jharkhand (above 40%).

Table 4. 9: Yield gaps during demonstration stage and at farmer's plot - Mustard

	State	Yield gap (%)	B:C ratio (Farmer's plot)	B:C ratio (Demonstration)	Yield (Farmer's plot) (q/ha)	Yield (Demonstration) (q/ha)
Major	Rajasthan	26.04	2.75	3.15	14.40	18.15
	Uttar Pradesh	42.02	2.44	3.03	12.87	18.28
	Madhya Pradesh	40.30	2.49	3.11	12.45	17.46
	Haryana	19.37	2.02	2.28	19.49	23.26
	West Bengal	33.72	1.91	2.29	10.03	13.41
Minor	Jharkhand	40.86	1.94	2.53	8.22	11.58
	Assam	40.52	1.84	2.23	6.80	9.56
	Gujarat	21.55	2.40	3.07	12.90	15.69
	Bihar	38.71	2.31	2.87	10.00	13.87
	Jammu & K.	29.05	0.94	1.15	7.40	9.55
	Chhattisgarh	45.56	2.01	2.39	5.37	7.82
	Punjab	33.17	2.32	2.92	14.92	19.88

The yield gaps between the demonstration stage and at the farmer's plot are also analyzed for some of the minor oilseed crops grown in India – sesame seed, sunflower seed, safflower seed, linseed and Niger seed.

Sesame seed

For the sesame seed, West Bengal perform better to deliver higher yield during demonstration stage and at the farmer's plot, at 11.7 quintals per hectare and 9 quintiles per hectare, respectively (Table 4.10). This is at the cost of a B:C ratio at two times, which is least among the major producing states. All the other major states of sesame seed - Uttar Pradesh, Madhya Pradesh, Rajasthan and Gujarat were able to record highest yield only up to 8 quintiles per hectare. Unfortunately, the yield is just between 2 to 3 quintiles per hectare for Madhya Pradesh, 3.5 to 5 quintiles in Uttar Pradesh and 4.4 to 6.1 quintiles per hectare in Rajasthan at the farmer's plot and during the demonstration stage, respectively. On the implementation part, these major producing states – Rajasthan (40%), Madhya Pradesh and Uttar Pradesh (48%-49%) reported higher yield at the demonstration level as compare to the yield at farmer's plot, those can be filled to achieve higher production of sesame seed. None of the minor producing states of sesame seed were able to achieve the yield up-to 8 quintals per hectare except Andhra Pradesh (9.5 quintal per hectare) and Telengana (8.7 quintals per hectare).

Table 4. 10: Yield gaps during demonstration stage and at farmer's plot – Sesame seed

	State	Yield gap (%)	B:C ratio (Farmer's plot)	B:C ratio (Demonstration)	Yield (Farmer's plot) (q/ha)	Yield (Demonstration) (q/ha)
Major	Uttar Pradesh	49.08	2.40	2.66	3.46	5.16
	Madhya Pradesh	48.44	2.29	3.15	1.92	2.85
	Rajasthan	40.09	2.34	2.80	4.37	6.12
	West Bengal	30.11	1.60	1.95	8.97	11.68
	Gujarat	21.58	1.90	2.32	6.60	8.03
Minor	Andhra Pradesh	33.98	3.06	2.18	7.11	9.52
	Maharashtra	65.75	2.29	1.88	4.00	6.63
	Telangana	20.61	3.33	0.96	7.20	8.68
	Chhattisgarh	56.29	1.84	2.47	2.97	4.63
	Odisha	43.17	1.66	2.00	4.38	6.28
	Assam	24.24	1.55	67.27	4.65	5.77

Sunflower seed

Two of the major producing states of sunflower seed reported the demonstration and is from 12.5 quintal per hectare to 14.5 quintal per hectare in Odisha and Karnataka, respectively (Table 4.11). Both states reported the yield of just above 10 quintiles per hectare at the farmer's plot. Among the minor producing states of sunflower, Andhra Pradesh and Punjab performed better in terms of actual yield during the demonstration stage (above 19.2 quintiles per hectare) and at the farmer's plot (above 15.6 quintiles per hectare). In all these states the higher yield is reported during the demonstration stage end filling the yield gap occurred in range of 15% to 43% can boost the sunflower production in the country.

Table 4. 11: Yield gaps during demonstration stage and at farmer's plot - Sunflower

	State	Yield gap (%)	B:C ratio (Farmer's plot)	B:C ratio (Demonstration)	Yield (Farmer's plot) (q/ha)	Yield (Demonstration) (q/ha)
Major	Karnataka	43.80	2.01	2.66	10.10	14.53
	Odisha	21.90	1.71	1.97	10.22	12.46
Minor	Andhra Pradesh	30.42	1.72	1.84	15.61	20.35
	Bihar	27.35	2.36	2.73	12.60	16.05
	Punjab	15.20	1.54	1.84	16.68	19.22
	Tamil Nadu	39.96	1.81	2.05	9.75	13.64
	Jammu & Kashmir	25.87	2.27	2.66	5.96	7.50

Safflower seed

Maharashtra is the major producing state of sunflower seeds in India reported a gap of 35.6% in the yield performance and at the demonstration stage as compare to at the farmer's plot (Table 4.12). The yield is comparatively high in Telangana but the yield gap is similar at 34%. Andhra Pradesh reported the extreme surge in yield between the demonstration stage as compared to at the farmer's plot due to low base at just 2.2 quintiles per hectare. All the three states were able to achieve the highest yield during demonstration stage up-to 16 quintals per hectare.

Table 4. 12: Yield gaps during demonstration stage and at farmer's plot - Safflower

	State	Yield gap (%)	B:C ratio (Farmer's plot)	B:C ratio (Demonstration)	Yield (Farmer's plot) (q/ha)	Yield (Demonstration) (q/ha)
Major	Maharashtra	35.56	3.23	2.69	9.01	12.22
Minor	Telangana	33.72	3.22	2.59	11.92	15.94
	Andhra Pradesh	487.11	1.35	0.61	2.25	13.21

Linseed

3 out of 4 major producing states of linseed witnessed the yield gap of above 45% during the demonstration stage and at the farmer's plot (Table 4.13). This reflects, there is a huge scope to increase the yield through better farming practices in these states. The highest reported yield is only at 10 quintiles per hectare during the demonstration stage in Madhya Pradesh. Bihar perform better among the minor producing states.

Table 4. 13: Yield gaps during demonstration stage and at farmer's plot - Linseed

	State	Yield gap (%)	B:C ratio (Farmer's plot)	B:C ratio (Demonstration)	Yield (Farmer's plot) (q/ha)	Yield (Demonstration) (q/ha)
Major	Madhya Pradesh	51.32	2.15	3.00	6.67	10.09
	Jharkhand	45.14	1.33	1.74	4.80	6.97
	Uttar Pradesh	27.57	2.85	3.42	6.52	8.32
	Chhattisgarh	52.11	1.73	2.45	4.71	7.16
Minor	Bihar	28.25	1.60	2.00	7.28	9.33
	Assam	43.10	2.05	2.45	5.27	7.54
	West Bengal	35.58	1.95	2.43	5.42	7.34
	Karnataka	63.70	1.59	2.00	1.84	3.02
	Tripura	60.99	1.54	1.89	3.23	5.20
	Manipur	39.17	1.97	2.50	5.01	6.98

Niger seed

The yield of Niger seed is just 5.5 quintiles per hectare at the demonstration stage and only up to 3.6 quintiles per hectare at the farmer's plot, considering all the major and minor producing states (Table 4.14). The yield gaps are very high ranging from 37.5% (in Chhattisgarh) to 64.3% (in Madhya Pradesh) reflects there is huge scope to increase the yield of Niger seed in all the producing states. The B:C ratio is above 1.8 times during demonstration stage and above 1.5 times during actual implication at farmer's plot in the states.

Table 4. 14: Yield gaps during demonstration stage and at farmer's plot - Niger seed

	State	Yield gap (%)	B:C ratio (Farmer's plot)	B:C ratio (Demonstration)	Yield (Farmer's plot) (q/ha)	Yield (Demonstration) (q/ha)
Major	Odisha	52.08	1.84	1.94	3.60	5.48
	Chhattisgarh	37.52	2.07	2.71	2.77	3.80
Minor	Madhya Pradesh	64.31	2.39	3.38	2.87	4.71
	Jharkhand	38.82	1.75	1.94	3.48	4.83
	Bihar	40.89	1.54	1.85	2.25	3.17

Yield gaps for major oilseeds from KVK stations – Variety-wise

The yield gaps of three major oilseed crops were analyzed considering the important varieties grown in the major producing states. This helps to understand the preference of any particular oilseed variety over others and the actual progress achieved as compared to the demonstrations at the farmer's plot. The district level responses from the KVK stations are aggregated to arrive at results at the state level.

Soyabean

In most of the soybean producing states, a limited number of varieties of soybean were reported by KVKs at the demonstration stage and further at the farmer's plot, except Maharashtra in which a large number of varieties was reported. Varying levels of yield gaps have been recorded by varieties. In Madhya Pradesh, the yield gaps, between the demonstration stage and actual farmer's plot, are varying from 33% to 75% for three of the reported varieties and the B:C ratio is better during demonstration stage (Table 4.15). Most of the KVKs had used 'JS 95-60' variety during the demonstration and at the farmer's plot. This variety is also used by many of the KVKs in Rajasthan. Similarly, in Maharashtra and gaps are varying from 11% to 67% across the varieties used. The 'M.A.U.S. -158' is the widely-used variety in Maharashtra. In most of the other states the gap in yield between the demonstration stage and at farmer's plot is varying from 13% to 42%. This suggests that for many varieties, better yield is reported at the demonstration stage but is not achieved during the actual plantation at the farmer's plot, which further impacted the B:C ratio at the farmer's plot.

Groundnut

In Gujarat, the yield gap at the farmers' plots compared to the demonstration stage is in range of 12% to 42% and the 'TG 37 A' and 'GG 20' are the widely-used varieties in Gujarat (Table 4.16). In the two major producing states of Rajasthan and Andhra Pradesh, the yield gap is in the range of 15% to 25% between the demonstration stage and at the farmer's plot. In

Karnataka, the yield gap is in the range of 26% to 51% and in Tamil Nadu this is from 18% to 82%.

Mustard

A large number of varieties of mustard are sown across major producing states – 19 varieties in Uttar Pradesh; 10 varieties in Rajasthan and 9 varieties in Madhya Pradesh are reported by various KVKs in the respective states. 'RH-749' variety is widely adopted by KVKs in Uttar Pradesh and Haryana, along with 'NRCDR-02' variety in Rajasthan. The range of yield gap between the demonstration stage and at the farmer's plot across varieties in these major states is varying between 13% to 33% in Rajasthan, 16% to 87% in Uttar Pradesh, 26% to 84% in Madhya Pradesh, 15% to 21% in Haryana and 14% to 65% in West Bengal (Table 4.17). These large gaps reflect that the actual yield at the farmer's plot is lagging to achieve the yield that is achieved during the demonstration level. Achieving the demonstration stage yield levels of various oilseed crops itself can boost the production of these oilseeds to meet the current edible oil demand.

Table 4. 15: Yield gaps during demonstration stage and at farmer's plot – variety-wise - Soybean

	State	Variety name	Yield gap (%)	Farmer's plot B:C ratio	Demonstration B:C ratio	No. of KVKs covered
Major	Madhya Pradesh	JS 97-52	75.4	2.3	2.9	2
		JS-9305	41.2	1.6	2.4	1
		JS 95-60	33.3	1.9	2.2	22
	Maharashtra	Pule Agrani (KDS-344)	67.3	2.7	2.7	1
		JS-9305	52.2	2.1	3.2	2
		MACS-1188	39.5	1.8	2.1	4
		JS-9560, Phule Agrani	33.7	1.1	1.3	1
		JS 95-60	26.5	1.4	1.6	3
		M.A.U.S.-158	26.5	1.9	2.1	8
		NRC- 37	25.8	1.9	2.1	1
		KDS-344	23.0	2.5	3.1	1
		JS- 335	20.9	1.3	1.5	1
		Phule Agrani	17.9	2.0	2.3	2
		MAUS-162	16.1	1.5	1.4	2
		JS-9560, MAUS-71	11.4	3.0	3.0	1
	Rajasthan	JS 95-60	29.0	1.8	2.1	8
		NRCDR-02	12.6	3.5	3.5	1
	Karnataka	JS- 335	35.4	2.6	2.8	1
		DSB-21	26.3	2.5	3.8	1
Minor	Gujarat	NRC- 37	27.8	2.3	2.8	2
		JS-335	19.6	2.2	2.5	2
	Chhattisgarh	JS 97-52	41.6	2.3	2.5	2
	Nagaland	JS-335	23.0	1.5	1.8	1
	Bihar	PS-1042	16.7	1.9	2.2	1

Table 4. 16: Yield gaps during demonstration stage and at farmer's plot – variety-wise - Mustard

	State	Variety name	Yield gap (%)	Farmer's plot B:C ratio	Demonstration B:C ratio	No. of KVKs covered
Major	Rajasthan	NRCHB - 101	32.9	2.5	2.8	4
		NRCDR-02	30.1	2.7	3.3	7
		Giriraj	26.5	2.5	2.7	1
		RH-406	25.7	4.3	4.8	2
		RH-406, DRMRIJ-13	23.8	2.5	2.9	1
		DRMRIJ-31	23.8	2.9	3.2	4
		PM-26	23.7	2.5	2.9	2
		RGN-229	21.3	2.5	2.7	3
		RH-749	18.3	2.6	2.9	3
		IJ 31	13.4	2.3	2.7	1
	Uttar Pradesh	DRMRIJ-31	87.2	3.1	4.0	1
		CS-56	63.6	3.2	4.0	1
		PM-26	56.8	2.2	3.1	1
		Vaibhav	53.5	2.8	3.7	1
		NDRE-4	53.5	2.0	2.4	1
		RGN - 73	51.9	2.3	3.2	4
		Varuna	50.0	2.3	3.2	1
		RH-749	46.6	2.8	3.4	12
		YSH-401	45.9	1.9	2.6	2
		PPS-1	45.7	1.2	1.5	1
		NDR 8501	41.2	2.2	2.5	1
		NRCHB - 101	28.7	1.6	1.9	1
		Urvashi	27.7	3.3	3.5	2
		Giriraj	25.1	2.5	3.0	2
		Pusa 28	25.0	2.3	3.0	1
		1990	23.1	4.8	5.5	1
		Pusa30	22.7	1.8	2.2	1
		NRCDR-02	18.7	2.5	2.8	1
		Pitambri & 2009	15.9	1.2	1.3	1
	Madhya Pradesh	Rohani	84.4	1.8	2.7	1
		Arpan	64.4	1.8	2.7	1
		Pusa Jay Kisan	63.9	2.1	2.8	2
		DRMR 2	53.3	2.6	3.8	1
		GIRRAJ (IJ31)	53.0	2.4	3.4	1
		RVM-2, RH-749	46.9	2.4	3.0	1
		NRCHB - 101	36.3	2.5	3.2	3
		NRCDR-02	28.3	3.0	3.7	2
		RVM-2	26.1	2.6	2.9	4
	Haryana	RH-749	21.1	2.0	2.3	5
		RB-50	16.3	2.6	2.5	1
		NRCDR-601	14.9	2.0	2.2	1
	West Bengal	PAN-70	64.7	1.7	2.4	1
		YSBNC-1	58.6	1.6	2.2	1
		B-9	36.8	2.1	2.5	3
		Pusa mustard-26	31.3	1.9	2.2	1
		Pusa Mahek	29.1	2.0	2.3	3
		NC - 1	26.3	2.0	2.5	1
		JD-6	13.8	1.5	1.7	1

Table 4. 17: Yield gaps during demonstration stage and at farmer's plot - variety-wise - Groundnut

	State	Variety name	Yield gap (%)	Farmer's plot B:C ratio	Demonstration B:C ratio	No. of KVKs covered
Major	Gujarat	GT-3	41.7	1.6	1.8	1
		TG- 37 A	38.4	1.9	2.1	5
		GG-20	25.0	2.0	2.5	9
		GJG-31	17.2	2.3	3.0	1
		GJG-9	14.4	2.5	3.0	2
		GG-2	12.1	1.5	1.8	2
	Rajasthan	HNG-10	21.6	2.8	3.3	1
		GG-20	19.1	2.5	2.9	1
		UG-5	18.9	2.2	2.5	1
		HNG-69	15.5	2.7	0.5	2
	Andhra Pradesh	TAG-24	24.6	2.0	1.7	2
		Dharini	23.9	3.1	3.1	5
		Kadri-6	23.5	1.8	2.0	4
	Karnataka	G2-52	51.2	3.1	3.9	2
		GPBD-4	46.0	2.9	3.1	4
		TMV-2	41.1	1.6	2.2	2
		K-9	37.7	1.8	2.4	2
		KCG-6	26.5	0.8	0.9	1
	Tamil Nadu	VRI-8	82.4	1.4	2.3	1
		GJG-9	50.0	1.6	2.5	1
		TG- 37 A	32.1	1.8	2.2	1
		GJG-31	30.7	2.4	2.8	1
		Co - 7	28.2	1.9	2.4	5
		K-9	22.6	2.2	2.6	3
		Co 6	19.3	1.8	2.1	1
		TMV-13	18.4	2.2	2.7	6

Factors affecting the oilseed crop yield

This section deals with the study of the factors impacting the oilseed crop yield in the country. The list of important factors is streamlined from the available set of factors which may influence the crop yield. For this purpose, the unit level Cost of Cultivation database is used. The dataset provides the farmer level data which is extracted for important oilseeds in major producing states. Finally, the panel data set is prepared using the crops, states, farmers and time into consideration. The time period of analysis includes 2000 to 2017, the latest available period. The final dataset for the analysis is considered in the log form.

Various inputs in the analysis include –labour costs (human labour – family, attached and casual labours; animal labour – hired and owned; and machine labour – hired and owned), seed cost, fertilizer cost (N, P, K and NPK combined), manure cost, insecticide cost, crop insurance cost, payment contractor cost, irrigation cost (machine irrigation – hired and owned), leased land rental cost, land revenue cost, imputed rent cost, depreciation and other miscellaneous costs. The oilseeds included in the analysis are soybean, groundnut, rapeseed & mustard, sesame, sunflower, safflower and niger seed. The states covered are Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal. These states are selected if the crop is grown in a particular state. The total number of observations is 62,904 and the frequency distribution is presented in Table 4.18. This suggests that the farm level data is concentrated in major oilseed crops – soybean, groundnut, rapeseed & mustard and sesame crop.

Table 4. 18: The frequency distribution (%) of the CoC farmers' dataset

Crops	Groundnut	Niger seed	Rp & m	Safflower	Sesamum	Soybean	Sunflower	Selected crops
Andhra Pradesh	14.7				1.7	0.4	20.8	3.9
Assam			11.9					4.4
Bihar			3.2					1.2
Chhattisgarh		2.4	0.0			0.7		0.2
Gujarat	41.6		6.1		30.9			14.0
Haryana			10.3					3.8
Karnataka	8.2		0.1	19.1	0.0	0.1	53.8	3.4
Madhya Pradesh	0.0	11.9	3.2		4.9	48.0		15.5
Maharashtra	11.4			80.9		40.8	25.4	15.2
Odisha	5.3	85.7	0.2		7.6			2.4
Punjab			1.3				0.1	0.5
Rajasthan	2.6		28.5		24.7	10.0		16.4
Tamil	15.9				8.4			4.1
Uttar Pradesh	0.3		21.3		5.3			8.4
West Bengal			13.7		16.5			6.7
Selected states	20.5	0.5	36.7	0.5	10.4	28.6	2.8	100.0

The final model specifications were reached exploring all the available input variables for model testing and the fixed effect model and the random effect model were run on the final set of variables. The final model specifications are tested by Hausman test to select between fixed effect and random effect model. The Hausman test selection criteria suggests that:

Null hypothesis: Random effect model is appropriate.

Alternative Hypothesis: Random effect model is not appropriate

The Decision rule: The P value of Chi-square test is statistically significant therefore the Null hypothesis is rejected that the Random effect model is appropriate and concluded that the Fixed effect model suits better for the Stochastic Frontier analysis (SFA). The test results reflect selection of fixed effect model based on significance of chi-square test statistics as suggested by the Hausman test.

The typical Stochastic Frontier Analysis (SFA) function given by Aigner et. al., (1977) is presented in the form of

$$ln(Output_{it}) = \ln f\ (Labour_{it}, Capital_{it}, T, \beta) + (v_{it} - u_{it})$$
$$u_{it} = f(z)$$

This is an extension of the classical production function with the possibility to deviate from the production frontier due to technical inefficiency. Kumbhakar (1990) modelled technical efficiency effects as a product of an exponential function of time involving two parameters as well as a time-invariant non-negative random variable. Battese and Coelli's (1992) also presented a modified model to measure the technical efficiency effect.

We considered the Stochastic Frontier Analysis (SFA) function given by Aigner et. al., (1977) in the form of

$$ln(Output_{it}) = \ln f\ (Labour\ cost_{it}, Fert.cost_{it}, Seed\ cost_{it}, irrig.cost_{it}\beta) + (v_{it} - u_{it})$$

$$u_{it} = f(z)$$

where the output (yield) is a function of labour cost, fertilizer cost, seed cost, irrigation cost and time trend, analysed in the stochastic frontier panel model considering the variables in the log form and model distribution as truncated normal and check for robustness. In specific, the labour cost is combined cost of all type of labours incurred by the particular household – i.e., manual labour (family, hired and casual labours), animal labour (hired and owned) and machine labour (hired and owned); fertilizer cost is combined cost of N, P, K and other fertilizers; irrigation cost is combined cost of machine irrigation (hired and owned) and the irrigation charges paid by the household.

The Stochastic Frontier Analysis (SFA) function in the basic form as given by Aigner et. al., (1977) is considered. The P-value of Chi-square test is statistically significant at 1% level. The result of the SFA analysis, are reported in Table 4.19, depicts that there exists a positive and statistically significant relationship between labour cost and yield per hectare implying that one percent increase in labour cost will increase the yield per hectare by 3.71%. Also, there is positive and significant association between seed cost and yield per hectare that is increasing seed cost by 1% will increase the yield per hectare by 0.78%. The elasticity of fertilizer cost with respect to yield per hectare is negative (-0.34%) and statistically insignificant. The coefficient of year is positive (+0.58) and statistically significant in the equation representing technical progress taking place over the time. The exogenous variable considered here is irrigation cost.

The coefficient of which is negative and statistically significant to technical inefficiency, that means the coefficient is contributing positive to technical efficiency (TE) achieved through irrigation to improve the yield.

Table 4. 19: The Stochastic Frontier Analysis (SFA)

True fixed-effects model (truncated-normal)		
Group variable: xt	Number of obs = 26162	Prob > chi2 = 0
Time variable: year	Number of groups = 3298	Wald chi2(4) = 509.78

Yield	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
Frontier						
Labour cost	0.037	0.006	5.970	0.000	0.025	0.049
Seed cost	0.008	0.004	1.870	0.061	0.000	0.016
Fertilizer cost	-0.003	0.004	-0.750	0.454	-0.012	0.005
year	0.006	0.001	9.700	0.000	0.005	0.007
Mu						
irrig_cost	-0.002	0.001	-3.180	0.001	-0.004	-0.001
_cons	-151.55	5.728	-26.46	0.000	-162.8	-140.3
Usigma						
_cons	4.123	0.033	123.93	0.000	4.058	4.188
Vsigma						
_cons	-3.566	0.063	-56.790	0.000	-3.689	-3.443
sigma_u	7.86	0.131	60.12	0.000	7.605	8.117
sigma_v	0.168	0.005	31.84	0.000	0.158	0.179
lambda	46.74	0.130	359.05	0.000	46.48	46.99

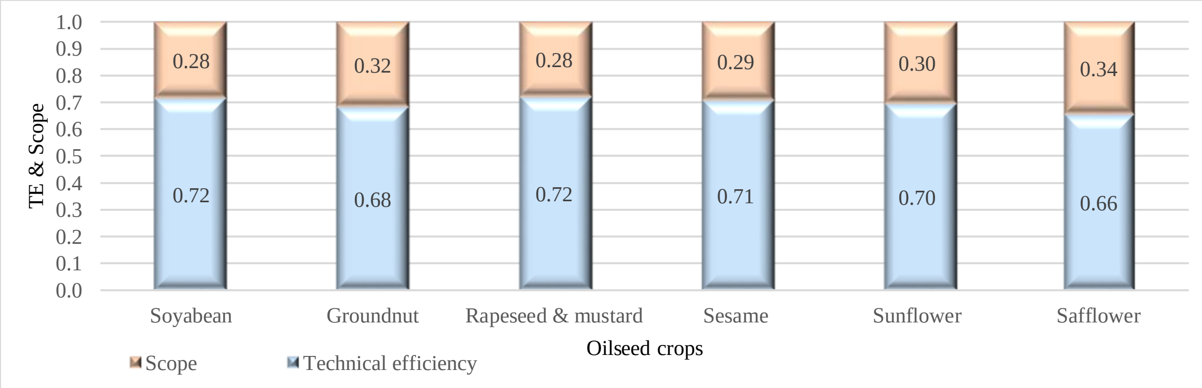
The presence of technical inefficiency is tested using the Likelihood Ratio (LR) test. The final Maximum Likelihood Estimates (MLEs) are run and the scores of the technical efficiency are generated.

Technical Efficiency based on the SFA model specifications

The presence of technical inefficiency is tested using the Likelihood Ratio (LR) test. The final Maximum Likelihood Estimates (MLEs) are run and the scores of the technical efficiency are generated. The technical efficiency scores were worked out based on the final SFA model specifications, for the mentioned set of oilseed crops and major producing states considering 18 years' time frame. On the overall basis, technical efficiency is worked out at 71%. This indicates, there is still 29% scope to enhance the output (yield per hectare) through technical efficiency to reach its full potential using different combinations of inputs (labour cost, seed cost and fertilizer cost). The technical efficiencies based on (i) crop-specific; (ii) states within crop specific and (iii) time-based are further worked out.

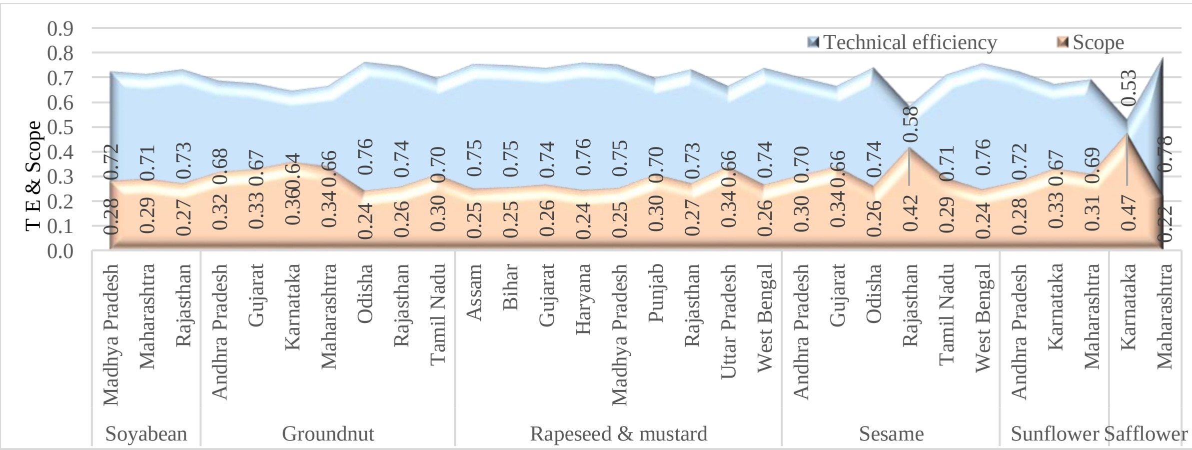
At the crop specific level, the highest technical efficiency score is observed for soybean and rapeseed & mustard crops (at 72%) (Figure 4.16). The lowest scores are recorded for safflower (66%), followed by groundnut crop (68%), indicating that up to 32% yield enhancement is achievable through better combinations of various inputs.

Figure 4. 16: Technical efficiencies (TE) scores and scope to enhance the efficiency - by crop



The state-specific analysis of technical efficiency scores replicates the crop level outcomes except in a few cases. The detailed analysis of the technical efficiency scores based on the crop and the state-specific observations is reported in Table 4.20 and Figure 4.17. The mean TE is observed to be high for states growing soybean and rapeseed & mustard (except Uttar Pradesh and Punjab). The other major producing states which recorded comparatively low TE scores are – Andhra Pradesh and Gujarat (for groundnut and sesame seed); Karnataka (for groundnut, sunflower and safflower); Maharashtra (for groundnut and sunflower) and Rajasthan (for sesame seed). There is 30% to 47% potential for enhancement in TE through better combinations of various inputs, especially in Rajasthan for sesame seed (47%) and Karnataka for safflower (42%).

Figure 4. 17: Technical efficiencies (TE) scores - by crop and state



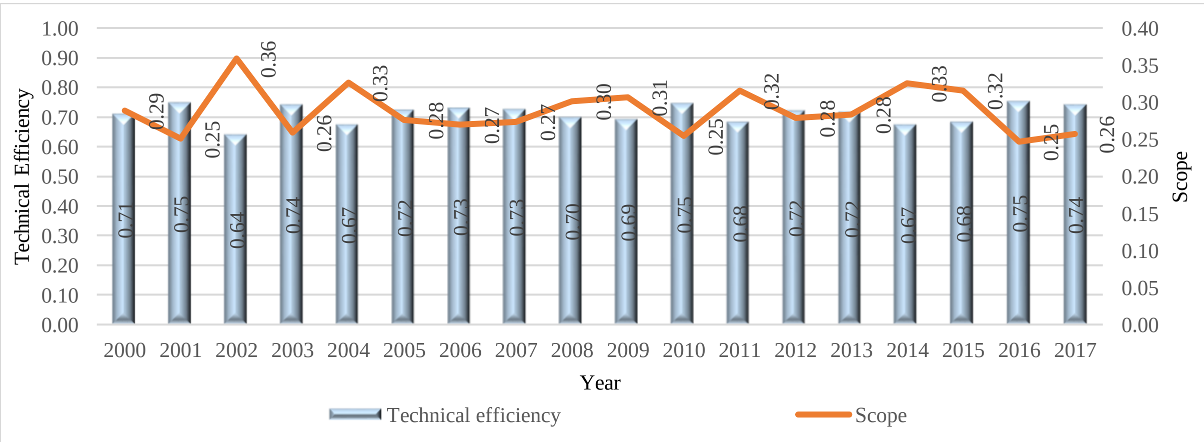
Some of the farmers recorded a very low TE of just 2-3%, possibly due to crop failure due to uncontrolled factors, which is a worrying sign. On the other hand, the maximum TE in some of the cases is close to 97% for farmers in many states growing rapeseed & mustard crop. The variation in mean TE is high in Rajasthan for sesame seed and in Karnataka for safflower.

Table 4. 20: Technical efficiencies (TE) scores - by crop and state

Crop	State	Obs	Mean TE	Std. Dev. TE	Min TE	Max TE
Soybean	Madhya Pradesh	134	0.721	0.197	0.195	0.904
	Maharashtra	487	0.712	0.208	0.020	0.921
	Rajasthan	44	0.731	0.185	0.174	0.904
Groundnut	Andhra Pradesh	723	0.684	0.214	0.090	0.951
	Gujarat	3085	0.673	0.221	0.031	0.963
	Karnataka	278	0.644	0.245	0.045	0.949
	Maharashtra	391	0.664	0.232	0.039	0.949
	Odisha	70	0.761	0.142	0.301	0.919
	Rajasthan	261	0.743	0.182	0.099	0.923
	Tamil Nadu	1273	0.697	0.190	0.096	0.964
Rapeseed & mustard	Assam	6	0.752	0.205	0.339	0.877
	Bihar	659	0.746	0.143	0.222	0.943
	Gujarat	1374	0.737	0.173	0.042	0.956
	Haryana	2282	0.759	0.141	0.108	0.964
	Madhya Pradesh	548	0.749	0.155	0.188	0.937
	Punjab	243	0.696	0.219	0.020	0.929
	Rajasthan	5576	0.730	0.171	0.030	0.968
	Uttar Pradesh	3993	0.664	0.222	0.038	0.957
	West Bengal	2800	0.736	0.155	0.109	0.964
Sesame	Andhra Pradesh	52	0.699	0.202	0.174	0.926
	Gujarat	586	0.663	0.241	0.037	0.953
	Odisha	8	0.740	0.131	0.564	0.919
	Rajasthan	2	0.584	0.415	0.290	0.877
	Tamil Nadu	322	0.709	0.183	0.084	0.949
	West Bengal	529	0.756	0.145	0.061	0.948
Sunflower	Andhra Pradesh	159	0.723	0.158	0.206	0.940
	Karnataka	165	0.672	0.247	0.072	0.933
	Maharashtra	108	0.692	0.206	0.135	0.932
Safflower	Karnataka	2	0.528	0.499	0.175	0.880
	Maharashtra	2	0.783	0.128	0.692	0.874

There is no clear trend in improvement, if any, of the TE over the years at the farm level, though it is close to maximum level in the past couple of years (Figure 4.18). Better insights can be achieved if TE trend is analysed at the crop and state levels. The mean TE is ranging from 64% (lowest in 2002) to 75% (highest in 2001, 2010 and 2016).

Figure 4. 18: Technical efficiencies (TE) scores – by year



Chapter 5: India's potential to produce oil from secondary sources

Production of oil palm fruit, production shifts and growth rates

The global palm fruit production in 2019 is reported at 410. 7 million tonnes which is higher than any of the field grown oilseed crop production. The total acreage allocated under palm fruit cultivation is 283 lakh hectares. The productivity of palm fruit is increased from 3.8 tonnes per hectare in 1961 to about 14.5 tonnes per hectare in 2019 (Figure 5.1). But the productivity witnessed a stagnation since year 2005 hence impacted the production in recent time. Indonesia is the largest producing country of palm fruits, about 60% of global production from about 52% of global acreage under palm cultivation. This is followed by Malaysia, contributes in another 24% of global production. Thailand, Nigeria and Colombia are other minor producing countries (Figure 5.2).

Figure 5. 1: Global production of oil palm

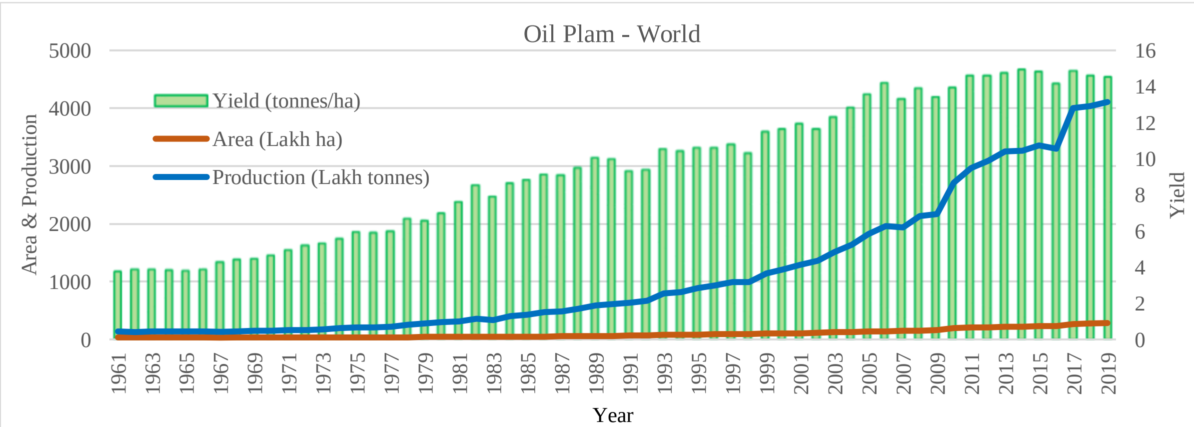
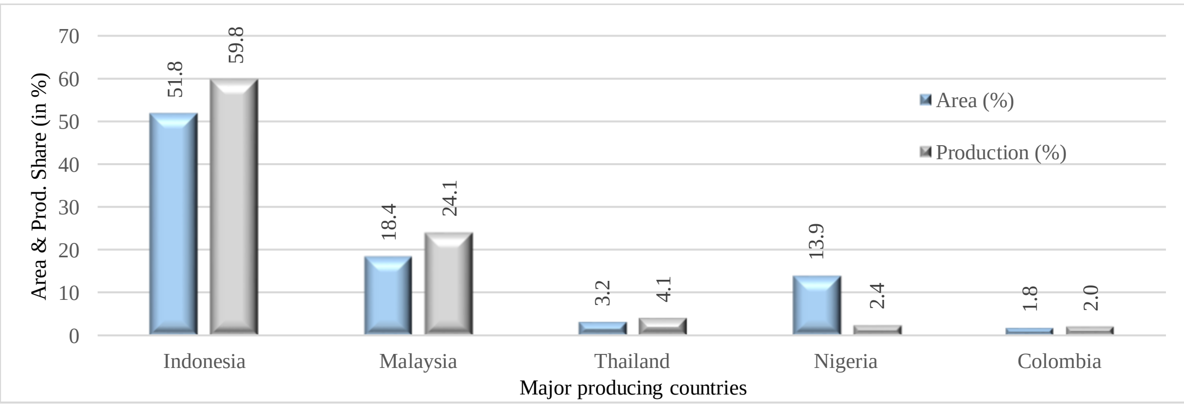


Figure 5. 2: Major growing countries of palm fruit - Area and production shares (%) in 2019

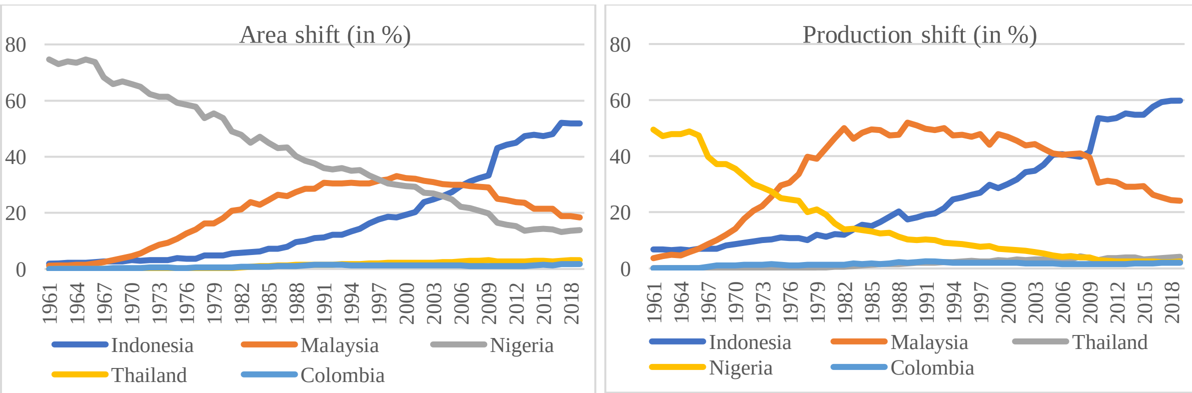


Overall, the growth in production of palm fruit is mainly driven by the increase in acreage in major producing countries during past six decades. Whereas, the yield of palm fruit is declined in all the major producing countries and the decline rate is sharpened during recent decades (Table 5.1). During the recent decade (2011- 2019), the yield witnessed least growth rate (actually declined by -0.1% rate). Infect, a stagnating trend in yield is witnessed since 1990 onwards on decadal growth basis. Increase in plantation and the time to reach at the maturity period may also have impacted global average yield. Over the time, the proportionate acreage and hence the production share among the major producing countries is shifted from Nigeria to Indonesia (Figure 5.3). The share during the transition phase from 1976 to 2006 was dominated by Malaysia.

Table 5. 1: Decadal growth rate in area, yield and production of palm fruit during 1961-2019

	Countries	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
Area	Colombia	38.9	5.6	13.3	3.0	3.0	11.6
	Indonesia	3.8	9.7	13.4	12.0	13.0	6.6
	Malaysia	15.0	16.9	8.8	5.8	3.6	0.4
	Nigeria	-2.8	1.0	1.9	2.4	-0.2	2.8
	Thailand	0.0	30.7	20.9	9.6	9.7	5.9
	World	-1.3	3.1	4.9	4.9	5.7	4.4
Yield	Colombia	-0.2	0.4	1.0	1.7	0.9	-2.6
	Indonesia	-0.3	-0.3	0.3	0.7	-0.6	-0.5
	Malaysia	2.3	1.0	-0.1	0.5	1.0	0.3
	Nigeria	0.0	0.0	1.1	0.0	-0.3	0.1
	Thailand	0.0	9.1	3.0	1.6	0.0	-0.8
	World	2.4	3.8	2.9	2.1	1.9	-0.1
Production	Colombia	38.6	6.1	14.4	4.8	4.0	8.7
	Indonesia	3.5	9.4	13.7	12.8	12.3	6.0
	Malaysia	17.6	18.0	8.7	6.2	4.6	0.7
	Nigeria	-2.8	1.0	3.0	2.4	-0.4	2.9
	Thailand	0.0	42.6	24.4	11.3	9.8	5.0
	World	1.1	7.0	7.9	7.1	7.7	4.3

Figure 5. 3: Oil palm fruit in top growing countries – area and production shift during 1961-2019



Yield of oil palm fruit and the oil extraction rates

The yield of palm fruits is reported highest in Malaysia, which is the second largest producing country, at about 19 tonnes per hectare as of 2019-20 (Figure 5.4). The largest producing country Indonesia and the other major producing countries like Colombia and Thailand also reported the yield of palm fruit above 16.6 tonnes per hectare. The yield of oil palm fruits in India is comparatively very low at just 4.36 tonnes per hectare which is only above the yield in the Nigeria. In Nigeria, the yield of palm fruits per hectare basis and the oil extraction rate are very low, much below as compared to other major producing countries. The oil extraction rates are witnessed highest in Malaysia and Colombia at the level of close to 20% (Figure 5.5). The extraction rate of oil palm from palm fruit in India is also reported close to that of in the countries like Indonesia and Thailand at close to 16-18%.

Figure 5. 4: Yield and yield gaps of palm fruits in major producing countries (Tonnes/Hact.) - 2019

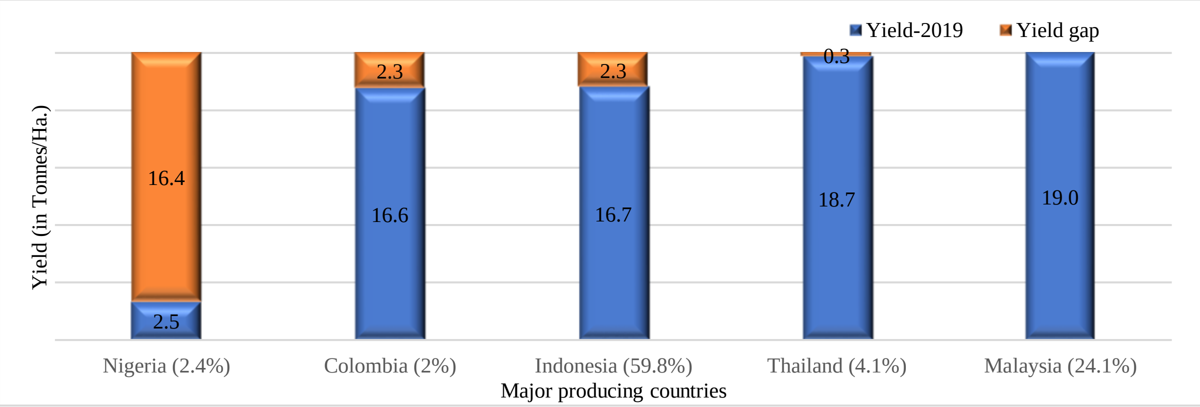
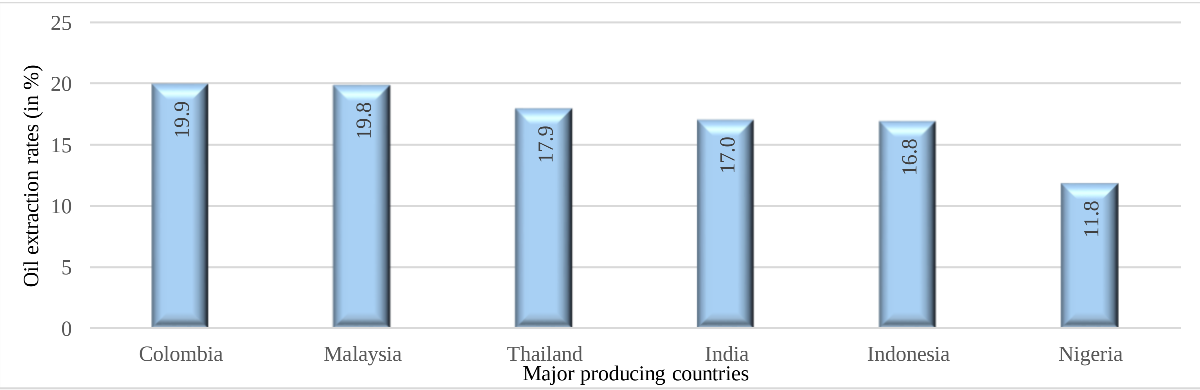


Figure 5. 5: Oil extraction rates of palm fruits (in %) in major producing countries and India



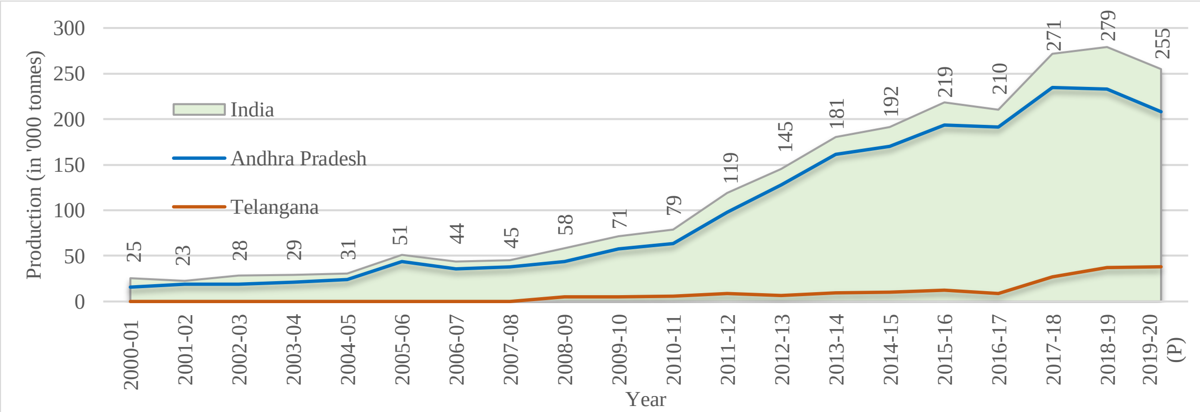
Source: FAOSTAT (major producing countries, 2019) and Ministry of Agriculture, GoI (for India, 2018-19)

Palm oil production in India

India produced nearly 279 thousand tonnes of crude palm oil in 2018-19. Andhra Pradesh is the largest producing state of the palm oil in India contributed nearly 83.5% production share in India (Figure 5.6). This is followed by Telangana (13.3%), Kerala (1.7%) and Karnataka (0.8%) as of 2018-19. The extraction rate of oil is recorded at nearly 19% in Telangana, followed by Goa (18%), Karnataka and Andhra Pradesh (nearly 17%, each) (Figure 5.7). India has a huge potential to produce the palm fruit across the states. The total cultivated area under palm trees in India in 2019-20 is about 3.55 lakh hectare, of which nearly 1.76 lakh hectare is in Andhra Pradesh, followed by Karnataka (0.46 lakh hectare), Tamil Nadu (0.32

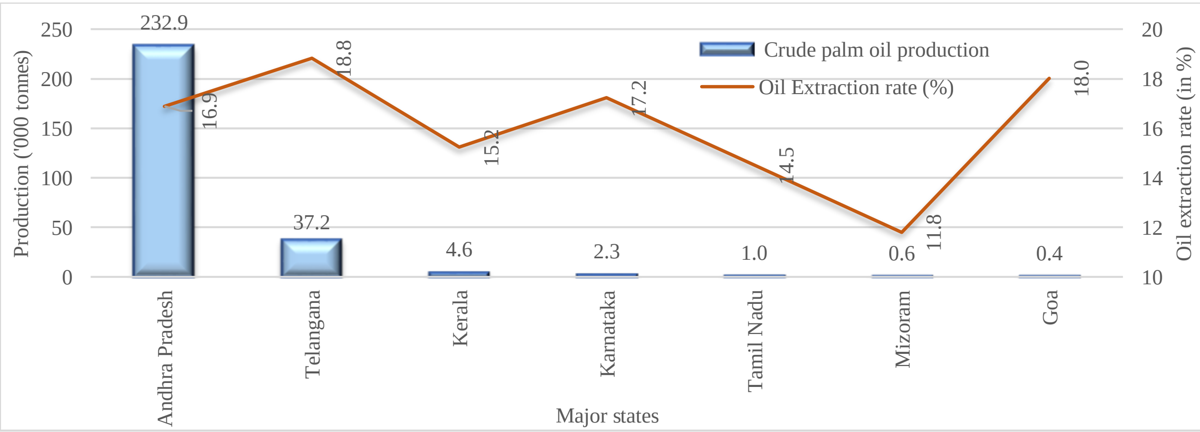
lakh hectare), Mizoram (0.27 lakh hectare), Odisha (0.23 lakh hectare) and Telangana (0.20 lakh hectare).

Figure 5. 6: Crude palm oil production in India and two of major producing states (in '000 Tonnes)



Source: Department of Agriculture, Cooperation & Farmers Welfare

Figure 5. 7: Crude palm oil production by producing states and the oil extraction rates: 2018-19



Source: Department of Agriculture, Cooperation & Farmers Welfare and author's computation

As per the assessment committee report in 2020 to assess the potential area under the palm oil trees, India can utilize nearly 28 lakh hectare acreage under palm trees plantation across the states. The new states emerged for the potential plantation of palm tree in India other than the above states are - Assam, Tripura, Maharashtra, Arunachal Pradesh, Madhya Pradesh, Bihar and Meghalaya having potential to increase area above 1.2 lakh hectare in each, along with a list of other minor states (Table 5.2). Since the plantation is in the initial stage in many of the state, the total production of fresh fruit bunches of palm is reported about 15.45 lakh tonnes as of 2019-20 majorly contributed by Andhra Pradesh (12.78 lakh tonnes) and Telangana (2.1 lakh tonnes). The production is expected to increase soon in other states as well. An attempt has been made to present two scenarios for potential for palm oil production in India based on the assumptions appears feasible at present time:

Scenario-1: the productivity of fresh fruit bunches of palm is same as reported for the states as in 2019-20 and the productivity is half (at 50% level) of the all-India productivity for the states for which the productivity is not reported as of 2019-20; and

Scenario-2: the productivity of fresh fruit bunches of palm is same as reported for the major states (Andhra Pradesh, Telangana, Kerala and Goa) as in 2019-20 and the productivity is half (at 50% level) of the all-India productivity for the states for which the productivity is not reported and also for the states with very less productivity (below 0.32 tonnes/hectare) as of 2019-20.

Under these two scenarios, the potential production of fresh fruit bunches of palm is worked out. The potential production of fresh fruit bunches of palm in India under scenario one and scenario too may increase up to 118.44 lakh tonnes and 126.27 lakh tonnes, respectively. Considering the oil extraction rates for different states reported the crude palm oil production as for the year 2018-19, and keeping this oil extraction rate fix at 11.8% for the un-reported states, the lowest among the states reported, the potential crude palm oil production is under scenario-1 and scenario-2 can be increased by nearly 592% and 629%, respectively. This means, under both the scenarios, once the country is able to utilize this potential area for palm production, the country may achieve the increased palm oil production by close to 6 times as compared to the present crude palm oil production in 2018-19.

This appears a reasonable better status as compared to the current production level as far as the supply side of palm oil production is considered. But is it enough to meet the current demand scenarios? An attempt is made to highlight the gaps and potential area to further increase, even above the potential area level.

The 'total availability/the demand' of fresh fruit bunches of palm for the year 2019-20 is calculated at 1500 lakh tonnes. This is considering the: i) import equivalent of fresh fruit bunches of palm, worked out at 1484.2 lakh tonnes by multiplying the import of palm oil (at 87.37 lakh tonnes in 2019-20) and the oil extraction rate of India (at 16.99%); and ii) the fresh fruit bunches of palm produced in India in 2019-20 at 15.45 lakh tonnes (Table 5.3). Again, three realistic scenarios are considered to increase the acreage under palm tree to meet this demand level:

Scenario-1: The productivity of fresh fruit bunches of palm is at 4.36 tonnes per hectare as in 2019-20 (the national average yield in India).

Scenario-2: The productivity of fresh fruit bunches of palm is at 7.61 tonnes per hectare as in 2019-20 (the weighted average of top two producing states – Andhra Pradesh and Telangana).

Scenario-3: The productivity of fresh fruit bunches of palm is at 8.71 tonnes per hectare (doubling the national average yield of India as in 2019-20).

To meet the demand level of nearly 1500 lakh tonnes of fresh fruit bunches of palm, the country needs to arrange nearly 344.26 lakh hectare of land under palm tree plantation (under scenario-1) (Table 5.4). This suggests, the country need to increase the current planted area under palm tree plantation as in 2019-20 by nearly 97 times. This is a huge target to achieve. Under scenario-2 and scenario-3, the land under palm tree plantation has to be increase to nearly 197.1 lakh hectare and 172.1 lakh hectare, respectively. Equivalently, the current acreage under palm tree plantation is to be increase by 55.6 times (Scenario-2) and by 48.5 times (scenario-3) as compared to the area under palm tree plantation as in March 2020. Again, this is nearly 7.04 times and 6.15 times higher, respectively, for Scenario-2 and Scenario-3, than the potential area assessments of the re-assessment committee-2020.

The dynamic import scenarios, changes in international prices of edible oils, impact of this on the domestic prices etc. factors impact edible oil production. To bring more acreage under the edible oil plantation, the long-term planned strategies are required. This is expected that the promotion of GM oilseed crops may increase oilseed production by nearly 15 to 20 %. Increasing the MSP for the edible oilseeds can bring more acreage under oilseeds cultivation and plantation. Additionally, the impact of linking the import duty to the MSP may further be explored. Many of such planes are already demanded by various stakeholders such as Solvent Extractors Association of India (SEA).

The details on the import of edible oils which is largely contributed by the palm oil in various importing form, is discussed in Chapter 6.

Table 5. 2: Palm oil production scenarios: For potential states and India

State	Potential area of re-assessment committee 2020 (in Hectare)	Total cultivated area up to March, 2020 (in Hectare)	Production of Oil palm fresh fruit bunches (2019-20, in Tonnes)	Productivity of palm fresh fruit bunches (2019-20, in Tonnes/Ha.)		Potential production of oil palm fresh fruit bunches (in Tonnes)		Crude palm oil production (2018-19, in Tonnes)	Oil extraction rate (OER)	Potential crude palm oil production (in Tonnes)	
				Scenario 1	Scenario 2	Scenario 1	Scenario 2			Scenario 1	Scenario 2
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Andhra Pradesh	531379	175839	1277760	7.27	7.27	3861343.8	3861343.8	232938	16.9	652149	652149
Karnataka	72642	46330	12685	0.27	*2.18*	19889.1	158224.1	2280	17.2	3426	27251
Tamil Nadu	95719	32409	3798	0.12	*2.18*	11217.3	208488.9	1017	14.5	1626	30230
Gujarat	62361	6049	745	0.12	*2.18*	7680.4	135830.7		*11.8*	906	16024
Odisha	34291	22667	7106	0.31	*2.18*	10750.1	74690.4		*11.8*	1268	8811
Goa	2000	970	1716	1.77	1.77	3538.1	3538.1	411	18.0	638	638
Tripura*	146364	530		*2.18*	*2.18*	318800.6	318800.6		*11.8*	37609	37609
Assam	375428	2196		*2.18*	*2.18*	817732.9	817732.9		*11.8*	96467	96467
Kerala	43676	5794	27201	4.69	4.69	205045.0	205045.0	4609	15.2	31222	31222
Maharashtra*	162210	1474		2.18	*2.18*	353315.3	353315.3		*11.8*	41680	41680
And & Nico*	3000	1593		2.18	*2.18*	6534.4	6534.4		*11.8*	771	771
Mizoram	66792	26642	4600	0.17	*2.18*	11532.3	145482.0	625	11.8	1360	17162
Chhattisgarh	57149	5383	279	0.05	*2.18*	2962.0	124478.2		*11.8*	349	14685
Telangana	436325	19522	208826	10.70	10.70	4667349.9	4667349.9	37205	18.8	878647	878647
Arunachal P.	133811	3126		*2.18*	*2.18*	291458.4	291458.4		*11.8*	34383	34383
Nagaland	51297	4072		*2.18*	*2.18*	111731.8	111731.8		*11.8*	13181	13181
Manipur	66652			*2.18*	*2.18*	145177.1	145177.1		*11.8*	17126	17126
West Bengal*	45463			*2.18*	*2.18*	99024.6	99024.6		*11.8*	11682	11682
Meghalaya*	122637			*2.18*	*2.18*	267120.0	267120.0		*11.8*	31512	31512
Bihar*	123148			*2.18*	*2.18*	268233.0	268233.0		*11.8*	31643	31643
Madhya Pradesh*	118079			*2.18*	*2.18*	257192.0	257192.0		*11.8*	30341	30341
Uttar Pradesh*	48663			*2.18*	*2.18*	105994.6	105994.6		*11.8*	12504	12504
All states	2799086	354596	1544716	4.36	4.36	11843622.7	12626785.8	279085	17.0	1930490.3	2035717.3
Remark	Total of potential area		Provisional figures for 2019-20	Productivity for 2019-21, considering 50% of 'All state' productivity for missing values in column 4)	Productivity for 2019-21, considering 50% of 'All state' productivity for missing values as well as for states with productivity less than 0.32 in column 5	Potential production as column 2 x column 5	Potential production as column 2 x column 6		OER fixed at 11.8 (lowest for reported states) for states with missing values in column 9	**592%**	**629%**

Source: Department of Agriculture, Cooperation & Farmers Welfare

*Note: * NFSM-OP is not being implemented, half of the productivity of all states in column 5 is 2.18, minimum extraction rate is of Mizoram (11.8) among reported states.*

Table 5. 3: Total availability/demand of Palm Fresh Fruit Bunches (2019-20)

S. No.	Variable	Quantity
1	Potential area of re-assessment Committee 2020 (in lakh hectare)	27.99
2	Cultivated Area (2019-20) (in lakh hectare)	3.55
3	Production of oil palm Fresh Fruit Bunches 2019-20 (in lakh tonnes)	15.45
4	Productivity - 2019-20 (Tonnes/Ha.)	4.36
5	Crude palm oil production - 2018 (in lakh tonnes)	2.7
6	Oil extraction rate - 2018-19 (in %)	16.99
7	Import of palm oil - 2019-20 (in lakh tonnes)	87.37
8	Import equivalent to Oil palm Fresh Fruit Bunches - 2019-20 (in lakh tonnes)	1484.2
9	Total availability/demand of Oil palm Fresh Fruit Bunches (2019-20, in lakh tonnes)	1499.7

Note: For S. No. 7 - source for import: DGCIS database; For S. No. 8 - considering the oil extraction rate for India (2018-19) = 16.99%; For S. No. 9 - adding S. No. 3 and S. No. 8'

Table 5. 4: Palm oil required area scenarios for India

Scenarios		Required area	Area to increase by, w.r.t.	
			Cultivated area	Potential area
Scenario-1	Considering average productivity of India of oil palm fresh fruit bunches (2019-20) = 4.36 Tonnes/Ha.	344.26	97.1 times	12.3 times
Scenario-2	Considering productivity of Andhra Pradesh and Telangana of oil palm fresh fruit bunches (2019-20) = 7.61 Tonnes/Ha.	197.08	55.6 times	7.04 times
Scenario-3	Considering doubling the average productivity of India of oil palm fresh fruit bunches (2019-20) = 8.71 Tonnes/Ha.	172.13	48.5 times	6.15 times

Note: Potential area as suggested by the re-assessment committee -2020; Required area in lakh hectare; Actual area is of year 2019-20.

Scope to produce oil from other secondary sources

Rice bran oil

Rice bran oil is the oil extracted from the hard outer brown layer of rice called chaff (rice husk). It is known for its high smoke point of 232 °C (450 °F) and mild flavour, making it suitable for high-temperature cooking methods such as stir frying and deep frying (*Wikipedia*). This oil is also popularly known as Wonder oil or heart healthy oil and extracted from the extremely nutritious bran layer which covers the Rice Grain after the paddy husk layer. Generally considered to be a light oil and is good for cholesterol management (*Fortune foods*). The rice bran oil is rich in vitamin E, antioxidants, and natural bioactive phytoceuticals such as oryzanol, tocopherols, tocotrienols, and lecithin. The global rice bran oil market reached a volume of 1.8 million Tons in 2020. India is the largest producing country of rice bran oil, accounting for the majority of the total global production. This can be accredited to the easy availability of raw material across the country (*Imarc group*).

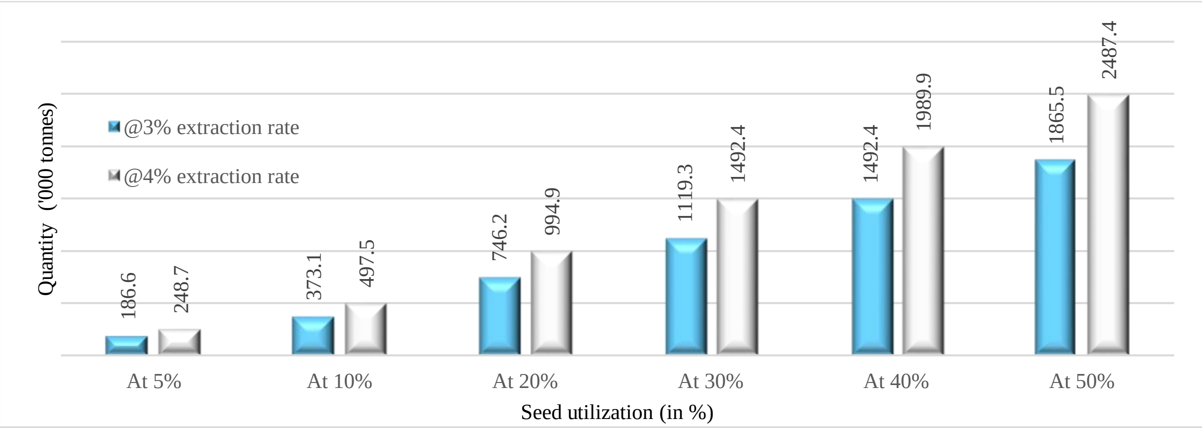
Rice bran oil is one of the fastest-growing categories among edible oils and their imports have been increasing over the past four years (2016-17 to 2019-20). In India, rice bran oil is also used for blending with mustard oil, which is one of the most expensive edible oils in the country. Imports of rice bran oil from Bangladesh have already hit 60,000 tonnes during the April to October 2021 period compared with 75,000 tonnes during 2019-20, so is expected to get double in 2020-21. The import of rice bran oil from Bangladesh is protected under the South Asian Free Trade Agreement (*Economic times – Nov. 2021*). India plan to push for more domestic rice bran oil production, from the current production of 11 lakh tonnes up to 18-19 lakh tonnes, in a bid to counter the inflation in edible oil prices across the country (*The print – Oct. 2021*).

The government has requested the states to assess the potential of rice bran oil production in the rice clusters and also enhance the capacity of rice mills so as to ensure that maximum rice bran oil is extracted. The major producing states have to advise the authorities concerned to promote setting up of rice bran oil plants in rice milling clusters, provide adequate financial incentives to rice mills for procuring required machinery for producing rice bran oil through industrial policies. For this, the states need to extract details on the number of rice mills and their milling capacity, total rice bran production, rice bran sent for cattle feed, rice bran sent for solvent extraction plant and number of mills required up gradation. States such as Telangana, Madhya Pradesh, Uttar Pradesh, and Punjab have already shown interest and agreed to set up rice bran oil solvent extraction plants. The FCI is to organise state level interactive workshops with the rice millers and field offices to assess their technological requirements. Rice bran is used in confectionery products such as bread, snacks, cookies and biscuits, also used as cattle feed, organic fertiliser (compost), medicinal purpose, and in wax making, soap and fatty acids manufacturing, also used in cosmetics, synthetic fibres, plasticisers, detergents, and emulsifiers. Rice bran oil production was 9.20 lakh tonnes in 2014-15, 9.90 lakh tonnes in 2015-16, and 10.31 lakh tonnes in 2016-17. The sale of fortified rice bran oil on commercial basis was launched by NAFED on June 15, 2021 through its multiple outlets in Delhi/NCR. An MoU was signed between NAFED and Food Corporation of India for the production and marketing of fortified rice kernel. Replace palm oil with rice bran oil to avoid importing the former at a huge cost (*The Hans India – Oct 2021).*

There are over 200 rice bran oil units as of 2018, including more than 100 in Punjab and Haryana. Currently, the total installed capacity of rice bran oil is around 1 million tonne per annum. About 30% of that is located in Punjab and Haryana. Rice bran oil is produced from rice chaff, an oily layer between the paddy husk and the rice grain. Its extraction involves a long chain where farmers sell paddy to rice millers. Millers sell the chaff to solvent extractors, who sell it to refiners. While farmers get nothing for the chaff, mill owners and extractors make huge profit from the by-product. The lessons from the past suggest, any price increase after government increased import duty on crude and refined edible oils, the benefits are only limited to organised extractors and millers and the same is not passed on to the farmers (*The tribute – Aug. 2018*).

The paddy harvesting time is also the peak season for processing of rice bran. In 2020-21, India produced nearly 124.37 million tonnes of paddy. Considering the basic conversion rate of about 12 to 13 kg (average 12.5 kg) of rice bran extraction from one quintal of paddy, and 3 kg of extraction of rice bran oil from 12.5 kg of rice bran or one quintal of paddy, an attempt is made to present a scenario for rice bran oil production in the country. The production data for the year 2020-21 from the Ministry of Agriculture database is utilised for the computation. An additional scenario considering 4 kg rice bran oil extraction from one quintal of paddy is also presented. This reflects that, by utilizing 5% of paddy (5 % of total paddy production in 2020-21 = 6.22 million tonnes) and considering 3% and 4% of the oil extraction rate, nearly 186.6 thousand tonnes of and 248.7 thousand tonnes of rice bran oil can be produced as the minimum capacity level, respectively. Over time, the rice bran oil production can be increased to 746.2 thousand tonnes or 994.9 thousand tonnes, respectively (by utilizing 20% of paddy with an extraction rate of 3% and 4%, respectively) and further to 1865.5 thousand tonnes or 2487.4 thousand tonnes (by utilizing 50% of paddy with an extraction rate of 3% and 4%, respectively) by the rice mills (Figure 5.8).

Figure 5. 8: Potential rice bran oil production ('000 Tonnes)



Source: Authors computation form MoA&FW database, reference year 2020-21.

Maize oil

In the past 4-5 years, India's maize oil production has almost doubled. Maize oil is consumed more in states of Gujarat and Maharashtra compared with other parts of the country. While cottonseed skin contains 7% oil, maize skin has about 12-14% oil. Maize skin, which is extracted directly from the expeller, considered useful for animals. The country's production of maize refined oil has increased to 8,000-10,000 tonnes per month from 5,000 tonnes a month four years ago (*The Economic Times – April 2021*).

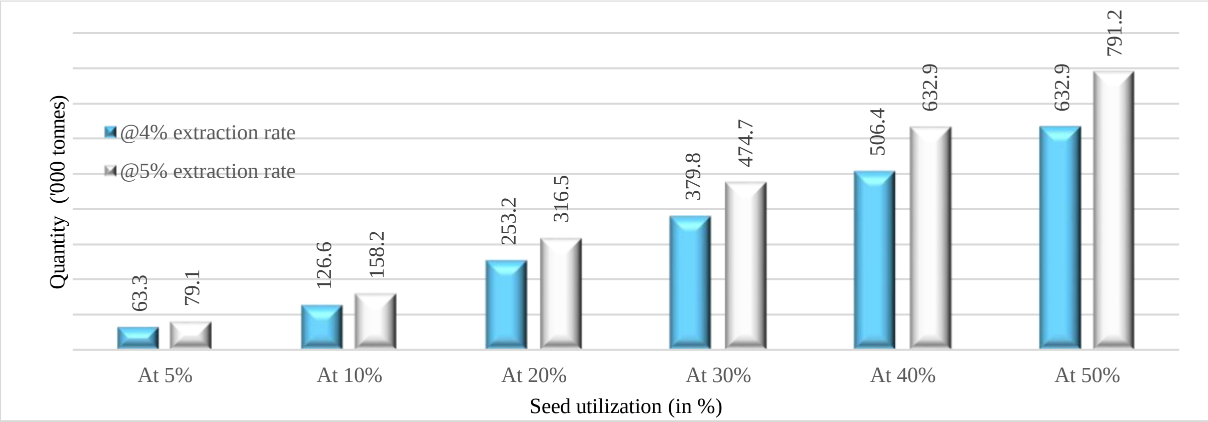
Industries consume 12-15% of corn production in India. Corn oil is a pale-yellow oil procured from the kernel of corn. Refined corn oil is tasteless and odourless oil. Corn having oil content of more than 6% is called high oil corn. Corn oil is a rich source of linoleic acid which is one of two essential acids necessary for the integrity of the skin, cell membranes and the immune system. Corn oil is used in margarine, soup, soap, paint, as rust preventative and many more products. In India, most of the corn is used for feed industry and starch extraction. Germ used to be a waste product obtained after starch extraction from seed. Currently, germ is in demand because of its high oil content and utilisation as by-product. The oil is typically extracted from the germ by a combination of mechanical expression and hexane extraction (*Ambika Rajendran et. al. – 2012*).

Sivala and Adhikary (2020) explained the wet milling of the corn and subsequent production of corn oil and refining process. The 'screw oil press' is mostly used for corn oil production compared to large scale 'solvent oil extraction method'. The use of corn oil in the production of bio-fuel and various other industrial products such as soaps, paints, textiles, pharmaceuticals, poultry feed and edible oil have further augmented the growth of the corn oil market.

Crude corn (maize) oil contains 95% triglycerides besides containing minor compounds like free fatty acids, waxes, phospholipids, pigments and odorous compounds. Before making the corn oil acceptable to the consumers these components are removed from the crude oil through a refining process. This process involves several steps. Majority of the corn-based starch factories are located in the states of Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Haryana and Punjab. Bihar and Uttar Pradesh lack such factories. High price of corn oil, limited public awareness, non- conventional food recipe nature are some factors limiting the popularization of corn oil in the country. On an average these factories can extract 3.0-3.5% oil from corn, which otherwise contain at least 5-6% oil. Thus, there is immense scope to increase the production of corn oil only by improving the efficiency of oil extraction from corn germs (*IASRI document*).

Considering the basic conversion rate of about 4% of maize oil extraction from one quintal of maize, an attempt is made to present a scenario for maize oil production in the country. An additional scenario considering 5% extraction rate is also presented. By utilizing 5% of maize (5 % of total maize production in 2020-21 = 1.58 million tonnes) and considering 4% and 5% of the oil extraction rate, nearly 63.3 thousand tonnes and 79.9 thousand tonnes of maize oil can be produced as the minimum capacity level, respectively. Over time, the maize oil production can be increased to 253.2 thousand tonnes or 316.5 thousand tonnes, respectively (by utilizing 20% of maize with an extraction rate of 4% and 5%, respectively); and further to 632.9 thousand tonnes or 791.2 thousand tonnes (by utilizing 50% of maize with an extraction rate of 4% and 5%, respectively (Figure 5.9).

Figure 5. 9: Potential maize oil production ('000 Tonnes)



Source: Authors computation form MoA&FW database, reference year 2020-21.

Cotton seed oil

The introduction of BT cotton in 2002 and a six-fold jump in cotton production within a few years boosted supply of oil and gave a further fillip to the market. More than 95% of the Cotton seed processed in India is extracted by the primitive method. Cotton Seed Oilcake has 6% oil content in general. Around 80% of the cottonseed production is crushed for production of oil and the remaining is used for feed. Cottonseed contains hull and kernel. The hull produces fibre and linters. The kernel contains oil, protein, carbohydrate and other constituents such as vitamins, minerals, lecithin, sterols etc. Cottonseed oil is extracted from cottonseed kernel. Refined and deodorised cottonseed oil is considered as one of the purest cooking medium available. An additional benefit that accrues from Cottonseed Oil is its high level of antioxidants – tocopherols (*CICR Technical Bulletin - 2003*).

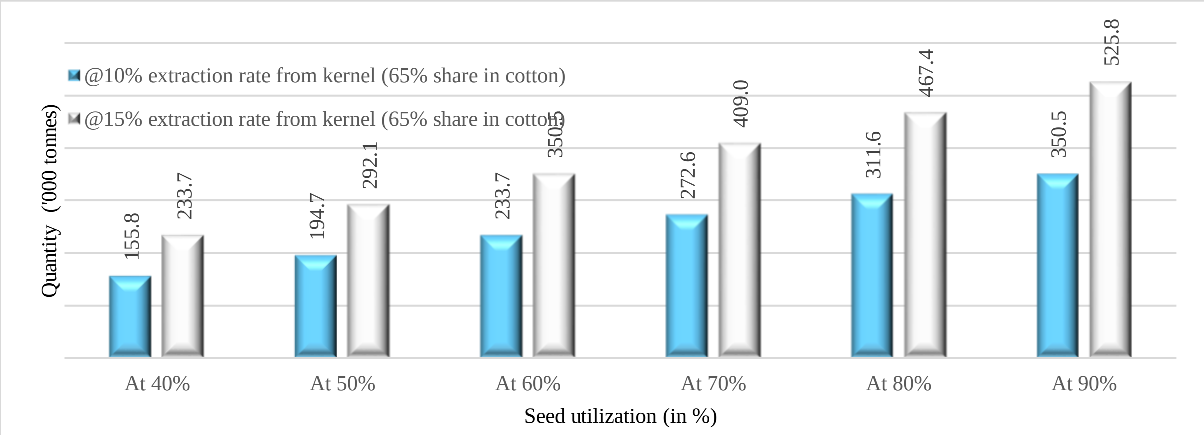
Global cottonseed production has ranged between 36 and 48 million tonnes in the last decade during 2008-09 to 2017-18. This value chain of cotton seed suggests that from about one tonne of cotton seed about 3.5 quintal of lint and about 6.5 quintals of fuzzy seed (kernel) are generally extracted. Of this fuzzy seed, further about 2.84 quintal of seed cake, 1.7 quintals of hull, 1.07 quintals of oil and about 0.5 quintals of linters. This reflects, about 16-18% oil extraction. India is leading the cotton seed oil market. India is the largest producing country of cotton seed oil (three-year average – 1.24 million tonnes during 2016-17 to 2018-19) and cotton meal (4.21 million tonnes during 2018-19), closely followed by China (*ICAC – June 2019*).

The highest cotton-seed oil consumption in 2018 is also reported in India (at 1.6 million tonnes) followed by China (at 1.4 million tonnes), Pakistan, together comprising 62% of global consumption, further followed by Brazil, Australia, Uzbekistan, Turkey, the U.S., Burkina Faso, and Myanmar, which together accounted for a further 25%. The countries with the highest cotton-seed oil consumption per capita in 2018 were Australia (10.84 kg per persons), followed by Uzbekistan (7.85 kg per persons). The U.S. (47 '000 tonnes) and Australia (42 '000 tonnes) are the key exporters of cotton-seed oil in 2018, resulting at approx. 28% and 25% of total exports, respectively (*Global news wire – Feb. 2020*). India produces about 1.2 million tonne cottonseed oil every year and nearly 60-65% production of it is done in Gujarat (*The financial express – Dec. – 2017*).

Similarly, as mentioned for paddy and maize oil extraction, at attempt is made to present scenarios for cotton oil production, considering the basic conversion rate of about 10% of cotton oil extraction from the kernel (which is about 65% of the whole cotton) production. An additional scenario considering 15% oil extraction from the kernel production of whole cotton is also presented. The Ministry of Agriculture estimates of oil extraction are ranging from 14% to 18%, but a conservative extraction rate of 10% is considered in this analysis. This reflects that, at the minimum level, by utilizing 40% of cotton kernel (40 % of total cotton kernel production (65% of whole cotton) in 2020-21 = 1.56 million tonnes) and considering 10% and 15% of the oil extraction rate, nearly 156 thousand tonnes and 234 thousand tonnes of cotton oil can be produced, respectively. Over time, this cotton oil production can be increased to 234 thousand tonnes or 350 thousand tonnes, respectively (by utilizing 600% of cotton kernel production with an extraction rate of 10% and 15%, respectively); and further to 312 thousand tonnes or 467 thousand tonnes (by utilizing 80% of cotton kernel production with an extraction rate of 10% and 15%, respectively (Figure 5.10).

The oil production scenarios from these various food and commercial crops as secondary and alternative sources to fulfil the edible oil demand in the country are just illustrations considering the general rate of oil extraction assumptions at present and also by considering minimum to moderate level, 5%, 20% and 50% (40%, 60% and 80%, for cotton, of the kernel constitute 65% of whole cotton), field crop utilization for oil extraction purpose. Considering the changing national and global production, demand and supply situations; and governments' policy stands, the more detailed analysis of these scenarios will lead to more realistic oil production estimates.

Figure 5. 10: Potential cotton oil production ('000 Tonnes)



Source: Authors computation form MoA&FW database, reference year 2020-21.

Chapter 6: Trade of edible oils and oilseed in India

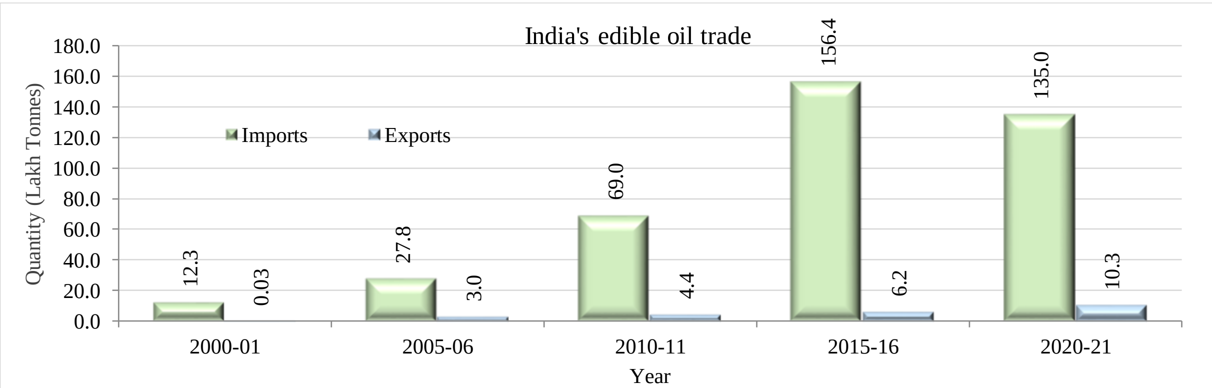
Overview of India's edible oil, oilseeds and oil cakes trade

At present, India is the net importer of the edible oils. India imports the edible oil in large quantity and at the same time also exports some of the oils, largely the castor oil to some of the countries which is not an edible oil. India is a net exporter of oilseeds and oil cakes. India changed from net importer status in the 1980s to a net exporter status during 1989-90, which again reversed later during 1997-98. India is the fifth largest producing country of oilseeds in 2019-20. India holds 5th rank in soybean production, 2nd rank in groundnut production, and 3rd rank in rapeseed and sesame production in the world. On the other hand, India is also one of the largest edible oil consuming countries in the world.

India's edible oil trade is about 145 lakh tonnes as of year 2020-21. This is including all the major edible oils traded under different sub-categories. India imported nearly 135 lakh tonnes of edible oil in 2020-21 (Figure 6.1). The import is ranging continuously above 140 lakh tonnes since 2015-16 for major edible oils except the year 2020-21. During the same period, the export of edible oil is restricted to 10.3 lakh tonnes but is witnessing an increasing trend over time.

The trade of edible oilseed is also growing overtime. Overall, India is a net exporter of edible oilseeds. In 2020-21, India imported nearly 6.3 lakh tonnes of edible oilseeds (Figure 6.2). and exported more than 11 lakh tonnes.

Figure 6. 1: Trend in India's import and export of edible oils



Note: the major edible oils considered in different forms are - Palm oil, Soybean oil, Sunflower and Safflower oil, Rapeseed and mustard oil, Copra oil, Groundnut oil, Olive oil, Cotton seed oil, Linseed oil, Sesame oil, Castor oil and Maize oil. Source: DGCIS database. This applies to all the tables and figures in this chapter.

Figure 6. 2: Trend in India's import and export of edible oilseeds

Note: the major edible oilseeds considered in different forms are - Soybean seed, Sesamum seed, Copra seed, Niger seed, Sunflower seed, Mustard seed, Linseed, Safflower seed, Groundnut seed, Castor seed, Rape or colza seed, Palm nut, Cotton seed and other oil seeds

From 2000-01 to 2020-21, the import of edible oil is about 95% and the export is just about 5% in the overall trade. On the other hand, India exports oil cakes to the world market in large quantities. The share of oil cake in combined export is about 70% (considering oil cakes, oilseeds and edible oil export, altogether). For the edible oilseeds, the export is about 19%. Though, oil cake export witnessed a decline after 2013-14, it still holds a large share. This shows that India is importing edible oils in large quantities but at the same time exporting edible oilseeds and oil cake in large quantities to the world market.

The share of edible oils imports in the import of 'edible oils plus oilseeds' is close to 99% in many years and more than 95% in 2020-21 (Figure 6.3). Similarly, the share of oil cake during 2005-06 and 2010-11 was close to 80% or above. It witnessed decline but is still close to 53% in 2020-21 (Figure 6.4).

Figure 6. 3: India's import of edible oil and oilseeds and share of edible oil in combined import

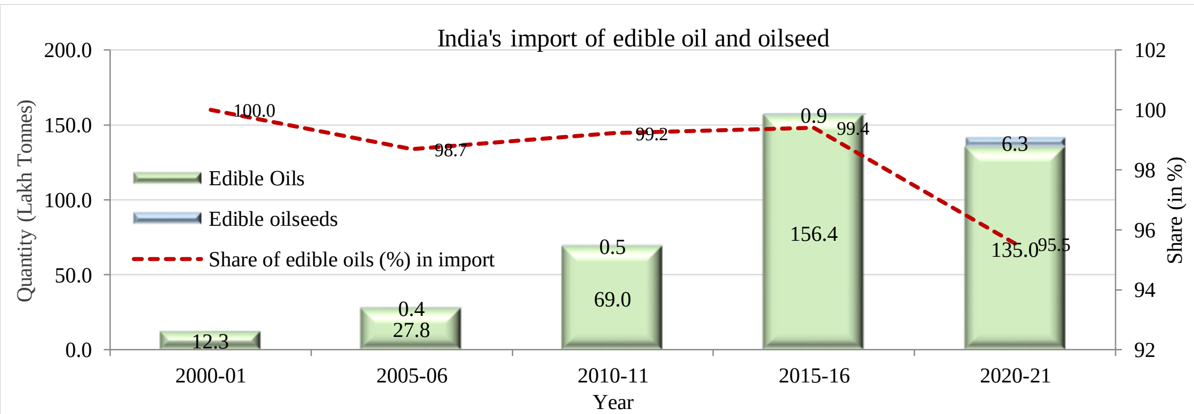
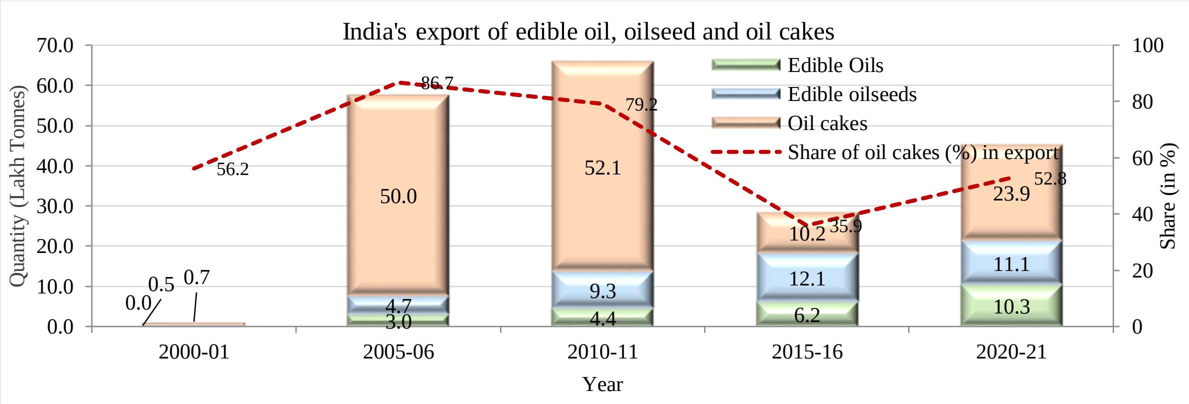


Figure 6. 4: India's export of edible oil, oilseeds and oil cakes and oil cakes share in combined export



Note: Important oils cakes considered are of Soybean seed, castor seed, Mustard seed, Groundnut, Cotton seed, Sunflower seed, Sesamum seed, Linseed, Copra seed, Niger seed, Palm nut and other oilseed cakes.

Import of edible oils

The major edible oils imported in the country are – palm oil, followed by soybean oil, sunflower & safflower oils; and rapeseed & mustard oils. Of India's total import of edible oils of nearly 135 lakh tonnes in 2020-21, nearly 56.4% is of palm oil. This is followed by soybean oil (27%); sunflower & safflower oil (16.2%) and rapeseed & mustard oil (0.3%). The details about the import of major edible oils in 2020-21 in quantity and value terms are reported in Table 6.1.

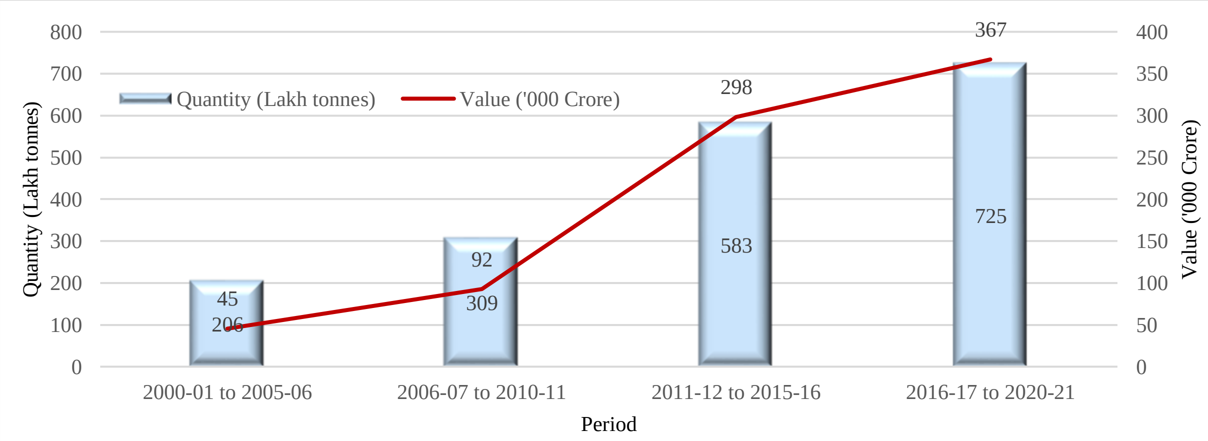
The import of edible oils has also been analysed to observe the period-wise trends in the import. One clear trend is that, the edible oil import of the country is continuously increasing. During the period of 2000-01 to 2005-06, the total import of edible oils was 206 lakh tonnes, which reached a level of 725 lakh tonnes during the period 2016-17 to 2020-21, nearly four times (Figure 6.5). The increase in in value terms is more than 7 times, increasing from 45 thousand crore to 3.67 lakh crores during the two comparison periods. This reflects a large fiscal burden for the country and the huge surge in import dependency still continues.

Table 6. 1: India's import of edible oils – 2020-21

Edible oil	Quantity (Lakh tonnes)	Value ('000 Crore)
Palm oil	76.11	43.39
Soybean oil	36.40	23.15
Sunflower and Safflower oil	21.84	14.67
Rapeseed and mustard oil	0.43	0.27
Other oil	0.20	0.37
All edible oils	134.97	81.84

Note: Palm oil includes - crude palm oil and its fractns, refined bleached deodrsed palm oil, refined blchd deodrsed palmolein, other refined palm oil, crude palm kernel oil, refnd palm kernel oil and its fractns and other refnd palm knl/babasu oils; Soybean oil includes - soya bean crude oil w/n degummed, soya bean oil of edible grade and soya bean oil other than edible grade; Sunflower and safflower oil includes - sunflower seed oil crude, safflower seed oil (kardi seed crude oil), sunflower oil edible grade, sunflwr oil non edible grade (excl crude oil) and othersunflwr and safflwr oil excld edible/non-edble grade; Rapeseed and mustard oil includes - crude rape oil, other crude low eruc acid rape colza oil, refnd rapeseed oil of edble grde, othr low eruc acid rape colza oil other thn crude, crude mustard oil, crude rape seed oil, refnd mustard oil edble grde, refnd *rapeseed oil edble grade and other rape colza mstrd oils excl crude nes; the other edible oil includes olive oil, linseed oil, cotton seed oil, sesame oil, copra oil, castor oil, maize oil and groundnut oil in different importing forms.*

Figure 6. 5: Trend of India's cumulative import of edible oil



Of the total import of edible oils during the five-year period from 2016-17 to 2020-21, the share of palm oil is close to 60% in quantity terms and about 55.5% in value terms (Table 6.2). Similarly, the share of soybean oil is 23.1% in quantity terms and about 25.1% in value terms. The share of sunflower and safflower oils is continuously increasing. While the import share of soybean was initially about 21%, it declined to 16-17% for two time periods and again rose to more than 23% during the recent period. Palm oil is witnessed a decline in import share due to increase in other edible oil imports.

Table 6. 2: Trend of India's cumulative import of important edible oils (in %)

	Edible oil	2000-01 to 2005-06	2006-07 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21
Quantity (%)	Palm oil	76.3	76.9	71.2	59.9
	Soybean oil	21.3	17.1	16.5	23.1
	Sunflower & Safflower oil	1.1	5.4	10.7	15.5
	Rapeseed &mustard oil	0.0	0.2	1.4	1.3
	Other edible oils	1.36	0.37	0.16	0.15
Value (%)	Palm oil	66.9	73.2	67.3	55.5
	Soybean oil	30.2	18.1	18.0	25.1
	Sunflower & Safflower oil	1.3	7.7	12.7	17.3
	Rapeseed &mustard oil	0.00	0.24	1.57	1.47
	Other edible oils	1.58	0.70	0.49	0.55

Note: other edible oils includes Olive oil, Linseed oil, Cotton seed oil, Sesame oil, Copra oil, Castor oil, Maize oil and Groundnut oil in different importing forms.

Edible oils import by type and importing countries

Palm oil is the largest imported edible oil in India. The major countries exporting palm oil to India are Indonesia, Malaysia, Singapore and Thailand (Figure 6.6, Table 6.3). Indonesia had nearly 56% share in total palm oil exports in 2020-21. Share of Malaysia is also growing over time.

The soybean oil is predominantly imported from Argentina in large quantity, except the most recent year 2020-21 (share 68.4%). Brazil is the second largest supplier with its share ranging from 10% to 21%. In the recent period, Switzerland, Nepal and Netherland also became the supplier countries, replacing Paraguay and U.A.E.

Ukraine holds nearly 80% and above share in the sunflower and safflower oil import to India. This was about 80% of total import in 2020-21. Russia holds nearly 12.7% share, followed by Argentina (6%) in 2020-21. Belgium (48.6%, share in 2020-21), Russia (40.3%), U.A.E. (9%) and Canada (1.1%) are the largest importers of rapeseed & mustard to India.

Figure 6. 6: Share of major importing countries in total oil import to India (quantity, in %) - 2020-21

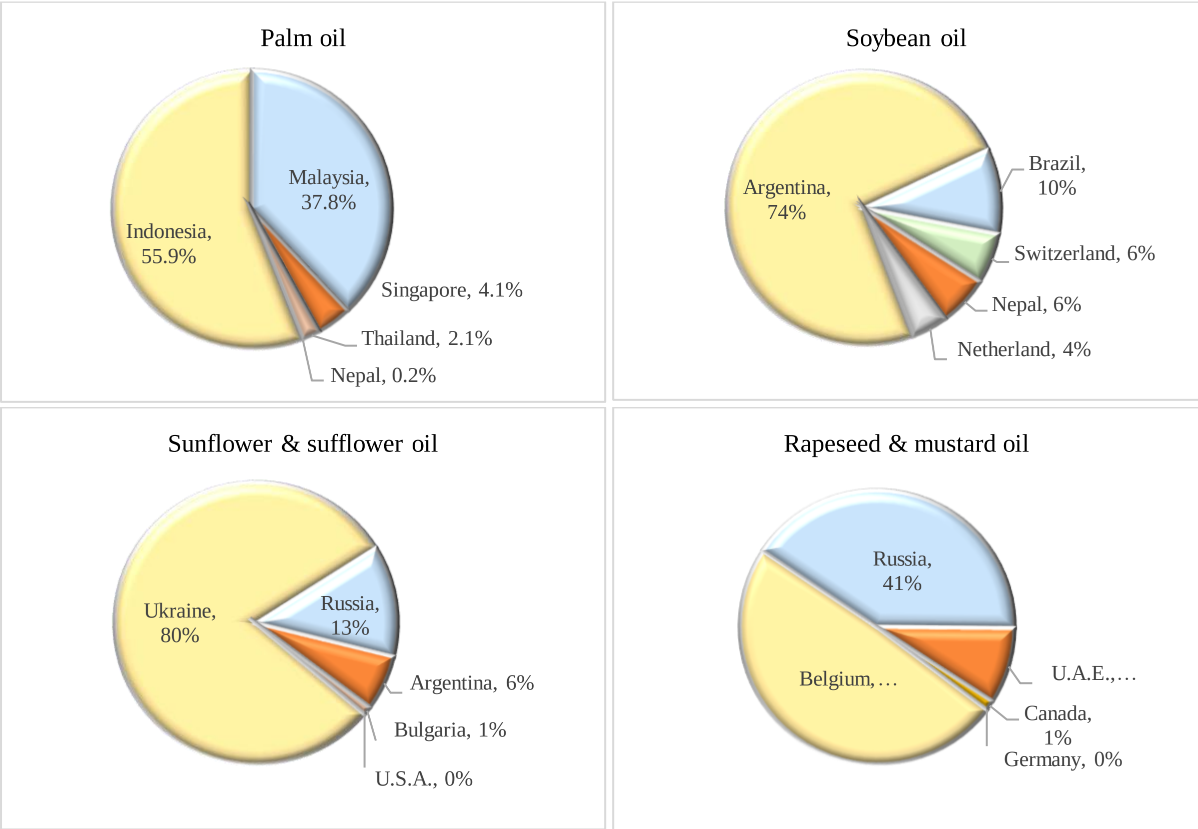


Table 6. 3: Country-wise import of major edible oils in quantity and value terms

Edible oil	Countries	Quantity (Lakh tonnes)				Value ('000 Crore)			
		2000-01 to 2005-06	2006-07 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21	2000-01 to 2005-06	2006-07 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21
Palm oil	Indonesia	105.4	194.4	273.6	274.7	20.5	55.0	132.8	128.3
	Malaysia	49.2	38.6	136.4	134.8	9.4	11.3	65.1	63.4
	Singapore	0.1	0.2	0.0	10.9	0.0	0.1	0.0	5.1
	Thailand	1.1	2.2	3.5	8.5	0.2	0.5	1.8	3.9
	Nepal	0.0	0.0	0.0	2.7	0.0	0.0	0.0	1.8
	World	157.4	237.5	415.2	434.1	30.4	67.6	200.5	203.7
Soybean oil	Argentina	41.9	39.8	73.4	123.9	9.5	12.5	40.8	67.3
	Brazil	14.1	8.3	17.6	22.9	3.2	2.5	9.8	12.1
	Switzerland	0.0	0.0	0.0	5.9	0.0	0.0	0.0	3.1
	Nepal	0.0	0.0	0.0	2.8	0.0	0.0	0.0	2.6
	Netherland	0.0	0.0	0.0	2.8	0.0	0.0	0.0	1.7
	U.S.A.	1.7	3.6	1.0	0.4	0.5	1.4	0.6	0.3
	World	60.1	52.9	96.5	167.6	13.7	16.7	53.7	92.2
Sunflower & Safflower oil	Ukraine	0.0	11.9	60.8	99.1	0.0	5.3	36.6	55.9
	Russia	0.0	1.1	0.2	7.2	0.0	0.4	0.1	4.1
	Argentina	2.1	3.1	0.9	5.9	0.6	1.2	0.7	3.2
	Bulgaria	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1
	U.S.A.	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0
	World	2.2	16.6	62.4	112.7	0.6	7.1	37.8	63.6
Rapeseed & mustard oil	Belgium	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1
	Russia	0.0	0.0	0.6	0.2	0.0	0.0	0.3	0.1
	U.A.E.	0.0	0.5	6.4	8.3	0.0	0.2	3.7	4.6
	France	0.0	0.0	0.4	0.0	0.0	0.0	0.2	0.0
	Ukraine	0.0	0.5	6.4	8.3	0.0	0.2	3.7	4.6
	World	0.0	0.0	0.4	0.0	0.0	0.0	0.2	0.0

These edible oils are imported in India in different forms, majorly are either in crude or in the refined form. The various sub categories of the edible oils imported in India along with the percentage share in total import are reported in Table 6.4. Most of the major edible oils (soybean oil, rape oil, sunflower seed oil and palm oil) are imported mainly in the crude form.

Table 6. 4: Importing categories (major) of majorly imported edible oils: Quantity share (in %)

Importing categories	2000-01	2005-06	2010-11	2015-16	2020-21	2000-01 to 2020-21 (Cumulative)
Soybean crude oil w/n degummed	100.0	0.4	100.0	100.0	94.0	98.3
Soybean oil of edible grade	n.a.	43.5	0.00	0.00	6.00	1.5
Soybean oil other than edible grade	n.a.	56.2	0.00	0.03	0.01	0.2
Soybean oil	100.0	100.0	100.0	100.0	100.0	100.0
Crude rape oil	n.a.	n.a.	n.a.	86.1	99.0	89.9
Refined rapeseed oil of edible grade	n.a.	1.1	39.8	6.4	1.0	1.5
Crude rape seed oil	n.a.	n.a.	0.1	7.4	n.a.	8.2
Refined mustard oil edible grade	n.a.	29.2	n.a.	n.a.	n.a.	0.0
Other rape colza mustard oils excl. crude nes	n.a.	69.7	55.7	0.1	0.0	0.1
rapeseed and mustard oil	n.a.	100.0	100.0	100.0	100.0	100.0
Sunflower seed oil crude	n.a.	95.7	99.4	99.5	99.6	99.1
Safflower seed oil (kardi seed crude oil)	n.a.	n.a.	0.63	0.46	0.00	0.6
Sunflower oil edible grade	n.a.	4.30	0.00	0.01	0.38	0.3
Sunflower and safflower oil	n.a.	100.0	100.0	100.0	100.0	100.0
Crude palm oil and its fractions	100.0	76.6	80.1	72.1	97.1	75.9
Refined blchd deodorised palmolein	n.a.	10.54	16.81	26.06	1.25	20.0
Other refined palm oil	n.a.	8.57	0.00	0.01	0.00	1.7
Crude palm kernel oil	n.a.	4.25	2.99	1.73	1.45	2.1
Palm oil	100.0	100.0	100.0	100.0	100.0	100.0

Import of oilseeds

Of the total oilseed imports, the largest share is of the soybean seeds, holding above 60% share in quantity terms on cumulative basis in past five years' period '2016-17 to 2020-21' (Table 6.5). During the same period, the share of sesame seeds was about 24%.the oilseeds categories as 'other category' contributed nearly 10% in total oilseed import. The share of these three major oilseeds imported (soybean seed, sesame seed, 'other' miscellaneous oilseeds) in value terms is nearly 45.7%, 41.4% and 6.6%, respectively, during the past five years' period '2016-17 to 2020-21'on cumulative basis.

There is a clear trend shift towards the import of soybean seeds in recent time. This is replacing the 'other' miscellaneous oilseeds, the share of this category remained above 50% in total import during past three comparison periods from 2000-01 onwards. Though the share in value term of 'other' oilseeds suggest they are usually get imported at a cheaper rate. The comparative importing rate for sesame seeds is costlier. Copra seed, mustard seed and 'other' minor oilseeds also holds up-to 3% share in quantity and value terms in total oilseed imported by India.

Table 6. 5: India's import of oilseeds – 2020-21

	Edible oilseeds	2000-01 to 2005-06	2006-07 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21
Quantity (%)	Soybean seed	0.0	0.1	6.6	60.6
	Sesame seed	9.6	11.4	39.1	24.3
	'Other' oil seeds	62.1	80.2	50.1	9.8
	Copra seed	6.6	0.0	0.1	2.2
	Mustard seed	9.9	2.7	0.4	0.1
	Other minor oilseeds	11.7	5.7	3.6	3.0
Value (%)	Soybean seed	0.0	0.1	4.5	45.7
	Sesame seed	15.2	22.4	67.1	41.4
	Other oil seeds	37.2	66.6	24.5	6.6
	Copra seed	4.8	0.0	0.2	3.0
	Mustard seed	10.7	3.4	0.4	0.1
	Other minor oilseeds	32.1	7.5	3.3	3.2

Oilseed import by type and importing countries

The major oilseed importing countries for three of the majorly imported oilseeds are discussed (Figure 6.7 & Table 6.6). Soybean is mainly imported to India through the African continent. The import of soybean seed is witnessed a sharp increase in recent time (2016-17 to 2020-21). In the west part, Benin and Togo, together contributes above two-third share (about 67%) to total import of soybean seeds to India in 2020-21. On the eastern part of Africa, Mozambique and Ethiopia are the major importing countries, along with the United Arab Emirates (U.A.E.), altogether holding nearly 24% import share as of 2020-21.

Sesame seed is also majorly imported from African continent as four out of five major importing countries – Sudan, Nigeria, Tanzania and Togo, together holds nearly 73% of total sesame seed imported to India in 2020-21. About 23% of total import of sesame seed in 2020-21 also arrived from Brazil. Though the total import of sesame seed during recent period (2016-17 to 2020-21) is close to that of soybean seeds in value terms, but the sesame seed import was at the peak during 2011-12 to 2015-16 period, as India imported nearly 582.5 lakh tonnes of sesame seed during this period, majorly from Sudan and Nigeria. The 'other' category of oilseed is also arriving in India mainly from the African countries – Ghana, Benin, Togo, Nigeria and Cote D Ivoire.

Figure 6. 7: Share of major importing countries in total oilseed import to India (quantity %): -2020-21

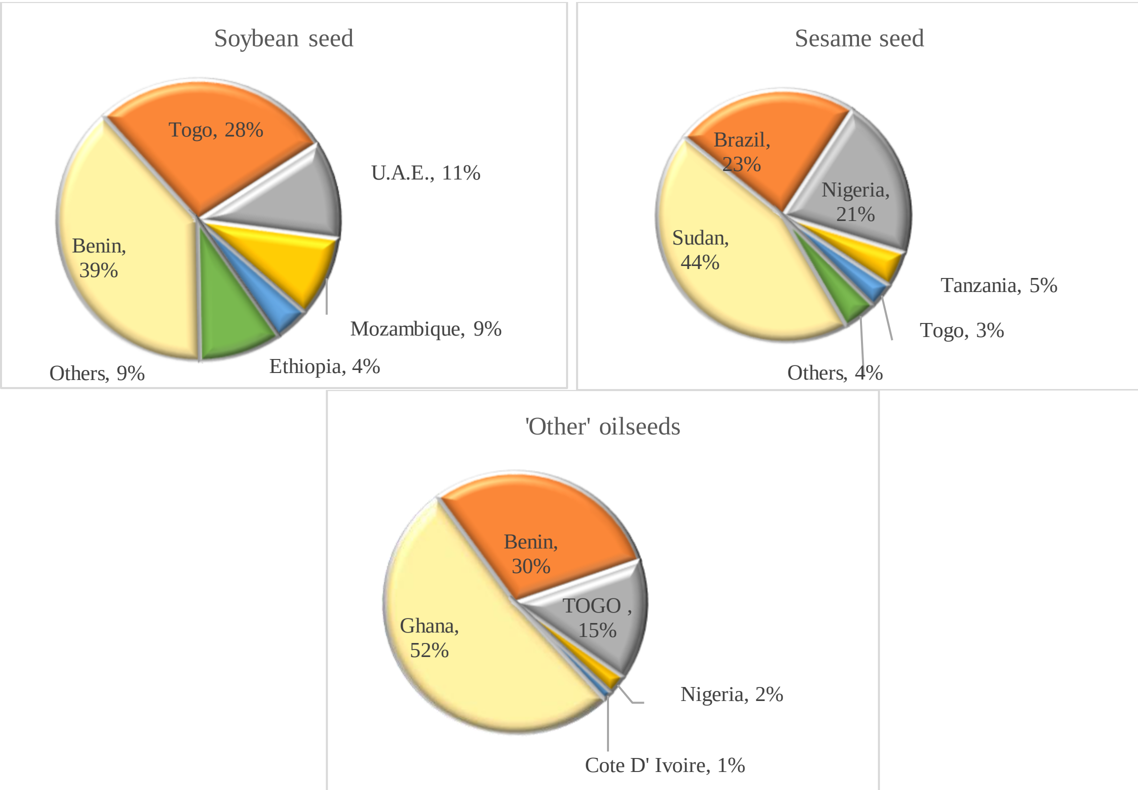


Table 6. 6: Country-wise import of major oilseeds in quantity and value terms

Edible oil	Countries	Quantity ('000 tonnes) 2000-01 to 2005-06	2006-07 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21	Value ('00 Crore) 2000-01 to 2005-06	2006-07 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21
Soybean seed	Benin				369.1				14.5
	Togo				222.6				8.9
	U.A.E.			0.4	61.3			0.0	2.6
	Mozambique			0.1	84.2			0.0	3.0
	Ethiopia			23.0	256.5			0.9	9.3
	World	0.0	0.2	28.7	1148.8	0.0	0.0	1.1	44.3
Sesame seed	Sudan	1.8	0.5	11527.3	239.4	0.1	0.0	114371.4	20.6
	Brazil			276.0	22.0			1689.6	1.7
	Nigeria		2.4	9451.7	86.4		0.1	76961.4	7.8
	Tanzania		1.4	890.9	6.0		0.1	10259.5	0.5
	Mozambique		0.0	282.3	4.0		0.0	3136.1	0.3
	World	6.8	32.7	58248.5	460.0	0.2	1.6	557824.3	40.2
Other oilseeds	Ghana	35.4	176.5	130.4	118.5	0.4	3.6	3.9	4.0
	Benin	0.6	16.0	32.4	25.4	0.0	0.3	0.9	0.9
	Togo	5.0	0.1		10.0	0.1	0.0		0.3
	Nigeria	1.0	5.2	8.5	10.7	0.0	0.1	0.2	0.3
	Cote.D Ivoire		3.4	3.2	8.4		0.1	0.1	0.3
	World	43.9	230.4	217.4	186.3	0.5	4.7	6.1	6.4

Export of edible oilseed products

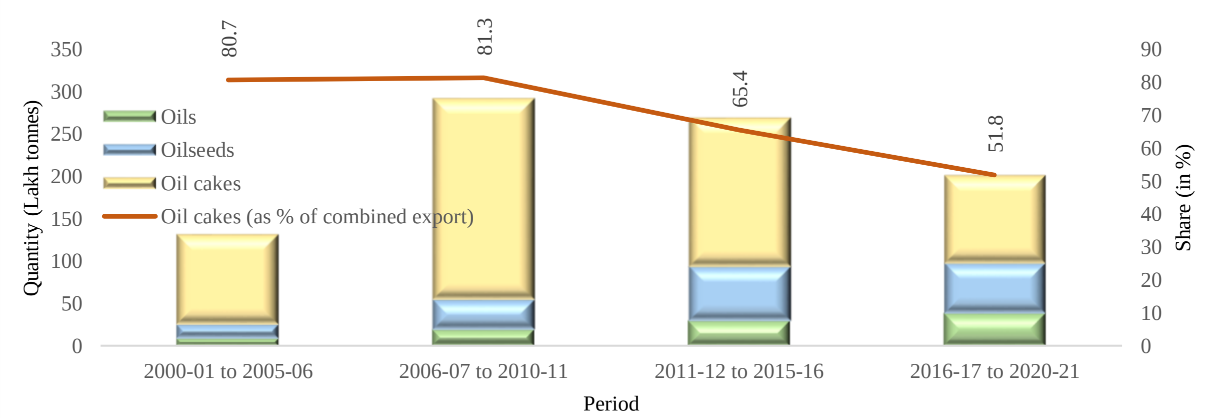
India is also exporting the oilseed products in different form such as - oils, oilseeds and oil cakes to other countries. In this combined total, the share of oil cakes in altogether export is highest. Although, the share is declined to nearly 52% during the 2016-17 to 2020-21 period on the cumulative basis but it was contributing 80% and above during 2000-01 to 2010-11 period (Figure 6.8). During this period, the share of oilseeds and edible oils in combined export was about 12-13% and 6-7% range, respectively, which is increased to recent period above 29% and 19%, respectively.

The value of edible oilseed products has increased from 18.29 thousand crores (during 2000-01 to 2005-06) to 110.5 thousand crores (during 2016-17 to 2020-21) over the time periods of five years' cumulative export (Table 6.7). The growth in oil export and oilseed export is exceeding the oil cake export, as during the comparison period the export of edible oils and oilseeds increased about 10 times in value terms.

Table 6. 7: India's export of edible oilseeds products - Quantity and value

	Product	2000-01 to 2005-06	2006-07 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21
Quantity ('000 Tonnes)	Oils	890.1	1940.0	2920.3	3773.7
	Oilseeds	1656.4	3512.7	6381.5	5904.0
	Oil cakes	10640.2	23691.5	17574.6	10399.7
	Overall	13186.6	29144.2	26876.4	20077.4
Value ('00 Crores)	Oils	36.0	107.4	246.7	376.9
	Oilseeds	45.9	161.8	453.7	452.8
	Oil cakes	101.0	351.8	431.3	275.4
	Overall	182.9	620.9	1131.7	1105.0

Figure 6. 8: India's export of edible oilseeds products (Quantity - Lakh Tonnes)



India majorly exporting castor oil, above 75% in total edible oil export during all 5 years periods since 2000-01 (Table 6.8, Figure 6.9), mainly to the China, Netherlands, France and U.S.A. Groundnut oil export also contributes above 11% share in recent period, majorly to China, Italy, U.S.A and Hong Kong. Limited export of copra oil, about 3% of total edible oil export, is mainly to the gulf countries.

Table 6. 8: Export of edible oilseed products by type – quantity and value (in %)

Product	Crop	Quantity				Value			
		2000-01 to 2005-06	2006-07 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21	2000-01 to 2005-06	2006-07 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21
Oils	Castor oil	77.4	90.6	93.7	86.0	74.2	89.9	91.5	81.1
	Groundnut oil	9.5	2.3	2.4	8.7	11.2	2.7	2.8	11.2
	Copra oil	3.2	1.5	1.2	1.8	3.9	1.8	2.2	2.8
	Other	9.9	5.7	2.7	3.6	10.8	5.6	3.5	4.9
	Overall	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Oilseeds	Groundnut seed	32.8	45.3	49.0	51.2	35.0	41.4	46.8	49.9
	Sesamum seed	33.6	38.8	25.9	25.6	47.1	48.7	37.1	36.1
	Soybean seed	15.3	2.7	10.5	13.5	6.6	1.3	6.5	7.1
	Other	18.3	13.2	14.6	9.7	11.3	8.7	9.6	6.9
	Overall	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Oil cakes	Soybean	90.1	91.4	82.9	70.3	94.3	96.1	94.2	88.5
	Castor	2.8	5.3	14.2	21.2	0.9	1.5	3.6	4.8
	Mustard	0.5	1.1	1.9	6.7	0.4	0.7	1.4	5.3
	Other	6.6	2.2	1.0	1.7	4.4	1.7	0.8	1.5
	Overall	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In the total oilseeds export, groundnut seeds and sesame seeds are the major two oilseeds exported by India, contributes nearly 35% to 50% share, varying over the periods (Table 6.8, Figure 6.10). The groundnut seeds are exported to east asian countries – Indonesia, Vietnam, Malaysia, Philippines and Thailand. Whereas, the sesame seeds are exported to Vietnam, Korea, U.S.A. China, Taiwan, Netherland, Germany, Greece and Turkey. Soybean seeds are exported to U.S.A., Canada and Belgium.

Oil cakes contributes largest share in combined oilseed product exported by India. Within the oil cake export, Soybean oil cake is the largest exported oil cake holds nearly 90% share in total oil cake export (Table 6.8, Figure 6.11). India export soybean iol cakes to Vietnam, Japan, Indonesia, Thailand, Iran, Korea, France, Bangladesh, France and Pakistan. In recent time, the cake is alo exported to U.S.A., Nepal, Canada, Germany and U.K. Oil cakes of castor seed and mustard seed are also exported by India, contributes about 5% share, each.

Figure 6. 9: Export of edible oils by type - Quantity ('000 Tonnes)

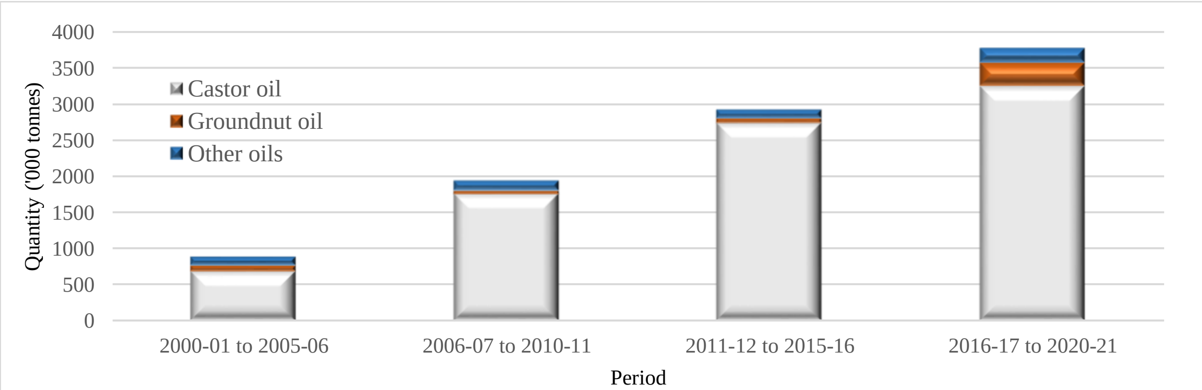


Figure 6. 10: Export of oilseeds by type - Quantity ('000 Tonnes)

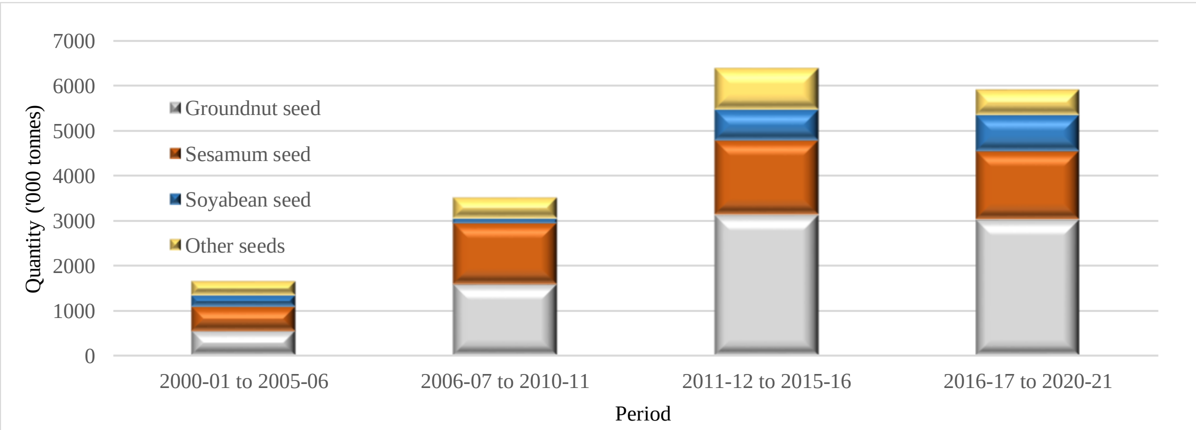
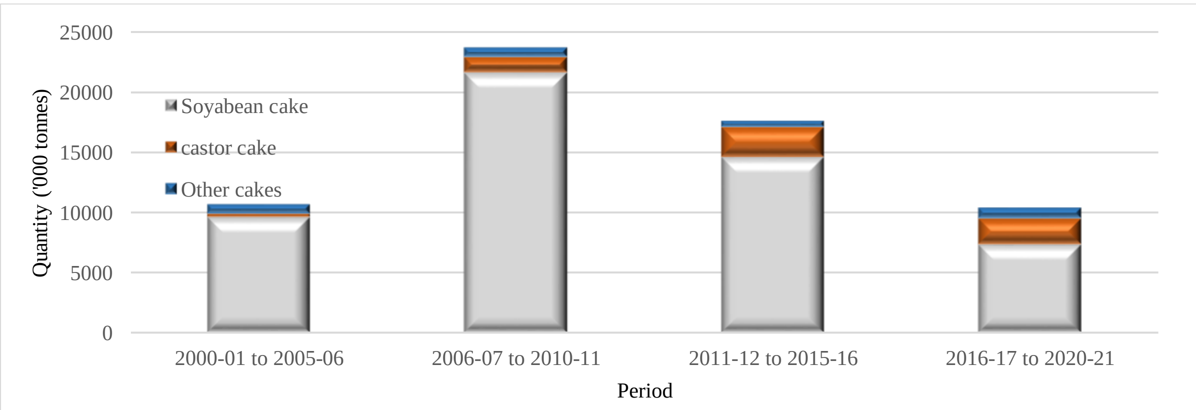


Figure 6. 11: Export of oilseed cakes by type - Quantity ('000 Tonnes)



Impact of trade policy on flow of edible oils imports

India is second only to China (34-35 million MT) in terms of consumption of edible oil. Palm oil (45%) is the largest consumed oil, mainly used by the food industry for frying namkeen, mithai, etc, followed by soybean oil (20%) and mustard oil (10%), with the rest accounted for by sunflower oil, cottonseed oil, groundnut oil etc.

Given the heavy dependency on imports, the Indian edible oil market is influenced by the international markets. The constant increase in consumption, low productivity of oilseeds and high price of traditional oils in India and low price in international market and liberalisation of trade policies resulted in the shift from self-sufficiency to highly import dependent in edible oils. Being a major importer of edible oil in the world, the domestic edible oil sector of India is highly responsive to the import policies. Therefore, government rationalizes trade policies by regulating import duties over the years to stimulate local oilseed production and curb edible oil imports. Starting from 1994 till date, India's trade policy can be broadly divided into five distinct phases which is recapitulated in Table 6.9 below:

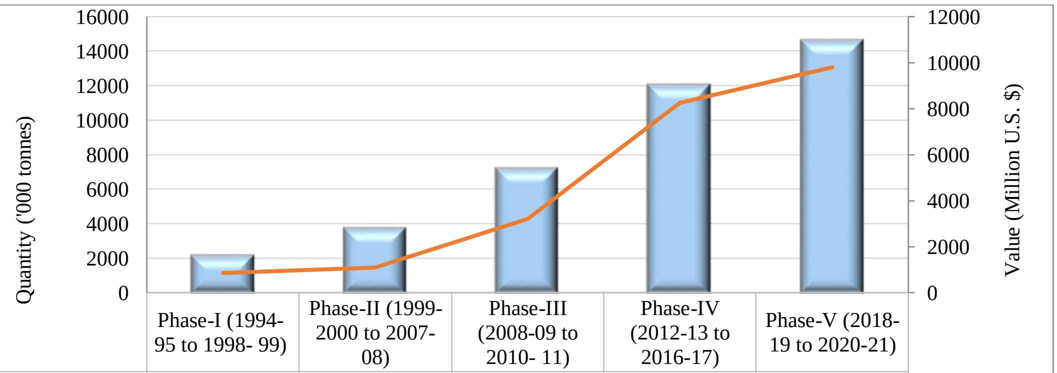
Table 6. 9: Evolution of India's Trade Policy

Phases of Trade Policy Regime	Key Characteristic of trade policy/ trigger that caused paradigm shift in policy	Average Imports	
		Quantity (Thousand MT)	Value (Million U.S. $)
Phase-I (1994-95 to 1998- 99) Liberalisation	During 1994-95, import of palmolein and subsequently, the import of other edible oils had been placed under Open General Licence (OGL) subject to 65% duty. Earlier, import of edible oils was partly canalised. Then Import duty gradually reduced to 25% in 1996-97 (Budget) and further to 15% in July 1998.	2141	850
Phase-II (1999-2000 to 2007-08) Reversal of liberalisation & high protection	After the East Asian financial crisis of 1997, palm oil prices dropped sharply. Farmers started uprooting oil palm plantations, necessitating a reversal in import duty structure in 1999. Import duties were revised upwards in 1999 and they went up to 92.2% for RPO in April 2001 and remained at that level till March 2003. Then, these varied in the range of 27.5% and 90% in the period from April 2003 to March 2008.	3720	1087
Phase-III (2008-09 to 2010- 11) Back to liberalisation	In 2008 (April), Import duties slashed due to high global prices, import duty on CPO & RPO reduced to zero & 7.5%, respectively, to meet rising domestic demand. Besides, export of major edible oils was banned from 17.3.2008 except for a small quantity in 5 kg packages.	7220	3215
Phase-IV (2012-13 to 2017-18)	From 2013 onwards, import duties on Crude palm, sunflower, soybean oil started increasing from 0 to 7.5% in 2014 and 30% in 2017 while duties on Refined palm, sunflower, soybean oil increased to 15% in 2014 and 40% in 2017.	12051	8246
Phase-V (2018- 19 to 2020-21)	By 2018, the Indian government increased the import duty on palm oil to 44% on crude and 54% on refined oil as there was a steep fall in the world prices and domestic prices of the oil. With effect from 06.04.2018, export of all edible oils except mustard oil was made free without quantitative ceiling. In 2020, import policy of Refined Palm Oil is amended from 'free' to 'Restricted' category. In Jan 2020, the import duty on Crude and Refined Palm Oil was revised to 37.5% and 45% respectively. The import duty on crude palm oil was further revised from 37.5% to 27.5% in Nov 2020.	14625	9797

Source: Department of Food & Public distribution, Government of India & Author's computation

In pre-1994 period, there were quantitative restrictions (QRs) on most of agri-imports, including edible oil imports. From April 1994, the country started opening up its agriculture sector when palm oil imports were placed under OGL. During this liberalisation period (phase-I), average quantity of imported edible oils increased to 5.8 times compared to average of preceding six years (1988-89 to 1993-94). During next phase-II, average quantity imported more than doubled compared to that during previous phase and it further increased during phase-III, IV and V. The impact of shifts in trade policy over the years is exhibited in Figure 6.12.

Figure 6. 12: Impact of Trade Policy on Imports of Edible Oils



	Phase-I (1994-95 to 1998- 99)	Phase-II (1999-2000 to 2007-08)	Phase-III (2008-09 to 2010- 11)	Phase-IV (2012-13 to 2016-17)	Phase-V (2018-19 to 2020-21)
Quantity ('000 MT)	2141	3720	7220	12051	14625
Value (Million U.S. $)	850	1087	3215	8246	9797

The recent conflict between the Russia and Ukraine impacting the edible oil supply and hence escalate the prices of the edible oils, especially that of sunflower oil, as both the nations are the two of the largest suppliers of crude sunflower oil to India. The supply of edible oil is also may get impacted due to the bad crops in Argentina and Brazil (*The Indian Express - Feb, 2022*). The prices of the domestic edible oil, which are already at a high may also get further surge due to palm oil exports ban by Indonesia, the world's largest producing country of palm oil (*The live mint – April 2022*). The reasons for high prices in near future due to high palm oil prices due to supply concerns from Indonesia, conflict in eastern Europe leaving India to scouring edible oils for alternative sources such as Argentina; and expected low production of soybean this year in South American nations such as Brazil and Argentina due to dry weather. India recently slashed the basic import duty on crude palm, soybean and sunflower oils (to 0% from 2.5%), reduced the agricultural infrastructure cess for crude palm oil (to 7.5%) and for crude soybean and sunflower oil (to 5% from 20%), and also cut the import duty on refined palmolein, soybean and sunflower oil (to 17.5% from 32.5%) (*The Business line – April 2022*). Food inflation is rising sharply, forcing India's central bank to raise interest rates to fight inflation (*Carnegie – April 2022*).

Chapter 7: Factors impacting oilseed yield: Evidence from field survey

This chapter is based on primary data collected through the field survey conducted in five of the major oil producing states in India. The analysis includes micro-level attempt to identify the constraints to increase oilseeds production. The analysis also covers the farmer's perception on the decision-making processes in acreage and input allocation towards oilseeds; listing of their problems in oilseed cultivation and important suggestions from the farmers. The sampling frame, sampling methodology and questionnaire is finalized with the multi-layer discussion with all the participating AERCs involved in the field data collection in the selected major oilseeds growing states. Based on the sampling frame and the sampling criteria adopted for the field survey, the study covered three major oilseed crops, namely soybean, groundnut and rapeseed & mustard. These crops cover nearly 91% of the nine-oilseed produced in the country as of 2019-20. Four states growing these oilseed crops, namely Madhya Pradesh and Maharashtra (for Soybean), Gujarat (for Groundnut) and Rajasthan (for Groundnut and rapeseed & mustard) are selected for field survey, as these covers nearly 75% of total oilseed production in the country in year 2019-20. The detailed approach followed for primary data is already mentioned in the methodology section in Chapter 1.

Broadly, for each oilseed crop, four strata of districts are formed based on the crop area and yield data for the year 2018-19 as (i) high yield-high area districts, (ii) low yield-high area districts, (iii) high yield-low area districts, and (iv) low yield-low area districts. The two of the strata, i.e., '(i) high yield-high area', and '(ii) low yield-high area' are considered for further analysis as the focus in on analyzing the oilseed crop productivity. Hence, for each of the selected state, two districts are chosen from the strata category (i) and (ii), i.e. one district from each category, based on the higher area share among all the districts occurring in the particular strata. Three villages from each of the district are selected randomly. Finally, from each village, a sample of 30 oilseed crop growing farmers is surveyed. Hence, from each of the state covered for any particular oilseed crop, a sample of 180 armers are surveyed, making an overall sample of 900 oilseeds producing farmers available for further analysis covering three of the major oilseed crops in five study states.

The sections on micro analysis of the oilseed production broadly include - the demographic profile of the farmer households, cropping details and acreage under oilseed crop, marketing of oilseeds; various input cost related factors influence the crop productivity are analysed such as - labour and machine used, operational cost variables; and the perception of the farmer households on the issues affects yield enhancement is also discussed.

Demographic profile of the households

The demographic factors such as the gender, age, education level, farming experience, caste, occupation etc. have an impact on the farmer's decision making. The distribution of the sample households based on these factors is categorised by major oilseed crops and producing states in Table 7.1. Across these major oil crop producing states, the farm households are headed majorly by a male adult (above 95%). Though in Maharashtra and Rajasthan, about 7% to 10% household heads are female. Close to 50% household heads are in the age group of "45 to 60 years", followed by the age group "25 to 44 years" (about 31%) and "age above 60 years" (above 18%). Most of the surveyed farmers are educated only up to primary level (41%), followed by secondary level farmers (24.4%), and intermediate level educated farmers (11%). Above 13% of the farmers are illiterate. Above 19% farmers in Madhya Pradesh are illiterate and above 54% have only passed primary level education. Most number of graduate farmers are reported in Rajasthan (rapeseed & mustard growers), followed by Maharashtra and Gujarat (about 7-8% in each).

Close to 82% of the households have above 10 years of farming experience. Only 4% households entered in farming recently within past 5 years. Most of the households are as joint family (about 71%), largely the groundnut growing households (above 95%). 27% households are unitary families, mostly the soybean and rapeseed & mustard growing households. The households are mainly Hindus (97%). Above two-third of the households (69.3%) are also involved in some kind of secondary occupation. Most of the rapeseed & mustard and groundnut growing farmers and about 44% of soybean growers reported this. Further details about the type of occupation of the households as the primary and secondary options are enquired. On the overall basis, 94% households are primarily cultivators, the rest 6% are primarily engaged in other occupations (mainly in dairying, and as salaried and casual labours) (Table 7.2). Of the households also engaged in secondary occupation, majorly are in dairying/fisheries/poultry (66.9%), as agricultural labour (18.4%) and cultivation (7.4%). About 21% of the households in Rajasthan and growing rapeseed & mustard are have cultivation as secondary occupation. Primarily, only 76% are engaged as cultivators.

Table 7. 1: Demographic profile of the sample household heads (% distribution)

Indicators		Soybean		Groundnut		Rapeseed & mustard	Overall sample response
		Madhya P	Maharashtra	Rajasthan	Gujarat	Rajasthan	
Gender	Male	96.7	90.0	92.2	98.3	98.9	95.2
	Female	3.3	10.0	7.2	1.7	1.1	4.7
Age groups	18-24	2.2	2.2	0.6	0.6	0.6	1.2
	25-44	36.7	28.3	42.8	31.7	15.0	30.9
	45-60	42.2	46.7	47.2	50.0	61.7	49.6
	60+	18.9	22.8	9.4	17.8	22.8	18.3
Education	Illiterate	19.4	15.0	11.1	15.0	6.1	13.3
	Primary	54.4	26.7	60.0	47.8	16.1	41.0
	Secondary	15.6	33.9	18.9	23.9	30.0	24.4
	Intermediate	6.1	12.2	4.4	5.6	28.9	11.4
	Technical	0.0	1.1	0.6	0.0	1.7	0.7
	Graduate	3.9	7.8	5.0	6.7	16.1	7.9
	Post Graduate	0.6	2.8	0.0	1.1	0.0	0.9
	Professional	0.0	0.6	0.0	0.0	0.0	0.1
Farming experience	Less than 5 Y	6.7	3.9	6.1	0.6	1.7	3.8
	5-10 Years	19.4	14.4	15.0	16.7	7.2	14.6
	More than 10 Y	73.9	81.7	78.9	82.8	91.1	81.7
Type of family	Joint	36.1	60.0	98.9	95.6	63.9	70.9
	Unitary	63.9	29.4	1.1	4.4	36.1	27.0
	Others	0.0	10.6	0.0	0.0	0.0	2.1
Religion/ Cast	Hindu	98.9	87.8	99.4	99.4	100.0	97.1
	Muslim	1.1	2.8	0.6	0.6	0.0	1.0
	Buddhist	0.0	9.4	0.0	0.0	0.0	1.9
Households- secondary occupation		44.4	43.3	100	58.9	100	69.3

Source: Author's computation from field survey data. This applies to all the tables and figures in this chapter.

Table 7. 2: Categorization of primary and secondary occupations of the households

Occupation	Soybean				Groundnut				r & m		Overall	
	Madhya P.		Maharashtra		Rajasthan		Gujarat		Rajasthan			
	Pri.	Sec.	Pri.	Sec.	Pri.	Sec.	Pri.	Sec.	Pri.	Sec.	Pri.	Sec.
Cultivator	100		96.7	2.6	97.8	2.2	99.4	0.9	76.1	21.7	94.0	7.4
Agriculture labour		65.0	0.6	26.9		8.3				15.0	0.1	18.4
Dairying/Fishing/Poultry		11.3		41.0	1.1	88.9		99.1	9.4	61.1	2.1	66.7
Salaried -government		5.0`	0.6	1.3	0.6		0.6		1.1		0.6	0.8
Salaried -private		2.5		2.6	0.6				4.4	0.6	1.0	0.8
Pensioner		1.3		2.6								0.5
Caste based profession		8.8		3.8					1.1		0.2	1.6
Trade & business (Shop)		3.8	0.6	3.8		0.6			1.1	1.7	0.3	1.6
Entrepreneur				1.3								0.2
Casual labour		1.3							4.4		0.9	0.2
Marginal work		1.3							1.7		0.3	0.2
Household work			0.6	5.1							0.1	0.6
Others			1.1	9.0					0.6		0.3	1.1
Overall	100	100	100	100	100	100	100	100	100	100	100	100

Cultivated area under oilseed crops

Of the overall area sown under oilseed crops by the sample households in the survey states, nearly two-third (66%) is under groundnut, largely contributed by Rajasthan (51% of the total oilseed cropped area (Table 7.3). This is because the average land holding on per household basis is recorded highest for groundnut growers in Rajasthan, at 13.3 acres per household (Table 7.4). This is close to 3 times as compared to other oilseed state covered. Nearly 94.2% of the cropped area under oilseed is owned by the farmers and rest is leased-in, highest in Rajasthan (under groundnut) at about 9%. The average land holding of the farmers growing soybean and rapeseed & mustard is about 3.5 to 4.6 acres per households and these farmers mostly grow such crops on own land. In Maharashtra, only 32.1% cropped area under soybean is irrigated. In Rajasthan too, nearly 10% cropped area under groundnut is unirrigated. In rest of the cases (Madhya Pradesh, Gujarat and Rajasthan - rapeseed & mustard) above 99% crop land is irrigated.

Ground water is the major source of irrigation in three out of five cases – for groundnut growers (in Rajasthan and Gujarat) and for soybean farmers (in Madhya Pradesh), in both the covered districts in each of these states. On the overall basis, this source of irrigation covers nearly 89.9% acreage under covered oilseed crops (Figure 7.1). Rest about 10% of covered land under selected oilseed crops is irrigated through canals, for the farmers growing soybean (in Maharashtra) and rapeseed & mustard (in Rajasthan).

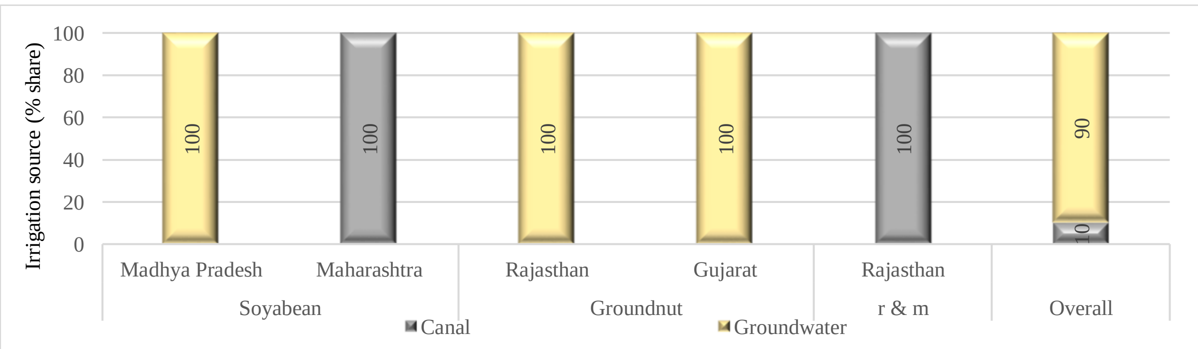
Table 7. 3: Percentage distribution of area under Cultivation (in acres): 2020-21

Crop	States	Area under Cultivation (in %)			Area irrigated (% of 'Area under crop')		
		Owned	Leased-In	Overall	Owned (in %)	Leased-In (in %)	Overall (in %)
Soybean	Madhya P.	98.6	1.4	100.0	98.9	100.0	99.0
	Maharashtra	99.6	0.6	100.0	32.2	0.0	32.1
Groundnut	Rajasthan	91.0	9.0	100.0	90.0	95.2	90.5
	Gujarat	94.1	5.9	100.0	99.9	100.0	99.9
R & M	Rajasthan	99.3	0.7	100.0	100.0	100.0	100.0
All crops	All States	94.2	5.8	100.0	87.7	95.2	88.2

Table 7. 4: Average land (in Acres per household)

Crop	States	Average land/household
Soybean	Madhya Pradesh	4.56
	Maharashtra	3.70
Groundnut	Rajasthan	13.29
	Gujarat	4.47
Rapeseed & mustard	Rajasthan	3.52

Figure 7. 1: Percentage distribution of source of Irrigation (in %)



The acreage allocated under different oilseed crops grown in survey states and districts is reported in Table 7.5. At the state level, the yield of soybean is ranging from 3 quintals per acre (Madhya Pradesh) to 7 quintal per acre (Maharashtra). The average yield is very low in Rajgarh district in Madhya Pradesh. The groundnut yield is high in Rajasthan, on an average about 11.7 quintals per acre whereas it is just above 6.3 quintals per acre in study districts in Gujarat. Bikaner district in Rajasthan reported the highest yield at 13.4 quintal per acre. The average land under groundnut by the farmers is very high in Bikaner district as compared to Jodhpur. The average yield of rapeseed & mustard is above 8 quintals per acre. Alwar reported higher yield than Tonk district. The large variation in crop yield is also reflected due to wide range of varieties used. The details on the acreage and yield extracted from different variety used by the survey households is reported in Table 7.6.

Table 7. 5: Area, production and yield of oilseed crops: 2020-21

Crop	State	District	Area	Production	Average yield	Average Area
Soyabean	Madhya Pradesh	Rajgarh	413.0	692.1	1.8	4.6
		Ujjain	408.1	1878.1	4.5	4.5
		Districts	821.1	2570.1	3.2	4.6
	Maharashtra	Latur	307.1	1950.1	6.5	3.4
		Nanded	358.0	2767.4	7.4	4.0
		Districts	665.2	4717.4	7.0	3.7
	States	All 4 districts	1486.2	7287.6	5.1	4.1
Groundnut	Gujarat	Banas kantha	404.8	2796.5	6.9	4.5
		Junagadh	399.7	2249.3	5.7	4.4
		Districts	804.5	5045.8	6.3	4.5
	Rajasthan	Bikaner	1668.2	22400.3	13.4	18.5
		Jodhpur	724.4	7222.0	10.0	8.0
		Districts	2392.6	29622.3	11.7	13.3
		All 4 districts	3197.1	34668.0	9.0	8.9
Rapeseed & Mustard	Rajasthan	Alwar	252.3	2682.3	10.4	2.8
		Tonk	381.2	2606.9	6.7	4.2
		Districts	633.4	5289.2	8.6	3.5

Note: Unit: Area -in acres, production - quintals, yield - quintals/acre.

Table 7. 6: Area, production and yield of oilseed crops – by state, land type and variety: 2020-21

Crop	States	Variety Name	Area	Prod.	Yield
Soybean	Madhya Pradesh	JS-1025	4.5	22.5	5.0
		JS-7322	17.1	75.1	4.4
		JS-9560	799.5	2472.5	3.1
	Maharashtra	9305 Eagle	200.3	1602.1	8.0
		JS 335	107.4	731.4	6.8
		335 Eagle	61.2	442.2	7.2
		Phule Sangam-9305	40.0	336.0	8.4
		Mahabeej-28	37.5	295.5	7.9
		162 Mahabeej	37.1	222.8	6.0
		335 Mahabeej	34.4	128.2	3.7
		228 Mahabeej	28.5	180.8	6.3
		93070 Eagle	16.0	119.0	7.4
		Krishna-9305	12.5	95.0	7.6
		771	11.8	77.8	6.6
		71 Mahabeej	10.3	66.6	6.5
		Other varieties	68.3	420.0	6.2
Groundnut	Rajasthan	G-12	15.4	200.0	13.0
		G-20	1130.8	14571.8	12.9
		G-10	1058.4	13483.5	12.7
		G-18	187.9	1367.0	7.3
	Gujarat	GG 37	395.9	2731.4	6.9
		GG 45	23.7	149.0	6.3
		BT 32	39.9	244.0	6.1
		GJG 39	1.2	6.7	5.7
		GG 20	267.9	1501.9	5.6
		GG 22	71.1	387.8	5.5
		Western No 66	4.7	25.0	5.3
Rapeseed & Mustard	Rajasthan	T-59	19.8	220.5	11.2
		Giriraj	154.7	1630.8	10.5
		Pioneer	193.6	1653.5	8.5
		Varuna	119.9	851.1	7.1
		Laxmi	64.2	436.5	6.8
		Local	81.2	496.8	6.1

Note: The other variety in Maharashtra includes - Mahico, TDS-726, D.S 228, Krushna, Vikrant, 1188, 9305 Yashoda, Karishma, Krushidhan and Mahabeej (726, 271, 229, 158, 230, 28).

Marketing of oilseeds

Mandi is the most preferred selling destination among the farmer households as on overall basis above 60% of them have preferred this. About 27% also preferred to sell to the agents, followed by selling to the retailers (9.2%) and government agency (4.2%) (Table 7.7). At the state and crop specific level, other than mandi the preferred choices are - agents (for rapeseed & mustard and groundnut in Rajasthan), retailers (for soybean in Maharashtra and Madhya Pradesh) and government agencies (for groundnut in Rajasthan).

Most of the produced oilseeds (above 96.5%) are sold to various marketing channels (Table 7.8). The average distance covered to sell the produce is in general about 10 to 15 kms, but the farmers growing groundnut in Rajasthan travelled far (average distance about 87 kms), making an overall average of above 43 kms. Similarly, the average transportation cost per household is below Rs. 2626.6 per households, except Rajasthan (for groundnut), where the farmers incurred very high transportation cost due to large distance covered. The farmers sold the oilseeds at an average rate of Rs. 4909 per quintal, with varied sale rate by oilseed type.

The details on marketing of oilseeds by marketing channels is reported in Table 7.9. On overall basis, about 67.7% produce sold at mandi and 25.7% to the agents. The average distance travelled to mandi and to the processor is comparatively large, hence the transportation cost. The average rate of selling groundnut to government agency in Rajasthan and Gujarat is comparatively better than other channels for different oilseed crops. Mechanized mode by road is the widely-preferred source of transportation.

Table 7. 7: Households preferring to sell produce to different marketing channels (%)

Crop	States	Government Agency	Mandis	Processor	Retailers	Agents	Other
Soybean	Madhya Pradesh		82.8		13.3		0.6
	Maharashtra		45.0	6.1	32.8	13.9	2.2
Groundnut	Rajasthan	16.7	43.9			63.3	
	Gujarat	4.4	96.7				
R & m	Rajasthan		33.9			58.3	15.6
	All States	4.2	60.4	1.2	9.2	27.1	3.7

Note: Column sum is not 100%, as multiple marketing channels for a single household.

Table 7. 8: Marketing of oilseeds - overall

Crop	State	Quantity Sold (% to production)	Sold Rate (Rs/Quintals)	Distance from farm (In km)	Transportation cost (Rs.)
Soybean	Madhya Pradesh	85.8	4014.9	12.7	618.3
	Maharashtra	73.6	4394.7	14.2	1383.9
Groundnut	Rajasthan	99.9	5017.7	86.9	36457.7
	Gujarat	99.9	4754.3	14.6	2202.7
Rapeseed & mustard	Rajasthan	99.8	5807.2	10.7	2626.6
	All States	96.5	4909.0	43.2	16563.6

Table 7. 9: Marketing of oilseeds by marketing channels

Crop	States	Marketing Channel	Quantity Sold (% to overall sold)	Sold Rate (Rs/Quintals)	Distance from farm (In km)	Transportation cost (Rs.)	Transportation mode
Soybean	Madhya Pradesh	Mandis	95.8	4037.4	13.16	638.60	Tractor trolley, Tempo
		Retailers	3.7	3212.5	1.06	92.17	Tempo, Bike
		Other	0.5	5500.0	n.a.	n.a.	
	Maharashtra	Mandis	40.6	4346.8	21.31	1736.76	Tractor, Tempo, Auto Cargo Pickup
		Processor	7.1	4336.4	18.87	1805.62	Tempo, Pickup
		Retailers	40.3	4377.1	8.27	1171.25	Tractor, Tempo, Auto, Cargo Pickup, Bullock cart
		Agents	9.0	4472.0	5.29	614.10	Tractor, Tempo, Auto, Cargo Pickup
		Other	3.1	5150.0	12.22	798.43	Tempo, Tractor
Groundnut	Rajasthan	Government Agency	2.4	5275.0	3.25	1342.11	Tractor
		Mandis	64.5	5008.3	89.92	37748.11	Truck
		Agents	33.1	4691.1	n.a.	n.a.	
	Gujarat	Government Agency	3.1	5375.0	14.30	1260.34	Tractor/Truck
		Mandis	96.9	4734.7	14.63	2232.50	Truck
R & m	Rajasthan	Mandis	63.9	5807.2	10.66	2626.63	Tractor/Truck
		Agents	30.8	5710.3	n.a.	n.a.	
		Other	5.3	5578.9	n.a.	n.a.	
Overall		Government Agency	1.9	5293.1	5.24	1327.34	
		Mandis	67.7	4955.7	60.98	24114.28	
		Processor	0.5	4336.4	18.87	1805.62	
		Retailers	3.2	4313.0	7.87	1111.86	
		Agents	25.7	4826.3	5.29	614.10	
		Other	0.9	5460.7	12.22	798.43	

Cost of oilseed cultivation

Sample farmers were enquired about various input and operational cost incurred by them to produce oilseed crops. This includes various cost for labour and machine use and the input costs such for fertilizer use, seed use, pesticide, weedicide, fungicide, bio-fertilizer, manure use and irrigation charges. The details on these costs are discussed.

Labour rates

The labour use and the wage rates of the labours by gender are and by type of labour (hired/owned) are reported. The average wage rates on combined basis for various agricultural activities are varying from Rs. 234 to Rs. 332 per day for male and Rs. 192 to Rs. 289 for female labours (Table 7.10). The highest wages are paid for the sowing and harvesting operations and the lowest wages are paid for intercultural activities of crop production, in general.

Table 7. 10: Average wage rates across states - by operation and by type of labour: 2020-21

Crop	State	Farm Activity	Hired Rate (Rs/Day)		Owned Rate (Rs/Day)		Combined Rate (Rs/Day)	
			Male	Female	Male	Female	Male	Female
Soybean	Madhya Pradesh	Sowing/Ploughing	196.0	200.0	191.3	180.1	193.0	181.9
		Intercultural activity	199.7	201.6	197.3	195.8	198.5	199.1
		Harvesting/Threshing	324.0	318.3	317.6	313.8	322.5	317.2
		Transportation	206.1	200.0	170.7	180.0	176.7	180.4
		Overall	286.9	280.7	227.0	235.9	261.7	263.3
	Maharashtra	Sowing/Ploughing	357.1	191.7	352.0	187.8	353.2	188.7
		Intercultural activity	339.8	191.7	328.1	190.3	335.4	191.5
		Harvesting/Threshing	389.6	244.5	336.9	200.8	374.1	238.9
		Transportation	379.6	250.0	360.3	250.0	368.1	250.0
		Overall	369.8	217.5	344.1	193.5	358.2	212.8
Groundnut	Rajasthan	Sowing/Ploughing	395.9	300.0	377.6	375.0	384.7	333.3
		Harvesting/Threshing	371.9	358.3	385.4	358.2	375.4	358.2
		Overall	376.7	357.9	381.3	358.4	378.4	358.0
	Gujarat	Sowing/Ploughing	333.7		304.9	300.0	317.4	300.0
		Harvesting/Threshing	238.6	237.3	240.6	290.1	239.2	246.8
		Overall	255.4	237.3	222.3	290.3	242.1	247.0
Rapeseed & mustard	Rajasthan	Sowing/Ploughing	450.0		450.0	450.0	450.0	450.0
		Intercultural activity	450.0		450.0		450.0	
		Harvesting/Threshing	350.0	350.0	350.0	300.6	350.0	322.2
		Overall	369.4	350.0	404.9	396.2	386.4	386.1
Overall		Sowing/Ploughing	327.4	200.0	334.5	298.5	332.0	284.9
		Intercultural activity	272.1	195.7	262.7	193.6	267.7	195.2
		Harvesting/Threshing	327.9	287.1	323.6	297.4	326.7	289.2
		Transportation	284.2	233.3	220.0	188.2	233.7	191.8
		Overall	320.9	258.0	306.7	268.5	314.9	260.8

On the overall basis, the wage rate of male is high in Maharashtra (soybean) and Rajasthan (rapeseed & mustard). The female wage rates are close to the male wage rate in Rajasthan where as these are quite varying and low in Maharashtra for female labour. In general, the wage rates Madhya Pradesh and Gujarat are low and nearly same for male and female.

The average cost of labour use for various agricultural operations is worked out for reference year 2020-21 on Rs. per acre basis. Overall, a household spends nearly Rs. 2075 per acre on labour for growing oilseed per crop season (Table 7.11). The average cost of labour use for harvesting is about Rs. 1384 per acre, whereas for sowing this is about Rs. 349 per acre. These costs vary across the state and by oilseed crop grown. The cost of labour use for growing soybean in Maharashtra and Madhya Pradesh is observed high, coving all the major agricultural operations, at about Rs. 4018 per acre and Rs 3739 per acre, respectively. While this cost is about Rs. 1160 to Rs. 2050 per acre for growing groundnut and rapeseed.

Table 7. 11: Labour use - average cost (Rs./Acre)

Crop	State	Sowing/ Ploughing	Intercultural activity	Harvesting/ Threshing	Transportation	All operations
Soybean	Madhya P.	186.0	769.5	2704.0	80.1	3739.0
	Maharashtra	1097.9	1580.3	1733.4	428.7	4018.1
Groundnut	Rajasthan	260.4		899.2		1159.6
	Gujarat	380.1		1670.6		2050.7
Rapeseed & mustard	Rajasthan	395.7	1160.2	787.2		1363.4
Overall		348.8	1127.8	1384.2	167.9	2074.7

Machine use

Similarly, the cost of machine use is also analysed. On an average a household spends about Rs 3839 per acre on machine-based operations for oilseed production (Table 7.12). A large share of this overall average cost is due to machine use for sowing and harvesting related operations. The cost of machine use is observed comparatively high, in range of Rs. 3487 to Rs. 4694 per acre for soybean and groundnut, while this is about Rs. 703 for rapeseed & mustard growers. The average hours utilized for specific agricultural activity by the machine and by its availability to owner (owned or hired) are reported in Tables 7.13.

Table 7. 12: Machine use - average cost (in Rs./Acre)

Crop	State	Sowing/ Ploughing	Intercultural activity	Harvesting/ Threshing	Transportation	All operations
Soybean	Madhya P.	1957.4	598.6	1372.4	106.6	3487.0
	Maharashtra	1747.0	520.9	985.0	422.4	3450.7
Groundnut	Rajasthan	2262.0		2431.9		4693.9
	Gujarat	969.5		3474.0		4443.5
Rapeseed & mustard	Rajasthan	489.0		214.2		703.2
Overall		1743.7	531.0	1981.7	236.9	3838.6

Table 7. 13: Average hours of machine use by operation and machine type

Operation	Crop	States	Machine Name	Hired	Owned
Sowing/ Ploughing	Soybean	Madhya Pradesh	Tractor	9.9	29.4
		Maharashtra	Tractor Primary	5.4	10.3
			Bullock Pairs	28.4	24.7
	Groundnut	Rajasthan	Tractor	8.2	29.7
			Seed Drill	4.3	17.3
		Gujarat	Tractor	2.1	5.3
			Seed Drill	2.0	5.1
	Rapeseed & mustard	Rajasthan	Tractor	1.4	1.3
Harvesting/ Threshing	Soybean	Madhya Pradesh	Tractor	5.0	12.3
			Combiner	4.6	n.a.
		Maharashtra	Thresher	13.6	7.0
			Tractor	5.0	n.a.
			Huller by Kamdhenu	6.0	n.a.
	Groundnut	Rajasthan	Groundnut Digger	6.4	27.5
			Thresher	4.9	20.6
		Gujarat	Tractor	3.8	13.1
			Thresher	2.5	8.6
			Groundnut Digger	6.7	16.9
	Rapeseed & mustard	Rajasthan	Thresher	0.5	2.3
Intercultural activity	Soybean	Madhya Pradesh	Tractor	n.a.	17.2
		Maharashtra	Bullock Pairs	12.5	27.6
			Tractor	6.2	n.a.
Transportation	Soybean	Madhya Pradesh	Tractor	1.1	2.1
			Bullock Cart	n.a.	3.0
		Maharashtra	Tractor	1.4	1.0
			Bullock Pairs	3.1	3.3

Fertilizer and other inputs used

The information on the quantity of fertilizer used, average rate of purchase and the overall average cost incurred on per acre are worked out. There is variation across the farmers on fertilizer use as per doses and frequency. On an overall basis, the farmer incurred cost of nearly Rs. 243 to Rs. 553 per acre on urea, Rs. 1153 to Rs. 1968 on DAP (except rapeseed and mustard crop). The requirement of fertilizer for growing rapeseed & mustard is comparatively low and few specific fertilizers are used. The details on the cost per acre of each type of fertilizer used across the states is reported in Table 7.14.

Similarly, the cost of various other inputs used by the farmers growing oilseed cops is reported in Table 7.15. The weedicides and bio- fertilizers are only used for the soybean in Madhya Pradesh and Maharashtra. A varied choice of brands with varying rates and with varying composition and recommended doses of these inputs are available with the farmers. The average rate and the final cost of these inputs incurred by the farmer households across the crop and state are worked out. Similarly, the seeds rate is also the average rate of the local and hybrid seeds used by the households. The rate of irrigation charges and seed rate on per acre basis are high in Gujarat and Rajasthan (for groundnut farmers) as many of the sampled farmers are paying high irrigation charges and using comparatively good quality/high-cost seeds in the covered regions.

Table 7. 14: Cost of fertilizers use

Crop	States	Fertilizer type	Quantity (kg/acre)	Rate (Rs/kg)	Average Cost (Rs./Acre)
Soybean	Madhya Pradesh	Urea	48.9	6.1	297.3
		DAP	47.4	24.7	1152.6
		NPK	47.1	24.7	1161.5
		SSP	135.6	6.2	920.9
	Maharashtra	Urea	42.3	6.2	243.3
		DAP	48.6	27.0	1489.1
		NPK	41.8	33.2	935.8
		MOP	50.0	20.7	985.3
		SSP	30.0	7.0	210.0
		Sulphur	16.6	27.4	418.1
		Ammonium Sulphate	0.5	400.0	200.0
Groundnut	Rajasthan	Urea	70.6	7.0	553.2
		DAP	73.2	24.0	1967.8
		MOP	75.9	34.0	1247.3
		SSP	33.7	6.0	267.5
		Liquid Potash	0.8	366.2	283.4
		Liquid Sulphur	5.5	118.0	418.7
	Gujarat	Urea	75.1	7.2	542.7
		DAP	47.8	25.0	1158.7
		NPK	32.2	19.9	616.3
		Sulphur	5.7	8.5	47.7
		Calcium Nitrate	12.7	7.0	88.6
		Ammonium Sulphate	40.0	13.5	479.2
Rapeseed & Mustard	Rajasthan	Urea	57.6	7.0	414.4
		DAP	21.2	24.0	484.3
		NPK	54.3	6.0	349.9

Table 7. 15: Cost of other input use

Crop	State	Quantity (kg/acre)	Rate (Rs/kg)	Average Cost (Rs./ Acre)
		Pesticides		
Soybean	Madhya Pradesh	0.46	3142.0	922.7
	Maharashtra	0.42	617.7	527.7
Groundnut	Rajasthan	1.13	3905.6	3341.9
	Gujarat	0.001	1246.0	-
		Fungicides		
Soybean	Madhya Pradesh	0.23	2415.9	520.2
	Maharashtra	0.51	347.7	220.5
Groundnut	Rajasthan	0.65	650.0	421.1
	Gujarat	0.06	269.9	6.9
		Weedicides		
Soybean	Madhya Pradesh	0.30	1578.4	556.3
	Maharashtra	0.36	743.4	622.1
		Bio- Fertilizers		
Soybean	Madhya Pradesh	0.48	979.8	229.7
	Maharashtra	0.27	391.3	55.9
		Seed		
Soybean	Madhya Pradesh	53.3	61.4	3378.0
	Maharashtra	29.0	100.0	2982.1
Groundnut	Rajasthan	61.1	109.7	8404.4
	Gujarat	64.5	103.9	6556.4
Rapeseed & mustard	Rajasthan	2.1	222.2	561.4
		Manures		
Soybean	Madhya Pradesh	4822.6	1.1	3028.1
	Maharashtra	1986.8	2.2	3094.0
Groundnut	Gujarat	1411.8	2.4	2936.0
		Irrigation		
Soybean	Maharashtra	-	-	819.2
Groundnut	Rajasthan	-	-	4271.7
	Gujarat	-	-	9054.5
Rapeseed & mustard	Rajasthan	-	-	534.9

Effect of input use on the oilseed yield

An attempt has been made to measure the effect of various inputs use on the yield of the oilseed crops grown across the study states. For this purpose, the basic OLS regression model is used in the following form:

$$Yield = f(Labour, Fert., manure, biofert., fungicide, weedicide, pesticide, irrig., others, error\ effect)$$

- *The labour use is the manual and machine labour used in numbers and hours, respectively. Also, the manual labour cost and the machine cost, both in hired and owned, is combined to reach at the final cost.*
- *Fertilizer use (and/or fertilizer cost) is the total combined quantity of different types of fertilizers used (and/or total cost of fertilizers) by the farmers.*
- *Similarly, the quantity used (and /or cost) of manure, bio-fertilizers, fungicides, weedicides and pesticides is also utilized as the independent variables.*
- *The cost of irrigation is considered as to measure the effect of irrigation on the crop yield.*
- *The other independent variables include the effect of education, gender, farming experience, family size and family type.*

The state specific regression equations are run for each of the major three oilseed crops considered in the analysis. The field survey data is utilized for the analysis collected by participating AERCs for one point of survey time period in the cross-sectional form. For each state an overall sample of 180 respondent farmers is considered as overall number of data observations. The model is tested for various diagnostic check to test the strength of the model.

The results suggest that, for the soybean yield in Madhya Pradesh, there is positive and significant effect of pest, manure and weedicide quantity use on the yield. Whereas, higher the seed, manure and weedicide cost impact the soybean yield in Madhya Pradesh. Similarly, in Maharashtra, higher the fertilizer use, seed use and machine cost, higher the crop yield, but the cost of fertilizers, higher fungicides and pesticides use impacted the yield, negatively (Table 7.16 & Table 7.17).

For rapeseed & mustard, seed and fertilizer use, higher machine hours and farming experience have positive effect on crop yield in Rajasthan, whereas the increasing machine and irrigation cost impacts the crop yield (Table 7.18).

In Gujarat, the farmers used higher fertilizers, seeds and labours, does not get higher yield of groundnut but the farmers who invested more on labour, seed, fertilizer and irrigation charges (as proxy to higher irrigation with uniform applicable rates) get higher groundnut yield in the state. In Rajasthan, except the increasing machine and pesticide cost, all other factors such as – higher labour, machine and fertilizer use, higher cost incurred on seed and irrigation helped farmers to get better groundnut yield (Table 7.19 & Table 7.20).

Table 7. 16: Regression results - Soybean – Madhya Pradesh

Yield	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Seed cost	-0.604	0.268	-2.250	0.029	-1.144	-0.064
Pest quantity	0.199	0.085	2.340	0.024	0.028	0.371
Weedicide quantity	1.270	0.453	2.810	0.007	0.358	2.183
Weedicide cost	-1.027	0.296	-3.480	0.001	-1.622	-0.432
Manure quantity	1.241	0.513	2.420	0.020	0.208	2.274
Manure cost	-0.929	0.497	-1.870	0.068	-1.931	0.072
Constant	11.046	3.634	3.040	0.004	3.726	18.365

Table 7. 17: Regression results - Soybean – Maharashtra

Yield	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Machine cost	0.196	0.079	2.490	0.014	0.040	0.353
Seed quantity	0.237	0.154	1.540	0.127	-0.069	0.542
Fertilizer quantity	0.821	0.208	3.950	0.000	0.409	1.233
Fertilizer cost	-0.973	0.235	-4.140	0.000	-1.438	-0.508
Pest quantity	-0.076	0.038	-2.000	0.048	-0.151	-0.001
Fungicide quantity	-0.027	0.044	-0.630	0.530	-0.114	0.059
Constant	2.830	1.057	2.680	0.009	0.735	4.924

Table 7. 18: Regression results - Rapeseed & mustard – Rajasthan

Yield	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Machine hours	0.144	0.075	1.920	0.057	-0.004	0.292
Machine cost	-0.196	0.058	-3.350	0.001	-0.311	-0.080
Seed quantity	0.123	0.057	2.150	0.033	0.010	0.236
Fertilizer quantity	0.236	0.059	4.040	0.000	0.121	0.352
Irrigation cost	-0.373	0.024	-15.570	0.000	-0.420	-0.326
Farming experience	0.002	0.001	1.730	0.085	0.000	0.003
Family type	-0.075	0.023	-3.300	0.001	-0.120	-0.030
Constant	4.622	0.489	9.460	0.000	3.657	5.586

Table 7. 19: Regression results - Groundnut – Gujarat

Yield	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Labour numbers	-0.104	0.057	-1.820	0.070	-0.217	0.009
Labour cost	0.094	0.038	2.510	0.013	0.020	0.168
Seed quantity	-0.278	0.187	-1.480	0.140	-0.648	0.092
Seed cost	0.380	0.200	1.900	0.059	-0.015	0.774
Fertilizer quantity	-0.529	0.134	-3.940	0.000	-0.794	-0.264
Fertilizer cost	0.233	0.145	1.600	0.111	-0.054	0.520
Irrigation cost	0.150	0.085	1.770	0.079	-0.017	0.317
Constant	-1.395	0.893	-1.560	0.120	-3.158	0.368

Table 7. 20: Regression results - Groundnut – Rajasthan

Yield	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Labour numbers	0.244	0.061	4.000	0.000	0.123	0.364
Machine hours	0.936	0.265	3.530	0.001	0.413	1.460
Machine cost	-0.528	0.213	-2.480	0.014	-0.948	-0.108
Seed cost	0.214	0.074	2.870	0.005	0.067	0.360
Fertilizer quantity	0.121	0.064	1.900	0.059	-0.005	0.246
Pest cost	-1.249	0.212	-5.880	0.000	-1.668	-0.829
Irrigation cost	0.370	0.104	3.560	0.000	0.165	0.576
Constant	9.519	1.843	5.170	0.000	5.882	13.156

Perception of the sample households on yield enhancement

The perception of the farmer households is essential to know the emerging difficulties at the ground level. This helps better understanding of the issue at the core level and better planning considering due weightage to the existing causes. The farmers were enquired about their satisfaction level on the yield they are getting and the potential options those can help farmers to achieve better crop productivity. About half of the farmer (49.6%) are satisfied with the yield what they are able to achieve (Table 7.21). Of this, nearly 76% are ‘moderately satisfied’ and about 17% have ‘low satisfaction’ (Figure 7.2). The ‘high satisfaction’ share with the current yield is observed highest in Gujarat (for groundnut, 18.7%). On the contrary, the ‘high dis-satisfaction’ with the current yield is observed in Rajasthan (for rapeseed & mustard, 43.6%) and in Madhya Pradesh (for soybean, 35.5%).

On the other side, optimist approach is witnessed for the scope for further improvement in the crop yields, as above 95% on overall basis thinks that the yield can be further improved. Mainly the soybean and groundnut farmers from the states except Rajasthan are not satisfied with the yield they achieve, moreover about 14% soybean growers in Madhya Pradesh and 9-10% in Maharashtra have no further expectations on yield improvement. Same fraction of farmers also shares similar thinking that the oilseed crops can’t be more profitable than other crops. 50% of groundnut growers in Gujarat also share same perception. Overall, close to 86% farmers think oilseed can be more profitable.

Overall, only 44% are able to get the improved subsidized seeds. Farmers from Rajasthan (growing groundnut) and Maharashtra are most dis-satisfied for not getting improved subsidized seeds for oilseed crops. Only 31.4% farmers are getting the trainings related to oilseed production. Again, the farmers from Rajasthan (growing groundnut) and from Maharashtra and Madhya Pradesh (growing soybean) got very limited or no exposure to any such training. Mostly, the state government provides training to the farmers. The benefits received by the farmers are discussed later.

It is very encouraging that about 71.3% of the oilseed growers had covered the crop under crop insurance. Above 92% soybean growers opted this. The exposure of crop insurance is limited to groundnut farmers or by choice, as only 50% farmers from two states insured their crop.

Overall, about 58.1% farmers performed the soil testing at least once on their soil but only 40.3% of the respondents, performed soil testing at least once, are using the fertilizers as per the recommended doses. The soil testing is performed largely by the groundnut growers in

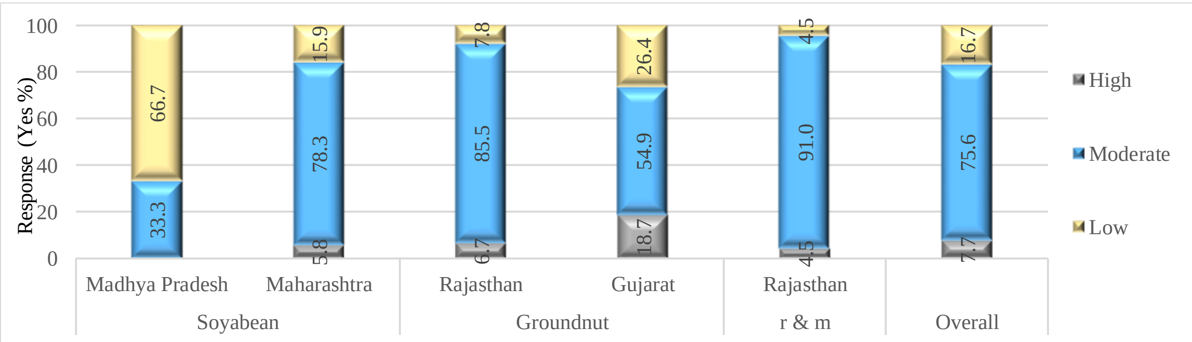
Gujarat and Rajasthan (above 95% and 61.7%, respectively); and rapeseed & mustard farmers in Rajasthan (80.6%). Of the farmers who performed soil testing once, close to 50% of groundnut growers and only 6% of rapeseed & mustard growers are using the fertilizers as per the recommended doses. Soybean growers in both the states have tested the soil once (about 18-34%), but, of those, only21.2% in Maharashtra are used recommended doses of fertilizers.

The drought like condition is faced by about 91% soybean growers in Maharashtra and 60% of groundnut growers in Rajasthan in past 5 years. These two states are largely the water deficit states already. Encouraging to report that the farmers in Rajasthan (above 74%, for both the crops) are using the post-harvest practices for oilseed crops, followed by groundnut farmers in Gujarat (50%) and soybean growers in Maharashtra (38.3%).

Table 7. 21: Farmers perception on yield of oilseed crops (Yes %)

Perception	Soybean		Groundnut		r & m	Overall
	Madhya P.	Maharashtra	Rajasthan	Gujarat	Rajasthan	
Satisfied with the yield?	23.3	38.9	80.6	42.2	62.8	49.6
Think yield can be further improve?	86.1	90.6	100.0	100.0	100.0	95.3
Oilseed crops profitable than other crops?	88.9	90.0	100.0	50.0	100.0	85.8
Get improved subsidized seed for oilseed?	66.1	7.8	0.0	63.3	82.8	44.0
Get any training on oilseed crop production?	0.0	18.3	0.0	56.1	82.8	31.4
Cover the oilseed crop for insurance?	92.8	92.2	47.2	53.9	70.6	71.3
Soil testing ever performed on your field?	34.4	18.3	61.7	95.6	80.6	58.1
- If yes, using fertilizers as recommend	75.8	21.2	45.0	57.0	6.2	40.3
Face draught during last 5 years?	-	91.1	60.0	2.2	-	29.6
Adopt any post-harvest practice for oilseeds?	-	38.3	81.7	50.0	73.9	48.8

Figure 7. 2: Extent of satisfaction with the current oilseed yield (Yes %)



Farmers were asked to report the factors which are affecting the oilseed crop yield the most. The 'seed quality' and the 'impact of the climate' (above 68%, each) appeared the most influencing factors in farmers' perception (Table 7.22). Although, the farmers also given due weightage to the other factors such as – fertilizer use, soil quality and irrigation have the impact on the oilseed crop yield (about 55%-59% of farmers).

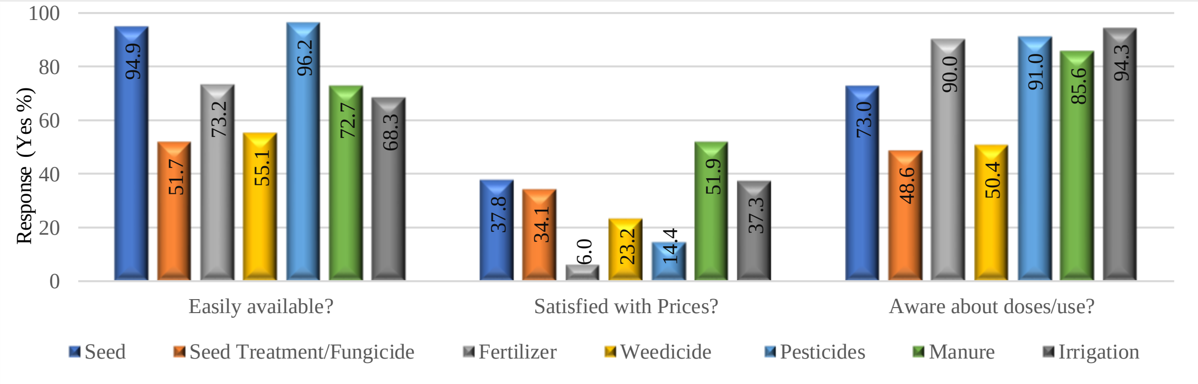
At the crop level, the factors impacting the crop yield are – Climate, seed quality and fertilizer use for soybean (in both the states); irrigation and seed quality in Rajasthan (for groundnut); climate and soil quality in Gujarat (for groundnut); irrigation, fertilizers, soil and seed quality in Rajasthan (for rapeseed & mustard). So, at the state specific, the natural factor 'impact of climate' is important factor in Madhya Pradesh, Maharashtra and Gujarat; and irrigation affects oilseed yield in Rajasthan.

Table 7. 22: Farmers perception on the factors affecting yield of oilseed crop (Yes %)

Factors	Soybean		Groundnut		r & m	Overall
	Madhya Pradesh	Maharashtra	Rajasthan	Gujarat	Rajasthan	
Climate	100.0	90.6	51.1	88.3	10.6	68.1
Seed quality	54.4	57.2	85.6	54.4	91.1	68.6
Soil quality	40.0	46.1	51.7	65.0	86.1	57.8
Fertilizers	57.8	52.8	50.0	40.0	92.8	58.7
Irrigation	2.8	38.9	99.4	39.4	96.7	55.4

Considering the above factors as important factors in general for crop yield, the farmers were further enquired about their views on use of some of such factors as input use while growing oilseed crop. The satisfaction level of farmers on the availability of such inputs, prices and use as per recommended doses are recorded. On the overall basis, the farmers consider that the crop seed and the pesticides are very easily available, fertilizers, manures and irrigation resources are also available moderately, but the availability of fungicides, weedicides and seed treatment options have limited penetration (Figure 7.3). This is mainly due to low level of farmer's awareness about the use as per recommended doses, which may have impacted the demand and hence the availability. The farmers are still not satisfied with the fertilizer prices (only 6% farmers are satisfied with prices) despite being heavily subsidized on governments head. The input price satisfaction level is also low for pesticides, weedicides (only up to 23% satisfied farmers), followed by seed, seed treatment and irrigation charges (up to 38%). At least, 52% farmers are satisfied with manure prices, as mainly dealt through unorganized and local demand-supply chains. Farmers are well aware about the recommended use or doses of fertilizer and pesticide, which is theoretically appears not due to low level of soil testing in many of the study states. Good level of awareness among the farmers about the seed doses (73%) and irrigation use (94.3%) but low awareness on seed treatment, fungicides and weedicides (below 50%). This may be due to difficulty to understand the exact and precise use/doses of such inputs due to low level of education among the farmers.

Figure 7. 3: Satisfaction and awareness of farmers about input uses – Overall ('Yes' %)



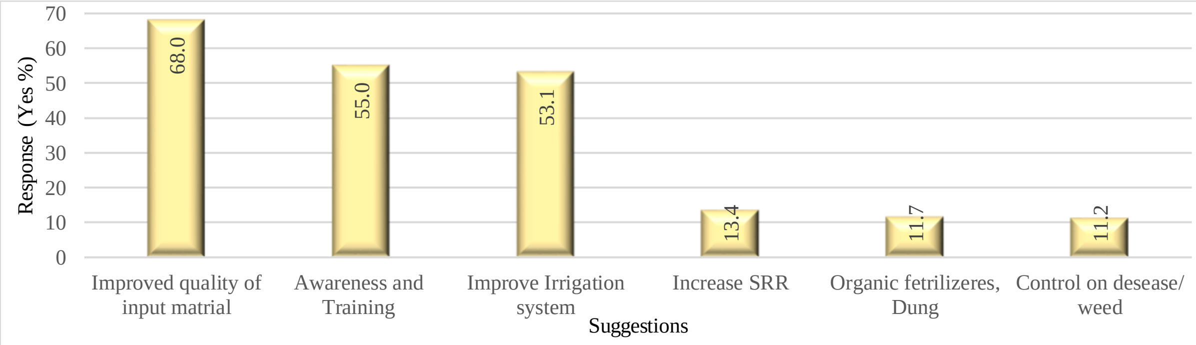
At the crop and state specific level, the availability of inputs is impacted in – Manure (for soybean – in Madhya Pradesh and Maharashtra, both), fertilizers (in Madhya Pradesh), and irrigation (in Maharashtra and Rajasthan) (Table 7.23). There is high dis-satisfaction among the farmers over the fertilizer prices in all the study states, weedicides and manure prices (in Maharashtra and Rajasthan), pesticides (in all study states), seed price and irrigation charges (in all study states except Madhya Pradesh) and seed treatment/fungicide prices (largely in Maharashtra and followed by Madhya Pradesh). The limited awareness among the farmers on the input use – seed and manure use (in Madhya Pradesh), seed treatment, fungicides, fertilizer and weedicides use (in Madhya Pradesh and Maharashtra).

Table 7. 23: Satisfaction and awareness of farmers about input uses – by crops and states ('Yes' %)

	Inputs	Soybean		Groundnut		Rapeseed & mustard
		Madhya Pradesh	Maharashtra	Rajasthan	Gujarat	Rajasthan
Inputs easily available?	Seed	97.2	77.8	99.4	100.0	100.0
	Seed Treatment/Fungicide	73.3	85.0			100.0
	Fertilizer	35.6	68.9	87.8	76.1	97.8
	Weedicide	95.0	82.8			97.8
	Pesticides	97.2	86.7	99.4	100.0	97.8
	Manure	30.0	37.8	100.0	100.0	95.6
	Irrigation	99.4	42.2	50.0	100.0	50.0
Satisfied with Prices?	Seed	76.7	24.4	37.8	10.0	40.0
	Seed Treatment/Fungicide	47.8	22.8		0.0	100.0
	Fertilizer	6.1	11.1		9.4	3.3
	Weedicide	94.4	16.1		0.0	5.6
	Pesticides	25.0	13.3		33.3	0.6
	Manure	84.4	21.7	50.0	100.0	3.3
	Irrigation	98.9	33.3		34.4	20.0
Aware about doses/use?	Seed	4.4	85.6	75.6	99.4	100.0
	Seed Treatment/Fungicide	73.3	69.4			100.0
	Fertilizer	82.8	72.2	100.0	99.4	95.6
	Weedicide	88.9	67.8			95.6
	Pesticides	92.2	68.9	99.4	98.9	95.6
	Manure	47.2	85.0	100.0	100.0	95.6
	Irrigation	100.0	72.2	99.4	100.0	100.0

Farmers were asked about their suggestions on improving the oilseed yield. The response as 'Yes percentages' were analysed based on the farmers responded on particular suggestions. The most important suggestion (about 68% farmers agree) came as to improve the quality of the inputs used in general, of seeds, fertilizers etc (Figure 7.4, Table 7.24). The two of the other important suggestions are – encouraging awareness of the farmer through training programmes on various aspects; and to improve the irrigation facilities and the infrastructure. Some other important suggestions which farmers also highlighted are – using the organic fertilizers, control on the diseases and weeds, and increasing seed replacement rate for oilseed crops.

Figure 7. 4: Farmers' suggestions to improve oilseed yield (Yes '%')



The responses of the farmers on the reasons for recording low crop yield are analysed. Various reasons are discussed with the farmers who are not satisfying with the present yield. The 'high input cost' appears the strongest reason that the farmers (48.5% of such respondent) cannot increase financial investment to increase yield. Farmers also reported other reasons as - low yield in general due to untraceable factors, adverse effect of changing climatic condition on yield, irrigation facilities, low seed replacement rate, erratic rainfall, crop damage and deteriorating land quality (above 20% farmers' respondent each of such reasons for low yield) (Figure 7.5, Table 7.24).

Figure 7. 5: Farmers' reasons for not satisfying with the present yield (Yes '%')

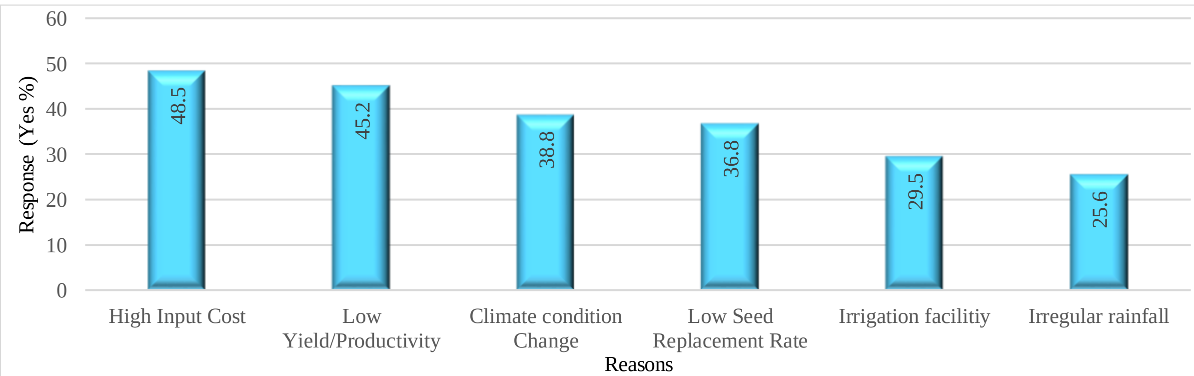


Table 7. 24: Farmers' suggestions (to improve) and reasons (not satisfying) with oilseed yield (Yes %)

Suggestions to improve yield	'Yes' %	Reason for low yield	'Yes' %
Improved quality of seed, fertilizers, pesticides, etc.	68.0	High input cost	48.5
Training on fertilizers, seeds, pesticides, and timely use	55.0	Low yield in general	45.2
Improve irrigation system	53.1	Climate condition changing	38.8
Increase Seed Replacement Rate	13.4	Low seed replacement rate	36.8
Use of organic fertilizers, dung	11.7	Irrigation facility	29.5
Control on disease/ weed	11.2	Irregular (heavy/low) rainfall	25.6
Change in cropping pattern	6.8	Crop damaged	22.7
Drainage system in the field	4.9	Low soil/land quality	20.3
Low cost of input material seed, fertilizers, labour	4.8	Weaker economic condition	16.7
Financial support, loan, easy claims, low interest rate	3.1	Low quality input material	15.9
Improve soil/ land quality	2.9	High water level depth	15.4
Control climate change rainfall	1.6	Absence of pod formation	12.6
Fencing from animals	1.1	Lack of awareness	7.9
Increase MSP/market rate	1.0	High labour cost	6.6

Note: suggestions are based on the farmers who said 'yes - yield can be improved further'; reasons are based on farmers who are 'dis-satisfied with the yield'. Other minor reasons are- diseases, insect, wild animal, drought, low market rate/MS, Govt. support, subsidy and electricity issues.

On the overall basis, very few farmers (about 31%) reported they got the training related to the oilseed production, mainly organised by the department of agriculture in the respective states. At the state level, the farmers are receiving major benefits related to crop sowing (24.4%), fertilizers and sprayers related (11.1%, each) and harvesting and seed testing related (8.9%, each) in Maharashtra (Table 7.25). Few farmers in Gujarat (for groundnut) got training related to ‘package of practice’ (39.1%), awareness on cultivation methods (38.3%) and on getting higher crop yields (10.4%). About 82% farmers in Rajasthan got training in general related to increase production and reducing the input cost for rapeseed & mustard cultivation.

Table 7. 25: Training sources and benefits of training to the farmers on oilseed crop production

State	Training source	Training benefits (and response %)
Maharashtra (For Soybean)	State Agriculture Department	Sowing related (24.4%); fertilizers and sprayers related (11.1%, each); harvesting related and Seed testing (8.9%, each); irrigation related and seed treatment (6.7%, each); bio-Farming (4.4%); on pesticides, fungicides, insects related and on soil testing (2.2%, each); (Overall – 17.2% respondents)
Gujarat (For Groundnut)	State Agriculture Department	Package of Practice (39.1%), Awareness on cultivation methods of groundnut (38.3%), Higher crop yields (10.4%), Demonstration (5.2%), ATMA and NFSM related (3.5%, each); (Overall – 56.1% respondents)
Rajasthan (For r & m)	State Agriculture Department	Increase production and Low input cost (82.8%, overall)

Farmers were enquired about the problems faced by them in post-harvest management of oilseed crops. The soybean growers in Madhya Pradesh, ‘lack of awareness’ on post-harvesting, high transportation charges, lack of remunerative price and malpractices in market are the major problems (Table 7.26). Storage related problem of soybean and lack of drying and cleaning facility are major two problems in Maharashtra. For groundnut, high cost of storage and other storage related problems, drying-grading-cleaning; low market price and other price related issues, and labour shortage related issues. For rapeseed & mustard in Rajasthan, high cost of post-harvest technology, price related issues and unawareness are the major post-harvest related issues among the farmers.

Table 7. 26: Problems arising in post harvesting of oilseeds crop

State	Problems details	Response %
Madhya Pradesh (for soybean, respondents = 180)	Lack of Awareness on, market, technology, warehouse, etc.	67.2
	High cost of transportation	52.8
	Lack of remunerative price	44.4
	Malpractice in market	41.1
	Lack of Road	31.1
	Time consuming	23.3
	Lack of storage facility	18.3
	High cost/ Unavailability of bardana (bags)	12.8
	High Labour, staff cost	8.9
Maharashtra (for soybean, respondents = 69)	Storage problem	91.3
	Drying and cleaning	47.8
	wild animal and disease	8.7
	Grading of seeds	5.8
	Financial Problem	4.3
Rajasthan (for groundnut, respondents = 147)	High Cost of storage, Grading, harvesting, labour, etc.	90.5
	Low Market price	81.0
	Market issue	53.7
	Labour shortage	4.8
Gujarat (for groundnut, respondents = 90)	Cleaning and Grading issue	100.0
	Storage issue	96.7
	Weight loss	42.2
	Price related issue	40.0
	Crop loss during harvesting by digger	2.2
Rajasthan (for rapeseed & mustard, respondents = 133)	High cost of post-harvest technology	99.2
	Lack of awareness	68.4
	Proper price facility	50.4

Note: Based on farmers who reported 'adopt any post-harvest practice for oilseeds'. In Madhya Pradesh, farmers do not adopt any post harvesting process but reported the problems.

The drought like situations were faced by the farmers in the Maharashtra and Rajasthan states. About 91% farmers in Maharashtra and nearly 60% in Rajasthan are impacted through drought in past 5 years (Table 7.27). Of those who faced droughts, about 57% in Maharashtra and 83% in Rajasthan reported it as of 'moderate' impact. Rest about 37% (in Maharashtra) and 17% (in Rajasthan) considered it as 'severe' impactful to them. Only about 2% farmers face moderate drought conditions in past 5 years in Gujarat.

Table 7. 27: Drought faced and its extent of severity (yes %)

State	Face draught during last 5 years (yes %)	Severity (% w.r.t. 'yes %' responses)		
		Severe	Moderate	Mild
Rajasthan	60.0	16.7	83.3	0.0
Gujarat	2.2	0.0	100.0	0.0
Maharashtra	91.1	36.5	56.5	7.1
Overall	29.6	29.1	66.0	4.9

Chapter 8: Investigator's observations: Field survey insights

This section deals with the insights observed by the investigators during field visits following the empirical analysis as provides in the previous section. There are many observations and state specific issues related to crop production which may not be justified through empirical analysis. These insights reflect the ground issues faced by the oilseed growers in oilseed production as in general or as region or state specific problems.

Maharashtra - Soybean

It is found in farmer's response that the weather-related factors are impacting the soybean yield in the state. About 91% farmers in Maharashtra are impacted through drought in past 5 years. The frequent prevailing drought conditions impacting the oilseed yield leaving farmers with the less output available and hence denting the profit gains. The changing weather conditions also impacted the post-harvest operations, especially the drying of soybean seed. Also, the quality of seed and soil, fertilizer use and irrigation issues also influence the yield of the soybean. Although, the farmers considering the oilseeds more profitable as against other field crops.

In particular, the major problems faced by soybean farmers in the state were on the ineffectiveness of Benzene hexachloride powder for insects, limited effect of Celphos powder used to control field rodents and insect pests during storage operation, lack of finance to construct store houses, changing weather conditions causing problem in terms of drying of soybean seed, difficulty in terms of grading of seeds, unpredicted rainfall at the time of harvesting, management of store hoses, safeguarding the produce against rodents and insects, destruction of crop by wild animals and birds like nilgai (Asian antelope), peacock and wild pigs, etc., lack of effectiveness of boron concentrations at the time of maturity/plant growth, ineffectiveness of application of boric acid powder, Gamazyme powder, etc.

A vast list of dissatisfying factors is reported by the soybean farmers for the low yield. The major reasons include - yield reduction due to climatic factors, high input cost in relation to output price, un-seasonal/unpredicted rainfall at the time of harvesting, economic conditions of farmers preventing them to optimize input use. The other reasons also listed by farmers were: destruction of crop by wild animals, shortage of irrigation water, rocky soil and depletion of water table, poor quality of land use, unstable power supply, lower market prices of output, lower

MSP on offer, lack of irrigation water, higher labour cost, lack of capital for investment, excess water discharges from river affecting crop growth, lack of availability of high yielding varieties of seeds, late arrival of monsoon etc.

Various government and private agencies were supporting farmers through trainings and advisories, such as – through Rao Saheb Patil Agro Producer Company Ltd. (on agricultural and animal husbandry), Krishi and Kisan Kalyan Vibhag, Agricultural Department, local Krishi Seva Kendra, Taluka level Agricultural Assistant, and ICICI Foundation (through relevant training as per local conditions, market linkages, and thereby ensuring sustainable livelihood for the lesser privileged). Although this is not reflected much from the farmer's response on this question as only about 18% agreed on this. The benefits received by farmers related to sowing, fertilizer application, insecticide and pesticide use, organic farming, soil testing, irrigation management, seed treatment, and soil testing. Most of the suggestions received from the farmers about the yield improvements are related to crop management and preparation of land as per the soil type, soil testing and hence the fertilizer use as per the recommended doses, better management various inputs used, and managing water availability.

Madhya Pradesh - Soybean

A large proportion of farmers is highly dis-satisfied with the current yield of soybean. The crop is largely irrigated through Canal in the covered districts of Ujjain and Rajgarh. Ujjain is in the Malwa Plateau and the Rajgarh is in the Vindhyan Plateau. The districts are receiving the annual rainfall of about 800 to 1400 mm annually and the soil type is medium black to deep black. The average productivity is observed comparatively less at just above 3 tonnes per acre. The crop is sold majorly at the mundi and rest to the retailers. The farmers growing soybean in Madhya Pradesh have very limited or no exposure to trainings.

There is dis-satisfaction among the farmers over the fertilizer weedicides and manure prices, and seed treatment/fungicide prices. The limited awareness among the farmers on seed treatment, fungicides, fertilizer and weedicides use. There are no incidences of the drought like situations were faced by the farmers in the state. Among the major problems faced, the farmers face the 'lack of awareness' on post-harvesting, high transportation charges, lack of remunerative price and malpractices in market.

Gujarat - Groundnut

The sample districts Junagadh and Banas kantha come under Arid Zone, jointly contribute near about 22 percent of area and more than 17 percent share of state groundnut production. This region receives very less rainfall and also the ground water level is very low. Usually, the farmers have own tube well for irrigation and also use flood irrigation, few are using the micro irrigation. The farmers procured seed from the local vendors and from state government seed agency/SAUs (provides good quality/productivity seeds), home-grown seeds are less in practice. The fertilizer consumption is reported higher among the farmers due to available irrigation facilities. The use of pesticide in selected districts, especially in Banas kantha, is relatively lower as comparison of other parts of Gujarat. The timely availability of the fertiliser, pesticides and seeds, especially during the season, is the major problem among the farmers. The crop losses due to bad seeds quality was also observed during field visits. There are incidences of the crop loss due to pigs, monkeys and bule bull which is encouraging the groundnut farmers to shift towards soybean cultivation. Erratic rainfall, is also a major problem for groundnut farmers. Farmers expects from government to encourage processing facilities in the survey region to supplement the significant area expansion under Groundnut crops in the region.

Rajasthan - Groundnut

Jodhpur and Bikaner districts jointly contribute near about 50 percent of area and production share in the state. Most of the farmers are unaware of the exact variety they are using as they relied on local seed vendors and the vendors also not able to specify it due to mixing and due to a new variety update. The seed use is comparatively higher in the region. The farmers are using the sprinkler for irrigation, especially in Bikaner, and the fertilizer, pesticide and insecticide consumption is also high in Bikaner compared to Jodhpur. The farmers are getting good yield of groundnut, 20-25 qt/ha in Jodhpur and 30-35 qt/ ha in Bikaner. The non-availability of human labour on time, especially during weeding and harvesting time, is the major problem with the groundnut farmers in Rajasthan. The erratic electricity supply also impacts irrigation. The farmers suggest the facilitating irrigation through IGNP canal, developing special APMC for Groundnut and initiatives on the processing facility in the region. The assured irrigation facility limited the desert expansion and encouraged the economic development in this western Rajasthan region which is received just 50 cm annual rainfall.

Rajasthan - Rapeseed & mustard

Rapeseed & mustard is grown in different cropping systems due to its adoptability and low irrigation requirement. Alwar is basically a flood prone eastern plain Zone delivers better crop yield and Tonk district occurs in semi-arid eastern plains have lower productivity. The seed requirement is observed only up to 5 kg per hectare and the local vendors provides the seed support along with the use of home-grown seed in the regions. The fertilizer consumption is also limited for the crop. The farmers use sprinklers for irrigation, especially due to better irrigation facilities are compared to Tonk. This is reflected through the higher crop yield in Alwar. The crop suiting the adoptability to grow is rainfed area also a major source of income, especially to the marginal-and small farmers, which are not able to invest much for better production technology due to limited financial and other relevant resources.

Majority of these farmers sell their produce to village traders and commission agents and also get the support price. Also, the selling the small produce in the far market is not economically viable option to them. In addition, the varying prices also impacts farmer decisions especially to the marginal and small farmers. The lack of unawareness on various aspects along with the limited marketing related information, erratic electricity supply, untimely and non-availability of good quality of seed, irrigation related issues are the major problems along the rapeseed & mustard farmers. There is need to enhance the crop productivity through improved and high yielding varieties, technological extension, irrigation facility through regular electricity supply, training and awareness to the farmers especially on the marketing related issues, strengthening the price support during the cultivation and marketing of crop.

Chapter 9: Industry perspective on the oilseed sector

Background[1]

The chapter highlights the industrial perspective on the oilseed production in the backdrop of increasing dependence on edible oil imports and concerning inflation as reflected through the rising wholesale price index, in particular of oilseeds amid the present global disturbances. Majorly, the industrial status of the Maharashtra state is discussed, as an especial attention, while reflecting the country's overall industrial picture on oilseed production. Edible oils constitute an important component of food expenditure in rural and urban households of the country. The per capita availability of edible oil has been showing an increasing trend over the years, in view of increasing population, rising per capita incomes, urbanization, etc. The per capita annual availability of edible oils which was as low as 3.2 kg in 1960-61, increased gradually over the decades of the 1970s as can be observed from Table 9.1.

Table 9. 1: Per Capita Consumption of Edible Oil (in kgs)

Year	Per Capita Consumption of Edible Oil (kg)
1970s	3.36
1980s	5.1
1990s	6.78
2000s	10.34
2010s	17.1

Source: calculated from data in Agricultural Statistics at a Glance, 2020, MoA&FW, GOI, 2021

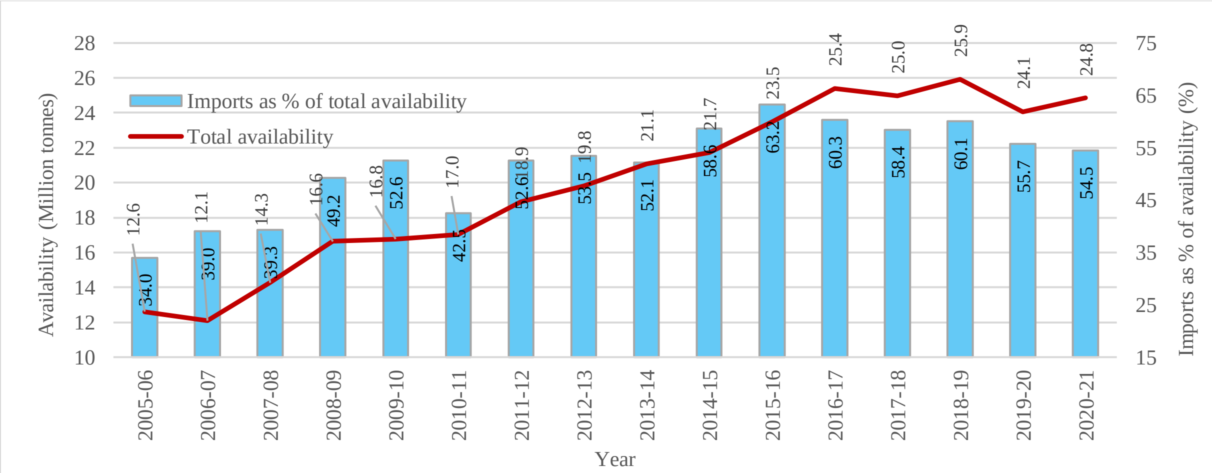
While per capita consumption of edible oils was 3.36 kgs on an average in the decade of the 1970s, it started showing considerable increase in the decade of the 2000s and touched 17.1 kg on an average during the period 2010-2020. However, the important point to note is that in India the domestic production of oil is not sufficient to meet the requirements of the population and there is a huge gap between demand and supply of edible oils, with demand outpacing supply. This shortfall is met through imports.

Dependence on Imports:

From the previous sections, it is clear that India depends largely on imports for meeting the edible oil consumption of the country. The tariff policy was also adjusted at regular intervals so as to promote imports. In Figure 9.1 indicates the total availability of edible oils and share of imports in it.

[1] Acknowledgement – We are thankful to Prof. Sangeeta Shroff, Head, Agriculture Economics Research Centre at Gokhale Institute of Politics and Economics, Pune, for her guidance to prepare this chapter and providing relevant information.

Figure 9. 1: Total availability of edible oils and share of imports

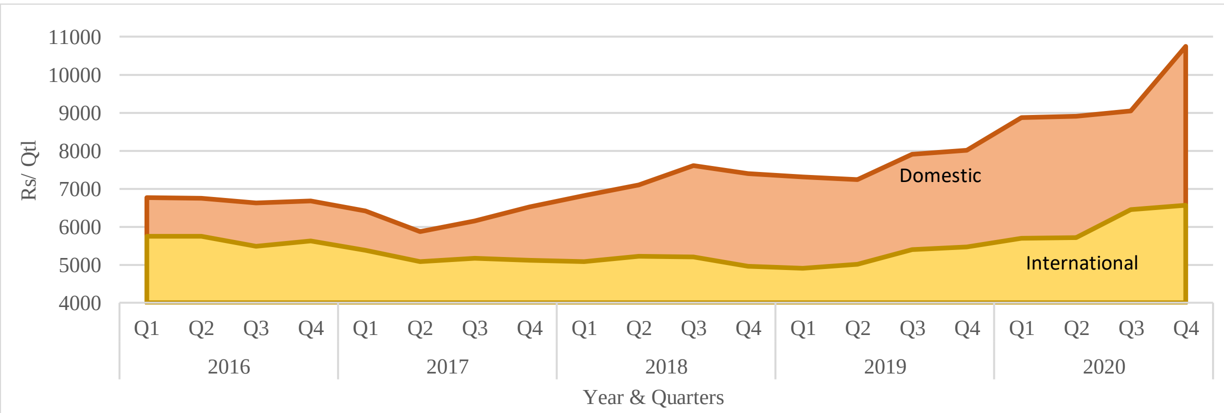


Source: Ministry of Consumer Affairs, Food & Public Distribution, 2022. [*https://dfpd.gov.in/oil-division.htm*](https://dfpd.gov.in/oil-division.htm)

The international prices of edible oil have normally been lower than domestic prices and keeping in tune with the principle of globalization, the imports of edible oil flourished while the domestic sector remained stunted (Figure 9.2 and 9.3). The tariff structure for edible oils have undergone several revisions with a view to protect the domestic industry as well as consumers of edible oils.

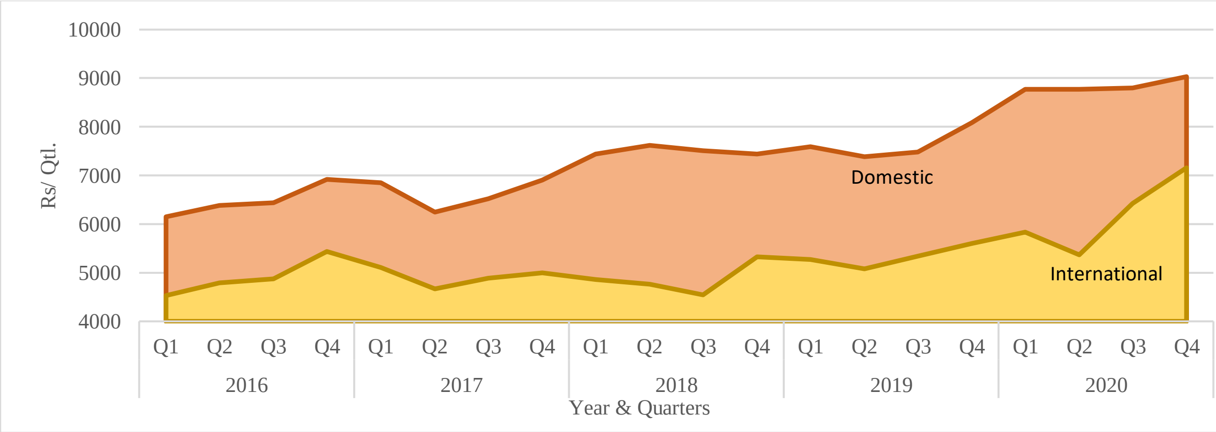
It can be observed from Figure 9.2, that the price of sunflower oil in the international market was lower than domestic prices by 19 percent in 2016 and by 54 percent in 2020. In case of soybean oil (Figure 9.3), the international price was 32 percent lower than domestic price in 2016 and 43 percent lower in 2020.

Figure 9. 2: Domestic and international prices of sunflower oil: 2016 to 2020



Source: Commission on Agricultural Costs and Prices, MoA&FW, 2021

Figure 9. 3: Domestic and international prices of soybean oil: 2016 to 2020



Source: Commission on Agricultural Costs and Prices, MoA&FW, 2021

Rising Wholesale Price Index (WPI) of Oilseeds

The Wholesale Price Index (WPI) for oilseeds and edible oils indicates an increasing trend in domestic economy in past decade with a sharp increase in recent years from 2020-21 to 2021-22 (Table 9.2). The WPI for oilseeds increased by 32.6 % from 2020-21 to 2021-22 and notably that of soybean increased by 61 % during the corresponding period. The WPI of edible oil increased by 28 % from 2020-21 to 2021-22, thus contributing to inflation.

Table 9. 2: Wholesale Price Index for Oilseeds and Edible Oils (Base 2011-12=100)

Year	Oilseeds	Groundnut Seed	Safflower Seed	Sunflower seed	Soybean seed	Edible oil
2012-13	126.8	120.5	114.4	112.0	149.4	106.3
2013-14	125.6	108.2	113.7	114.3	157.5	104.0
2014-15	129.2	106.9	99.0	108.7	154.6	102.0
2015-16	136.6	127.9	107.4	114.5	151.1	98.7
2016-17	136.0	138.2	114.0	111.5	143.8	107.0
2017-18	129.9	122.5	135.0	99.8	129.9	109.4
2018-19	140.5	118.3	145.0	112.7	150.1	117.6
2019-20	151.4	142.5	185.3	121.1	164.0	119.3
2020-21	161.7	154.8	162.2	129.6	174.6	143.5
2021-22	214.4	164.2	196.8	174.5	280.8	184.0
Growth Rate (2012-13 to 2020-21)	3.1	3.2	4.5	1.8	2.0	3.8
Growth rate (2012-13 to 2021-22)	6.0	3.5	6.2	5.1	7.3	6.3

Source: Agricultural Statistics at a Glance, 2020, MoA&FW, 2021; https://www.ceicdata.com>india>consumer-price-india

The country is heavily dependent upon imports for meeting the edible oil consumption of the population. This has often caused hardships to all stakeholders, i.e., producers, consumers and oil processors. In order to reconcile the requirements of all stakeholders, the government has resorted to trade and continuously changed the tariff structure from as low as 7.5 percent to as high as 90 percent. However, while trade has its benefits so that cheap imports can benefit consumers, it also makes the economy vulnerable to external shocks such as huge spurt in international prices due to geo-politics, supply constraints in export markets, and export policies of other countries. Such situations have arisen in the recent past which have all caused the WPI of oilseeds and edible oil to increase. However, the demand for edible oils is continuously increasing and dependence upon imports has brought about huge increase in price for consumers as indicated in Table 9.3.

Table 9. 3: Consumer Price Index (CPI) for 'Oils and Fats' (Base 2011-12)

Year	Rural	Urban	Total
2013	107.0	102.0	105.2
2014	110.0	103.2	107.5
2015	113.9	106.6	111.2
2016	119.5	110.7	116.3
2017	121.4	114.2	118.8
2018	123.7	117.1	121.3
2019	124.9	119.8	123.0
2020	139.1	132.8	136.7
2021	183.7	166.7	177.7
CAGR	6.99	6.34	6.78

Source: eaindustry.nic.in

It is clear from Table 9.3 that there was a sharp increase in CPI for 'Oils & Fats' by 30 % from 2020 to 2021 mainly due to dependence on imports to satisfy domestic consumption. This increase in price causes inflationary pressure in the economy which in turn may bring about overall instability in other sectors. In such cases intervention by RBI to control inflation may not help but the real solution lies in increasing the supply of edible oils in the country. Hence the country should be self-sufficient in producing edible oils which is an important commodity in the consumption basket of consumers and also promotes the agro-processing sector.

Technology and institutional factors play an important role in promoting self-sufficiency in the edible oilseed and edible oil sector. The view from industry was also captured in order to understand the constraints in the edible oilseed and oil sector so that policy can be suitably addressed.

Industry perspective on oilseed sector

It is clear that there is need to increase the supply of edible oils so as to cope up with the increasing demand. Discussion was therefore held with industry experts who own oil processing units, so as to get a clear understanding on issues that plague the oilseed sector.

A number of soybean oil processing units are located in Latur and Nanded in Maharashtra and detailed discussions with personnel of such units revealed that although Maharashtra is a major soybean growing state, there is still scope to improve the productivity. The proprietor of an oil processing unit which sells soybean oil under the brand name *Vijay Soya Agro*, revealed that the domestic oil sector responds immediately to international forces, and has therefore become very volatile. However, in order to reduce dependence on imports and bring in self-sufficiency in edible oils, it is important to take two crops of soybean in a year. This is possible and is being experimented by some farmers. However, scaling up the cropping of soybean two times a year successfully, would require research by agricultural scientists to develop seeds which will suit the poor quality of soil in Marathwada which is the main soybean region of the state. The soil in Marathwada is hard and if drought resistant seeds are developed for soybean, it will help to increase productivity. Also, if there is sufficient moisture in the soil, it is possible to take another crop of soybean. Whenever the oil processing units face shortage of the raw material, they import from countries such as Ethiopia in order to meet their shortfall. Hence increase in domestic production would help to increase the production of oil and the country would be less dependent upon imports of edible oil. It was also revealed that farmers get up to date information on prevailing prices, which serve as a signal on crop allocation. Overall, the most important point raised by the oil processing unit was that it is necessary to promote technology with respect to seeds so that the seed is suitable for the soil and agro climatic conditions of Marathwada. It was also revealed that efforts are being made for water harvesting, recharge of ground water, etc which will help to increase yield.

Another detailed discussion was held with the Vice President, Soybean Processors Association (SOPA) of India. He mentioned that the government must have a stable policy with respect to imports of edible oils and all stakeholders must be involved in making any trade policy. This will bring less volatility in the edible oil sector and farmers too would be able to systematically plan the area under the crop.

It was stressed upon by SOPA that soybean processing turns out about 18 to 20 percent of oil, while the remaining 80 percent is de-oiled soya cake. This de-oiled soya cake is rich in protein and serves as an important ingredient in poultry and other livestock feed. However, post lockdown, while the price of poultry declined, that of de-oiled soya cake increased sharply from Rs 40 per kg to Rs 100 per kg. The increase in prices of de-oiled cake was due to steep rise in price of soybean, which reached historic highs due to shortage of the commodity in the domestic and international markets. The price of soybean increased by about 30 percent or more, between September 2021 and November 2021. This obviously made livestock feed costlier and the sector was already reeling under stress because of decline in poultry price due to pandemic. With pressure from poultry and related sectors, the government relaxed the rules for import of crushed and de-oiled soya cake (Non living organism only), so as to reduce their input cost. However, this decision served as a setback to soybean prices and this is likely to have negative impact on the area under soybean cultivation. Due to imports of de-oiled soya cake, the domestic industry is likely to suffer. While the normal requirement of soya meal is 6 million tonnes, the production is about 7.5 million tonnes and hence there is surplus production in the domestic sector.

Therefore, any policy to promote import of de-oiled soya meal will be detrimental to the domestic industry as well as farmers. The import of de-oiled soya cake led to fall in prices of soybean which in turn will impact the area allocated to soybean. Hence again the government will become dependent upon import of oil to meet the increasing demand. However, government intervention to arrest the price of soybean was not only confined to allowing imports of de-oiled soya meal. It reduced the import duty of soya oil to zero and also banned futures trading on soybean seed and derivatives. The purpose of the ban was to restrict any scope for speculation in soybean and thus help to arrest the price rise. These ad hoc measures bring instability in the oilseed sector and serve as a constraint to any stable policy which will promote self-sufficiency in the edible oil sector.

Another proprietor of a major oil processing unit, which sells edible oils under the brand name, *Kirti Gold*, also expressed concern about allocation of Tariff Rate Quota (TRQ) for import of two million tonnes crude soybean oil and crude sunflower oil. The purpose of imposing TRQ is to arrest the rise in domestic prices of edible oils which is contributing to inflation. However, the view of industry was that promoting imports will certainly harm the farmers as well as local producers of oil. Since the demand for edible oils is greater than supply, in order to meet the shortfall, the government must encourage the farmers to allocate area to oilseed crops and further develop technology to increase the yield of these crops. Further, mechanisms such as increase in Minimum Support Price must serve as a price incentive to induce the farmers to increase the acreage under oilseed crops. Hence rather than reducing tariffs and imposing TRQ, the government must resort technology and price incentives to increase the productivity and production of oilseed crops. This will also bring about a stable policy in the domestic oilseed sector and go a long way in making the country self-sufficient in edible oils.

Overall, the government therefore made several interventions in the oilseed sector in order to arrest the prices of soybean, protect livestock sector through relaxation of imports of de-oiled cake and overall control inflation. Such intervention by the government reduces the price, and farmers become reluctant to increase the area under cultivation. In order to become *Atma Nirbhar* or self-sufficient in the production of soybean and other oilseeds, it is important to have a stable domestic and trade policy. Sudden interventions to arrest the rise in price, continues to have long term impact. For example, the price of soybean began to decline due to measures such as allowing imports of de-oiled meal, ban on futures and fixing stock limits of soya meal with traders. However, while these measures lead to sudden fall in prices, the farmers react by withdrawing their supplies from the market and prefer to hold their stocks in the hope of obtaining higher prices in future. Thus, the industry does not get adequate raw material which may restrict crushing of soybean and hence lead to limited production of de-oiled cake. Poultry firms and other livestock units face the brunt of this situation and again put pressure on the government to ease imports. Thus, there is again dependency on imports and instability in the oilseed sector.

The real answer to the problem is to increase the yield through technology, which will benefit both industry and farmers. Increase in production of de-oiled cake will help the industry to export soya meal which is in great demand in the international markets as the de-oiled cake produced in India is not produced from *genetically modified* soybean seeds. There are very few countries in the world, mainly located in Africa which produce soybean, that is not *genetically modified*. India has this advantage and must therefore capitalize on it. However, efforts must be made to become more competitive in global markets, as there are several countries which can export de-oiled cake at lower prices. Hence policy measures by the government often serve as a detrimental factor to increasing production of soybean. There is also often shortage of seeds, especially of good quality, which acts as a major constraint for farmers during the sowing season. Besides shortage of seeds, the other problem was that of spurious seeds. Whenever there is a shortage of seeds, poor quality seeds which do not germinate, begin to enter the market. Farmers often buy these seeds, but after sowing, the seeds, they are unable to reap a harvest. This not only causes a shortage of the crop for the economy as a whole but also the farmers suffer hardships as they have invested in other inputs such as fertilizer, labour, etc but it turns out to be a dead investment. In order to meet the shortfall in production, the country has to again resort to imports. Overall, it was revealed by SOPA, that the government does not have a stable policy for oilseed production and therefore for the edible oil sector. The policies are ad hoc without any long-term planning.

The oil industry stakeholders also revealed that machinery for processing the seeds into oil was modern and quite up to date. The technology is needed with respect to producing the oil seeds. Hence high-quality planting material, protective irrigation in drought years and machinery for harvesting suitable for small farms must be promoted.

Discussion was held with stockists of soybean in Maharashtra and they revealed that imports do serve as a setback for oil processing units as well as for farmers. More domestic production of oilseeds will increase the capacity utilization of the plant as often industry has to depend upon imported seeds from other countries for raw material. It was also aired that with good agricultural practices, there is scope to increase the yield by at least 30 percent. Another major problem is that of storage losses. High quality warehouses do not bring about storage losses and there is need to invest in warehouses so that the produce remain in good condition, leading to more production of oil.

Overall, the industry perspective with respect to oilseed sector was that the real constraint lies in the production and availability of soybean seeds. There is dire need for technology interventions in seeds which should be drought resistant and suit the soil conditions. It is also possible to cultivate soybean crop two times, provided there is suitable input management. As far as machinery to convert raw material into oil is concerned, the view was that it is fairly modernized with considerable crushing capacity per day. Also, a suitable and stable domestic and trade policy must be framed, so that there are no major fluctuations in prices and farmers get remunerative returns without hurting the price that is paid by consumers. Frequent changes in tariff rates have had a negative impact on area under soybean cultivation and tariffs must not be used as a weapon to control edible oil prices in the domestic economy, but instead through technology and institutional mechanisms, the country must become self-sufficient in edible oil so as to balance demand and supply.

Chapter 10: Summary, conclusions and policy suggestions

Oilseeds are an important field crops grown in many parts of India. At present, the country is not able to meet the demand of edible oils. The existing low yield of these oilseed crops which are grown in unirrigated or less irrigated regions in many parts is an important reason to not able to increase and sustain the oilseed production. India is lagging as compared to the other major oilseed growing countries in the world. There is a lot of variation in oilseed yield among the major producing state within the country and among the major producing districts within the growing states. There are various factors impacting the yield and hence the production of oilseeds is dragging India to become the net importer.

The edible oil consumption has also increased many folds during past four decades, about 19.2 kg of edible oil per capita per year in India in year 2019-20 as compared to 3.8 kg per capita per year during year 1980-81, to raise the demand of the edible oils to the all-time high level. The unmet demand managed through the surging imports, followed by the unfavourable global situation such as climatic and the war like situations have impacted the price of edible oils and related products. This is a high time for the country to invest in yield improvement measures along with precision technologies of oil extraction, organised industrial operations, focusing on the secondary and other alternative sources of edible oils.

This study highlights the global and Indian oilseed and edible oil production focusing on the oilseed yield at the core. The yield gaps in the major oilseed crops are presented at the global level and within the state and district level in India. For this purpose, majorly the secondary data sources are used to reflect the trend, variations and growth rates in oilseed yields. For this purpose, the major states and districts with high acreage under the oilseed crops are selected using a suitable sampling methodology to mainstream the focus on important states and districts. The presentation of the yield gaps is preferred through the state and district level mapping to highlight the lagging regions. The yield gaps in the yield at the demonstration level results of KVKs and at the farmers plot are also highlighted to reflect the lagging status of oilseed yield within country. This is supplemented through the variety level yield performance of different oilseeds crops for major producing states. The factors impacting the yield of oilseed crops are elaborated using the secondary data based on CoC database and also through the primary data collected from field survey. The perceptions of the households on important ground level issues impacting crop yield are also discussed. The status of oilseed and edible oils' trade during recent two decades is discussed and an attempt is made to highlights India's potential to produce edible oil from secondary alternative sources.

Yield gaps in oilseeds

The average yield of selected edible oilseed crop at the global level has increased about 2.7 times from the historical levels of 1961. It took about four decades to oilseed yield get doubled during in 2000, and additional two decades to reach at 2.7 times in 2019. The oilseed acreage also increased about 3.3 times till 2019 from 1961. Hence, reflected the production increase of 8 times till 2019 as compared to 1961. The major oilseed crops produced from the field crops in the world are soybean, 'rapeseed & mustard', sunflower seed, groundnut and sesame seeds. Indonesia is the largest producing country of tree born oilseed from palm fruits, followed by Malaysia and other minor producing countries - Thailand, Nigeria and Colombia. At the global level the yield of palm, groundnut, sesame seed mustard and castor seed witnessed stagnation or decline in the recent decade 2011 till 2019.

India stands 5th in global oilseed production from field-based crops with 6% production share as of 2019 from close to 11% of global acreage share, stands 3rd in global acreage share. Brazil is the largest producing country of the oilseeds, holds about 22% of total oilseed production, followed by USA, Argentina and China in this order. Palm fruit and oil production in India is negligible as compared to other major producing countries. India is also among the top producing countries in the world of many of the edible oilseeds and also one of the top consumers of the edible oils. The domestic consumption of major selected vegetable oils in India is close to 10.7% of world consumption. India also accounts for about 17.2% import of these selected major vegetable oils. At the crop specific level, India is world's largest producing country of castor seed, the second largest in groundnut production, third largest in rapeseed and sesame seed production, fifth largest in soybean production and sixth largest producing country of sunflower seed and linseed in the world as of year 2019.

But the country is witnessing a low yield of many of the oilseeds produced in India as compared to most of the other major global producing countries. The yield of soybean in India in 2019 is less than the yield of all other major producing countries in year 2000. India reported the 'yield gaps' by nearly two-third of the yield of soybean and groundnut as compared to the 'highest yield' country and the 'largest producing' country of these oilseed crops. The yield of rapeseed, sunflower, linseed, safflower and sesame in India is almost at the lowest level among the major producing countries except a few cases. The yield of castor seed is high in India hence standing country as the largest producing country of castor seed and oil in the world.

India produced about 116.3 lakh tonnes of edible oil from the primary and the secondary sources in 2019. The edible oil production in India witnessed an annual growth of about 2.2% since 1995-96 till 2019-20, the growth is majorly contributed from the secondary sources holding low base in combined edible oil production reflects the increasing share of alternative edible oils in India’s edible oil basket. There is demand shift towards the edible oils in India over a period of time. But the production targets set for the oilseed production are hardly achieved in past many years compared to the targets set for wheat and paddy production. Among major oilseeds, soybean is the largely grown oilseed crop in India holds about 34% production share in 2019-20, followed by groundnut (30%), rapeseed-mustard (27.5%). Rajasthan, Gujarat, Madhya Pradesh and Maharashtra are the largest oilseed producing states in India. There is about 16.3% of area under nine-oilseeds of the total area shown in 2020-21 under the major food groups. Measures to be taken to enhance the productivity of these oilseed crops considering limited acreage allocation options and to reduce dependency on imports and to fulfil the unmet demand of edible oils. Though, the yield of most of the oilseed crops is improved over time but the yield of some of the minor oilseed crops it is still very low levels.

At the state level

The state level yield growth is analysed for each of the major oilseed crops for three phases - phase I (from 1966 to 1985), phase II (from 1986 to 2004) and phase III (from 2005 to 2019). For most of the oilseed crops the yield growth during three phases (phase I -from 1966 to 1985, phase II -from 1986 to 2004 and phase III - from 2005 to 2019) witness positive side except few cases – soybean and safflower during phase I & III, sunflower during phase I and Niger seed during phase II. Groundnut, sunflower and Linseed witnessed a positive yield rate over the phases while safflower and castor seed reflected a positive but declining rate over the periods mainly due to high initial growth. Rapeseed & mustard and sesame witnessed stagnating growth and soybean and no clear direction of growth is noticed for Niger seed over the study phases.

In general, for most of the oilseed crops, the yield volatility is ranging from 10% to 20% range except few cases of high yield variability such as safflower and castor seed during phase I and phase II; and groundnut and Niger seed during phase III. Similarly, the decomposition analyses suggest, the change in oilseed production during phase I and phase III is mainly contributed due to increase in yield of different oilseed crops but during the phase II, change in area and yield equally contributed the production increase, also reflected through the combined interaction effect. For soybean, the change in production is mainly driven by the area effect during all the three phases. Contrary to this, for groundnut and for rapeseed & mustard, with less clarity, the change is driven mainly due to the change (increase) in yield, especially during phase I and III.

Based on the yield gap analysis, an attempt is made to abstract the summary of the analysis at the state level in the following table (Table 10.1).

Table 10. 1: Major oilseed crops - yield levels by region and states

Crop	High yield			Low yield		
	Region	States	Comment	Region	States	Comment
Soybean	South	Telangana, Karnataka	States hold 4% area share. Not much improvement in yield	West, Central	Rajasthan, Maharashtra, Madhya Pradesh	States hold 95% area share. Yield stagnated around 0.8 to 1.2 T/Ha.
Groundnut	South, West	Tamil Nadu, Gujarat, Rajasthan	States hold 26% area share. Yield improved overtime from 0.62 to 3.92 T/Ha.	South	Andhra Pradesh, Karnataka	States hold 24% area share. nearly 2.5 times to 3 times lower yield w.r.t. high yield states
Rapeseed & mustard	North	Haryana	9-10% area share, Yield improved about 2.3 times from 1985-86	Central, West East	West Bengal, Rajasthan, Madhya Pradesh Uttar Pradesh	States hold 75% area share, Yield improved but not much, 0.66 to 1.56 T/Ha.
Sesame	East	West Bengal	16% area share, high base yield, yield stagnated around 0.6 to 0.8 T/Ha.	North, West, Central	Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat	States hold 65% area share, yield stagnated around 0.1 to 0.6 T/Ha.
Sunflower	North, East	Haryana, Odisha	States hold 11% area share; better yield in HR (1.6 to 1.9 T/Ha.), yield improved in OD (0.5 to 1.25 T/Ha.)	South, West, East	Maharashtra, Karnataka and Andhra Pradesh	States hold 72-73% area share, yield stagnated around 0.4 to 1 T/Ha.
Safflower	South	Karnataka, Telangana	States hold 54% area share, high base yield, yield stagnated around 0.5 to 0.8 T/Ha	Central, South, West	Andhra Pradesh, Jharkhand and Maharashtra	States hold 44% area share, low yield, yield stagnated around 0.3 to 0.6 T/Ha
Castor	West	Gujarat, Rajasthan	States hold 90% area share, high base yield, In GJ yield stagnated around 1.2 to 2 T/Ha; In RJ yield improved from 0.2 to 1.4 T/Ha	South, West	Maharashtra, Telangana and Andhra Pradesh	States hold 7-8% area share, low yield, yield stagnated around 0.2 to 1 T/Ha
Linseed	North, Central	Uttar Pradesh, Madhya Pradesh	States hold 44% area share, low yield stagnated around 0.2 to 0.7 T/Ha	Central, East	Chhattisgarh, Jharkhand, Odisha	States hold 36-37% area share, low yield stagnated around 0.3 to 0.6 T/Ha
Niger seed	East	Assam	4% area share, low yield at 0.6 T/Ha	Central, East, West	Maharashtra, Madhya Pradesh, Chhattisgarh, Odisha	States hold 87% area share, low yield stagnated around 0.2 to 0.4 T/Ha

Source: Authors' computation

At the district level

An attempt is made to analyse the yield gaps of the major oilseed crops at the district level in major producing states utilizing the recent district level data for the year 2018-19. The emphasis is given to the major producing states. The production of many of the minor oilseed crops is concentric to a limited number of states and districts. The list of districts within the major producing states of oilseeds with specific geographical zone delivered low yields are reported in the following table (Table 10.2).

Table 10. 2: Major oilseed crops - yield levels by districts and state-regions

Crop	State	Districts with low yield
Soybean	Madhya Pradesh	Whole of the state (except Indore, Ashoknagar, Dhar, Shajapur)
	Maharashtra	Whole of the state (except Gadhchiroli, Kolhapur and Sangli)
Groundnut	Gujarat	Amreli, Rajkot, Jamnagar, Kuchchh, Porbandar, Junagarh and Surendranagar (West), Kheda, Sabar Kantha (North), Dang and Tapi (South east)
	Rajasthan	Whole of the state (except Churu, Jhunjhunu, Sikar and Bikaner districts)
Rapeseed & mustard	Rajasthan	Whole of the state (except few Eastern districts – Bharatpur, Dholpur, Alwar, Baran and Karauli)
	Madhya Pradesh	Whole of the Easter and Western part and districts of Northern part except Bhind and Morena
Sesame	Madhya Pradesh	Whole of the Central and East part; Bhind, Morena, Seopur, Shivpuri (North); Betul, Chhindwara, Seoni, Khandwa (South)
Sunflower	Karnataka	Koppal, Dharwad, Gadag, Chikmangalur, Haveri, Davangiri, Bagalkot (Central), Baijapur, Yadgir, Gulbarga (North), Raichur, Bellary, Chitradurga (East), Belgaum (West)
Safflower	Karnataka	Koppal, Dharwad, Gadag, Bagalkot (Central), Baijapur, Yadgir (North), Raichur, Bellary Chitradurga (East)
Castor	Gujarat	Kuchchh, Surendranagar, Amreli, Rajkot, Jamnagar and Junagadh (West), Panch Mahals, Bharuch, Ahmedabad, Kheda, Anand and Patan (East)
Linseed	Madhya Pradesh	Whole of the Easter part; Neemuch, Mandsaur and Ujjain (West)
Niger seed	Odisha	Sundergarh, Kendujhar (North), Makangiri, Kalhandi Gajapati, Kandhamal, Rayagada and Koraput (South west)

Source: Authors' computation

The yields at the 'farmer's plot' and at the 'demonstration' stage is reported by KVKs for major oilseed crops. The 'yield gap', at the farmer's plot compared to at the demonstration level are analyzed. At the aggregate state level responses from the KVK stations suggests, for soybean, Madhya Pradesh reported the highest yield gap between the demonstration level and at the farmer's plot, followed by Maharashtra. Among the minor producing states of soybean this gap is high in Chhattisgarh and Karnataka. For groundnut, the highest yield gaps are observed in Karnataka and Tamil Nadu (major producing states) and in Chhattisgarh, Maharashtra and Jharkhand (minor producing states). Rajasthan performed better in yield during both the phases, compared to other major states. For mustard, Haryana is the only state witnessed the highest yield during both phases, infect none of the other major such producing state able to reach at the 'plot' yield of Haryana during the demonstration level. Yield gaps reported high for Uttar Pradesh, Madhya Pradesh (major) and Chhattisgarh, Jharkhand and Assam (minor).

West Bengal performed better to deliver higher yield of sesame during demonstration stage and at the farmer's plot with low yield gaps, also witnessed in Gujarat. The higher yield gaps are observed in Karnataka (for sunflower), in Andhra Pradesh and Maharashtra (for safflower), in Chhattisgarh, Madhya Pradesh and Jharkhand (for Linseed) and in Odisha (for

Niger seed). The results of the yield gap analysis at the variety level reflects the widening the gap range across the varieties during actual implication. There are varying yield and the yield gaps for same variety across the states and KVKs.

Factors affecting the oilseeds' yield

An attempt is also made to analyse the factors affecting the oilseed yield at the state level using the secondary data and primary data sets. Using the secondary data from the plot level Cost of Cultivation (CoC) database from year 2000 to the latest available point, the oilseed yield is modelled using the Stochastic Frontier Analysis (SFA) and the technical efficiency scores at the state, cop and year specific level are analysed. The final model specifications were reached by comparing the fixed effect model and the random effect model using the Hausman test as prior diagnosis for SFA. The analysis resulted that there exists a positive and statistically significant relationship between labour cost and seed cost with yield. The fertilizer cost does not reflect much significance to the yield. The positive and statistically significant time coefficient representing technical progress taking place over the time for yield improvements. The coefficient of the exogenous variable irrigation cost is negative and statistically significant to technical inefficiency, i.e., contributing positive to technical efficiency (TE) achieved through irrigation to improve the yield. There is scope to enhancement yield up-to 34%, for safflower and groundnut; and 28% for soybean and rapeseed & mustard through better combinations of various inputs used. At the state specific, yield enhancement is still achievable in Rajasthan (for sesame seed) and Karnataka (for safflower).

The similar analysis of factor impacting the oilseed yield is also performed using the primary data gathered from the field surveys in the study states by the participating AERCs. The Ordinary Least Square regression model is applied to the dataset for major three major oilseed crops in study states. The results suggest that there is positive and significant effect of pest, manure and weedicide quantity use on soyabean yield in Madhya Pradesh, whereas, higher the seed, manure and weedicide cost impact the crop yield. In Maharashtra, higher the fertilizer use, seed use and machine cost, higher the crop yield, but the cost of fertilizers, higher fungicides and pesticides use impacted the yield, negatively. In Gujarat, the farmers used higher fertilizers, seeds and labours, does not get higher yield of groundnut but the farmers who invested more on labour, seed, fertilizer and irrigation charges (as proxy to higher irrigation with uniform applicable rates) get higher groundnut yield in the state. In Rajasthan, except the increasing machine and pesticide cost, all other factors such as – higher labour, machine and fertilizer use, higher cost incurred on seed and irrigation helped farmers to get better groundnut yield. For rapeseed & mustard, seed and fertilizer use, higher machine hours and farming experience have positive effect on crop yield in Rajasthan, whereas the increasing machine and irrigation cost impacts the crop yield.

Farmer's perceptions

About 50% sampled farmers are not satisfied with the yield they are getting. Only 44% are able to get the improved subsidized seeds and only one-third of the farmers received the trainings about oilseed production. Better coverage of crop insurance is an encouraging sign, especially for soybean but the coverage can be improved for groundnut. There is scope to improve the soil testing on regular basis. There is limited exposure of post-harvest management, especially for soybean. The groundnut farmers in Gujarat and the soybean growers listed the 'seed quality' and the farmers from Rajasthan listed 'climate factors' affecting the oilseed yield. There is scope to improve the availability of weedicides and fungicides/seed treatment facilities, beside these farmers are also not aware about the doses of these inputs. Most of the farmers in Maharashtra and more than half of the farmers in Rajasthan are impacted through drought in recent 5 years. The farmers are not satisfied with most of the inputs, especially of the fertilizers and pesticides, followed by that of weedicides. In general, the high input cost, effect of changing climatic condition and lack of irrigation facilities impacting yield of the dis-satisfying farmers. While, improving the input's quality, encouraging awareness of farmer through training programmes improving the irrigation facilities are the important suggestions from farmers to improve oilseed yield.

Broadly, the study highlights, in Maharashtra, the frequent prevailing drought conditions impacting the soybean yield leaving farmers with the less output available and hence denting the profit gains. In addition, the quality of seed and soil, fertilizer use and irrigation issues also influence the yield of the soybean. In Madhya Pradesh, the farmers growing soybean facing very limited or no exposure to trainings. limited awareness among the farmers on inputs use especially on seed treatment, fungicides, fertilizer and weedicides. The dissatisfaction among the farmers over the fertilizer, weedicides and seed treatment/fungicide prices. The farmers are not much aware on post-harvesting, and also face high transportation charges, lack of remunerative price and malpractices in market.

The groundnut growers in Gujarat face issues such as un-time availability of the fertiliser, pesticides and seeds during the season, crop losses due to bad quality seeds and wild animals, erratic rainfall as major problems. Farmers expects from government to encourage processing facilities to support groundnut selling in local regions. In Rajasthan, groundnut farmers are unaware about variety use, non-availability of human labour during weeding and harvesting time, erratic electricity supply for irrigation. Farmers are willing to get support on better irrigation, better marketing for groundnut and opening of processing facility in the local region.

In Rajasthan, the marginal and small farmers growing rapeseed & mustard are unaware on marketing related information and not able to get support price. The erratic electricity supply, untimely and non- availability of good quality of seed, irrigation related issues are the major problems for these farmers. The improved and high yielding varieties, technological extension, irrigation facility through regular electricity supply can help them to enhance the crop productivity. There is need to trained and aware the farmers on marketing related issues.

Prudence and optimism

Of the India's total import of edible oils of nearly 135 lakh tonnes as in 2020-21, nearly 56.4% share is of the palm oil, followed by soybean oil and sunflower & safflower oil. The import of edible oil is witnessed an annual growth of about 10.6% during the period of 1995-96 to 2019-20 as compared to annual growth rate of about 2.2% in production. India is importing edible oils in huge proportion but at the same time exporting the raw material - edible oilseeds and the by-products - oil cake in large quantity to the world. Indian edible oil market is much influenced by the international markets. The constant increase in consumption, low productivity of oilseeds and high price of traditional oils in India and low price in international market and liberalisation of trade policies resulted in the shift from self-sufficiency to highly import dependent in edible oils.

There is huge potential within the country to produce edible oil from secondary oil sources to reduce this import dependency through increase acreage under palm oil trees and ensuring raw material supply to the mills and other extraction points to produce oil from maize, rice bran and cotton seeds. The yield of oil palm fruits in India is comparatively very low at just 4.36 tonnes per hectare which is only above the yield in the Nigeria may be mainly due to being in initial phase of encouraging plantation. But the oil extraction rate from palm fruit is about 17% indicating positive signals. Andhra Pradesh is the largest producing state of the palm oil in India contributed nearly 83.5% production share in India followed by Telangana (13.3%). As per the assessment committee report in 2020, India can utilize nearly 28 lakh hectare acreage under palm trees plantation across the states. Assam, Tripura, Maharashtra, Arunachal Pradesh, Madhya Pradesh, Bihar and Meghalaya having potential to increase area above 1.2 lakh hectare in each. Considering the suggestions of the assessment committee, the potential production of fresh fruit bunches of palm in India can increase up to 126.27 lakh tonnes and the potential crude palm oil production can be increased above 6 times. This appears a reasonable better status as it will not be fulfilling the huge import gaps but will definitely reduce the dependency of India on the top imported edible oil. To fulfill the 'zero import' demand, and considering the best possible scenario, the country need to increase the current acreage under palm tree plantation by 48.5 times compared to the area under palm tree plantation as in March 2020, and by 6.15 times compare to the potential area assessments of the re-assessment committee-2020.

There is need to prepare a long-term road map through the central and state government coordination to explore the potential production of Rice bran, maize and cottonseed oils. To explore the potential of rice bran oil production in India, it is required to mainstream all the stakeholders from various rice clusters in India. The timely investment in enhancing the capacity building of the rice mills for better oil extraction may pay in the long run to meet the demand and reduce dependency on importing countries. The cautions need to pay to maintain the existing supply chain and the food security in India. The maize oil production has almost doubled in India in past few years. The crop is also an important raw material for various industrial uses. The edible oil production from the maize and cottonseed also has huge potential in India and to be further explored through formulating long term guidelines and policies on time. Further, there are expectations that the promotion of GM oilseed crops may increase oilseed production by nearly 15 to 20 %. Also, increasing the MSP for the edible oilseed can bring more acreage under oilseeds. Additionally, the impact of linking the import duty to the MSP may further be explored. Many of such planes are already demanded by various stakeholders over the time.

India's concerns on the edible oil import considering the challenging global situations to be addressed carefully and the country is progressing well in this direction, be it the recently slashed basic import duty on edible oils, reducing the agricultural infrastructure cess, cutting the import duty on various products, speculating the processors margins, revising the minimum support price and tracking and revising the interest rates to fight inflation etc. At the same time there is a need to take the long-term measures which can bring the country back to the minimum importing edible oils status.

The industrial perspective should also be considered while formulating the short- and long-term decision making on oilseed sector. There is need to include all stakeholders on policies on imports of edible oils and trade to reduce the volatility in the edible oil sector. This is also necessary to promote technology with respect to seeds to strengthen the oil processing units as per the demand. Many a times they face shortage of the raw material. Similarly, the stable policy making is required on the oil meal/cake trade as this can reduce the import burden through additional income to the country. Sudden interventions to arrest the rise in price, continues to have long term impact and may lead to additional import burden on the government. Stable domestic and trade policy can help to become self-sufficient in oilseed production. Increasing the oilseed yield through technology which will benefit both industry and farmers. It needs high-quality planting material, protective irrigation in drought regions and drought years and machinery for harvesting suitable for small farms. These is also need to invest in warehouses to reduce the storage losses.

Conclusions

For most of the oilseed crops, India's production share is high as compared to the acreage share at the global production and area, among the major producing countries. Reflects low yield of most of the oilseed crops in India compared to other countries, especially for the minor oilseed crops. This suggests that the country is missing or lacking some common factor which is hindering to enhance oilseed yield, be it the climatic condition, farming practices, input use resources, policy measures, technological laggardness for various operations, or many other factors. The farmer is one of the important stakeholders at the centre to reflect the results of the efforts made by all other stakeholders to improve the implementation inefficiencies caused by such factors. The past study findings as well as the present survey findings suggest that the farmers are not much aware about the input-use and technology-use precisions.

Many of the Indian farmers just have received the basic education and not much aware about the basic techniques and also have limited resources, most importantly the financial resources. There is greater need to invest in technological demonstration to the farmers. The theoretical trainings alone are not enough to encourage the farmers. Building a resourceful training network of field experts to provide basic common agricultural operational practices will help the farmers, especially the marginal and small farmers with limited exposure, knowledge and resources.

They also need authentic guidance about the input use, what is exactly needed for productivity enhancement out of various available inputs, their brands, compositions, doses, timings, requirements etc. Most of the cases, they follow what is influence them to use through the local venders based on their experience. There is need to enhance the supply of good quality, improved and hybrid seed varieties to the farmers before the sowing starts. Also, there is a need to encourage farmers about efficient water use practices and techniques. This will help to enhance yield, saving input cost to farmers and sustain the diminishing natural resources. There is also limited exposure of mechanization for the oilseed production in general, from field preparation, intermediary operations to the harvesting and digging operations. Considering the huge supply gaps, the farmers are needed to be encouraged to consider growing oilseeds as preferred choice, realising the better price expectations. Pin-pointing various regions for effectively adopting IPM, INM, RCT, CCP etc. where these practices need the most. Other than these yield enhancement centric measures, there is also need to support the production through enhancing the efficiency of the oilseed processing sector, enhancing production share of edible oil through secondary sources through raw and by product utilization for oil extraction such as rice bran, maize and cotton; region specific area enhancement under tree born oils such as oil palm; ensuring farmers interests while framing marketing, trade and price policies will also encourage farmers to stay in oilseed production.

Some specific highlights reflecting through this report indicates that:

- The yield of the minor oilseed crops in many producing states is still very low and have huge potential to support production. Also, the yield of many of the crops in some of the major states is stagnating over the time.
- There are huge yield gaps across the states, even in the same agro-regions and geographical regions, the lowest yield gaps are ranging from -42% to -86% for various oilseed crops.
- It is observed that the whole specific region or most of the districts of a particular region within the state reported the lowest yield of the oilseed crop.
- There is at least 16% to 45% higher yield across the major and minor producing states of major three of the oilseed crops during the demonstration phases as compared to the actual implementation at the farmer's plot. The yield gaps are ranging from at least 11% to 87% across the varieties during these two phases for major states.
- The crop-specific, states within crop specific and time-based efficiency analysis suggests that there is still about 30% scope to enhance the yield through using different combinations of inputs.
- The country can produce up-to 6 times to the present crude palm oil production if able to utilize this potential area for palm production as per the recommendations of the assessment committee report 2020. Also, there is huge unexplored potential to enhance edible oil production through rice bran, maize and cotton seed utilization.
- India is importing edible oils in huge proportion but at the same time exporting the raw material - edible oilseeds and the by-products - oil cake in large quantity to the world but the growth in oil export and oilseed export is exceeding the oil cake export, increased (about

10 times in value terms and about 4-5 times in quantity terms, 5-year period cumulative basis, since 2000-01).

- The less exposure to formal and technical education, limited resources, small land holding of farmers in India to take risk, followed by unawareness about input use and lack of training and demonstration impacts farmers agricultural decisions.
- Field survey highlights that the shortage of the improved and quality seed; limited or no exposure to trainings; limited awareness among the farmers on marketing related information, post-harvesting and inputs use especially on seed treatment, fungicides, fertilizer and weedicides; frequent prevailing drought conditions; timely availability of inputs etc. are major factors impacting oilseed yield.

Policy suggestions

i. There is need to pay special attention to increase the yield in states with high oilseed area but low crop yield. The specific states, regions within the states and the district withing the state regions with highest yield gaps are also need to be in focus in policy formulation.

ii. Emphasis should be on the major producing states of the oilseed crops with higher yield gaps during the demonstration phase and at the farmer's plot. Similarly, the varieties reflecting higher yield gaps need to be further explored.

iii. Considering the huge potential to utilize more acreage under tree-based oils, and oil extraction from other secondary sources, there is needs to invest on the primary and secondary oilseed industrial infrastructure such as mills and extraction points to meet the future requirement.

iv. The country has huge potential to balance the trade deficit of edible oil import through exporting the oilseed and edible oil based processed products but the high growth in oilseeds and edible oil export need attention.

v. Ensuring the timely availability of inputs to the farmers such as improved and quality seed along with other inputs is important.

vi. Provisions for frequent training and demonstration to the farmers on various theoretical and technical aspects, precision in input and resource use and on other related agricultural practices for yield enhancement.

vii. Efforts for a stable domestic and trade policy with a long-term vision including all the stakeholders on all edible oil products to strengthen industry and farmers to stabilize prices, technological developments, smooth flow of raw materials and to enhance the industrial efficiency.

viii. Priority to implement various past and present policy suggestions such as focus on the region-specific factors in research and investment; measures to increase the irrigation coverage; promoting pest-resistant and high yielding varieties; encouraging oilseeds production through secondary and alternative sources with focus on non-traditional areas and industrial capacity enhancement; research and investment in low-cost technology; promotion, training and demonstrations to aware farmers, provisions to encourage domestic competitiveness in the oilseed sector.

***

References:

- Ambika Rajendran. R, Nirupma Singh, Vinay Mahajan, D.P. Chaudhary, Sapna & R. Sai Kumar (2012). Corn Oil: An emerging industrial product. Directorate of Maize Research, New Delhi, Technical Bulletin, No. 8: 36 p.

- ANI News (2021), Centre planning to reduce import of edible oil by increasing production, awareness of rice bran oil: Food Corporation of India, Dec. 23, 2021 - https://www.aninews.in/news/national/general-news/centre-planning-to-reduce-import-of-edible-oil-by-increasing-production-awareness-of-rice-bran-oil-food-corporation-of-india20211223092004/
- Battese, G. E., & Coelli, T. J. (1992). Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. *Journal of productivity analysis*, *3*(1), 153-169.

- Bhatia, V. S., Singh, P., Wani, S. P., Chauhan, G. S., Rao, A. K., Mishra, A. K., & Srinivas, K. (2008). Analysis of potential yields and yield gaps of rainfed soybean in India using CROPGRO-Soybean model. *Agricultural and forest meteorology*, *148*(8-9), 1252-1265.

- Bhatia, V. S., Singh, P., Wani, S. P., Rao, A. K., & Srinivas, K. (2006). Yield Gap Analysis of Soybean, Groundnut, Pigeonpea and Chickpea in India Using Simulation Modeling: Global Theme on Agroecosystems Report No. 31.

- Bhattacharyya, A., Lovell, C. K., & Sahay, P. (1997). The impact of liberalization on the productive efficiency of Indian commercial banks. *European Journal of operational research*, *98*(2), 332-345.

- Bisaliah, S. (1977). Decomposition analysis of output change under new production technology in wheat farming: Some implications to returns on research investment. *Indian Journal of Agricultural Economics*, *32*(902-2018-1394), 193-201.

- Business Line (2021), ‘why-India-is-not-self-sufficient-in-oilseed-production, The Hindu – Business Line, Radheshyam Jadhav Pune, September 13, 2021. https://www.thehindubusinessline.com/data-stories/deep-dive/why-india-is-not-self-sufficient-in-oilseed-production/article36418723.ece

- Carnegie (April 2022), Why Indonesia’s Palm Oil Export Ban Could Backfire, April 28, 2022. https://carnegieendowment.org/2022/04/28/why-indonesia-s-palm-oil-export-ban-could-backfire-pub-87014

- Chand, R., Jha, D. and Mittal, S., (2004), WTO and Oilseeds Sector: Challenges of Trade Liberalisation, Economic and Political Weekly, Vol. 39, No. 6 (Feb. 7-13, 2004), pp. 533-537.

- Chandel, B. S. and Ramarao, D. (2003), “Investment in Oilseeds Research in India”, Economic and Political Weekly, Vol. 38, (43).

- Chhattrapati, A. C. (1980), Trends in Oilseeds Production, Economic and Political Weekly, Vol. 15, No. 37 (Sep. 13, 1980), pp. 1557-1561.

- CICR Technical Bulletin No. 25 – 2003. ‘Cottonseed oil quality utilization and processing’, Central Institute for Cotton Research, Nagpur, 2003. https://www.cicr.org.in/pdf/cottonseed_oil.pdf

- Dalheimer, B., Kubitza, C., & Brümmer, B. (2021). Technical efficiency and farmland expansion: Evidence from oil palm smallholders in Indonesia. *American Journal of Agricultural Economics, Vol 104,* No. 4, pp. 1364-1387.

- Dhandhalya, M. G., & Shiyani, R. L. (2009). Production potentials, yield gaps and research prioritization of production constraints in major oilseed crops of Saurashtra region. *Indian Journal of Agricultural Research*, *43*(1), 18-25.

- Economic times (2020), India’s rice bran oil imports from Bangladesh are set to double in 2020-21, Nov 15, 2020. https://economictimes.indiatimes.com/news/economy/foreign-trade/indias-rice-bran-oil-imports-from-bangladesh-are-set-to-double-in-2020-21/articleshow/79232823.cms

- Fischer, R. A., Byerlee, D. R., & Edmeades, G. O. (2009). *Can technology deliver on the yield challenge to 2050?* (No. 138-2016-2032).

- Fortune foods - fortune rice bran health oil. https://www.fortunefoods.com/oil/fortune-rice-bran-health-oil

- Global news wire (2020). Global Cotton-Seed Oil Market Insights 2007-2019 and Forecast 2020-2025, Feb. 2020. https://www.globenewswire.com/news-release/2020/02/25/1989783/0/en/Global-Cotton-Seed-Oil-Market-Insights-2007-2019-and-Forecast-2020-2025.html
- Gulati, A. and Sharma, A., (1997), Freeing Trade in Agriculture: Implications for Resource Use Efficiency and Cropping Pattern Changes, Economic and Political Weekly, Vol. 32, No. 52 (Dec. 27, 1997 - Jan. 2, 1998), pp. A155-A164.
- Gulati, Ashok, Anil Sharma and Deepali S Kohli (1996), 'Self-Sufficiency and Allocative Efficiency - Case of Edible Oils', Economic and Political Weekly, XXXI (13): A-15 to A-24.
- Hegde, D. M., (2012), Carrying capacity of Indian agriculture: oilseeds, Current Science, 25 March 2012, Vol. 102, No. 6 (25 March 2012), pp. 867-873.
- IASRI document - http://agridaksh.iasri.res.in/html_file/maize/Introduction_highoilcorn.htm
- ICAC – June 2019. 'Recent Developments in the Global Cotton Market: Cotton By-Products', Presentation by Kai Hughes, Executive Director, International Cotton Advisory Committee – June 2019. https://www.wto.org/english/tratop_e/agric_e/item_3_icac_wto_cotton_by_products_june_2019_final.pdf
- Imarc group - https://www.imarcgroup.com/rice-bran-oil-processing-plant
- Jat, R.S., Singh V.V., Sharma Pankaj and Rai, P.K., (2019), "Oilseed Brassica in India: Demand, Supply, Policy Perspective and Future Potential", ICAR-Directorate of Rapeseed-Mustard Research.
- Jha, G. K., Pal, S., Mathur, V. C., Bisaria, G., Anbukkani, P., Burman, R. R., & Dubey, S. K. (2012). *Edible oilseeds supply and demand scenario in India: Implications for policy*. Division of Agricultural Economics, Indian Agricultural Research Institute.
- Jha, Girish Kumar, (2011), "Yield Gap Analysis of Major Oilseeds in India", Journal of Community Mobilization and Sustainable Development, Vol. 6(2), pp. 209-216.
- Jhala, M. L. (1984), Restructuring Edible Oil and Oilseeds Economy of India, Economic and Political Weekly, Vol. 19, No. 39 (Sep. 29, 1984), pp. A111- A128
- Kalirajan, K. (1981). An econometric analysis of yield variability in paddy production. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, *29*(3), 283-294.
- Kidula, N., Okoko, N., Bravo-Ureta, B. E., Thuo, M., & Wasilwa, L. (2010, November). A preliminary analysis of yield gaps in groundnuts between research and non-research farmers in Kenya. In *12th KARI Biennial Scientific Conference, Nairobi, Kenya, November* (pp. 8-12).
- Külekçi, M. (2010). Technical efficiency analysis for oilseed sunflower farms: a case study in Erzurum, Turkey. *Journal of the Science of Food and Agriculture*, *90*(9), 1508-1512.
- Kumar, V. and Tiwari, A. (2020), Sparking Yellow Revolution in India Again, Rural Pulse, NABARD, Issue – 34, June-July 2020.
- Kumbhakar, S. C. (1990). Production frontiers, panel data, and time-varying technical inefficiency. *Journal of econometrics*, *46*(1-2), 201-211.
- Malathi, B., Prasad, Y. G., Reddy, A. R., Jogamba, N. S. R., Appaji, C., Prasad, J. V., & Singh, A. K. (2019). Bridging Yield Gaps in Oilseeds through Cluster Frontline Demonstrations-Experiences of KVKs.
- Meena, B. L., Meena, R. P., Meena, R. H., & Balai, C. M. (2016). Yield gap analysis of rapeseed-mustard through front line demonstrations in agro climatic zone IVa of Rajasthan. *Journal of Oilseed Brassica*, *1*(1), 51-55.
- Minhas B.S. and A. Vaidyanathan (1965), "Growth of Crop Output in India: 1951-54 to 1958-61 – An Analysis by Component Elements", Journal of Indian Society of Agricultural Statistics, Vol. 17, No. 2, December.
- Mitra, A. (1999). Total factor productivity growth and technical efficiency in Indian industries. *Economic and Political Weekly*, M98-M105.

- Nabard (2020), Sparking Yellow Revolution in India Again, Rural Pulse, Dr. K.J.S. Satyasai, June-July, 2020, NABARD, Mumbai. https://www.nabard.org/auth/writereaddata/tender/2106212557Rural%20Pulse%20Issue%20XXXIV%20(1).pdf
- Nainwal, K., Shiv, D., & Singh, B. D. (2019). Comparative yield gaps, economic analysis and constraints in frontline demonstrations of black Soybean (Glycine max L. Merril) under Rainfed Conditions in Uttarakhand hills. *J. of Pharmacognosy and Phytochemistry*. *SP2*, 926-928.
- Nayik, Gulzar & Majid, Ishrat & Gull, Amir & Muzaffar, Khalid. (2015). Rice bran oil, the Future Edible Oil of India: A mini Review. Journal of Rice Research. https://www.researchgate.net/publication/282356727_Rice_bran_oil_the_Future_Edible_Oil_of_India_A_mini_Review
- Nehbandani, A., Soltani, A., Rahemi-Karizaki, A., Dadrasi, A., & Noubakhsh, F. (2021). Determination of soybean yield gap and potential production in Iran using modelling approach and GIS. *Journal of Integrative Agriculture*, *20*(2), 395-407.
- Ninan, K. N., (1987), Edible Oilseeds: Growth and Area Responses, Economic and Political Weekly, Vol. 22, No. 39 (Sep. 26, 1987), pp. A97-A110.
- Ninan, K. N., (1989), Self-Sufficiency in Oilseeds: Within Grasp or Elusive Goal? Economic and Political Weekly, Vol. 24, No. 39 (Sep. 30, 1989), pp. A133-A135.
- Nyein, K. M., Sirisupluxana, P. and Titapiwatanakun, B., (2013), Trade Liberalization Effects on Myanmar's Oilseed Markets, Journal of Southeast Asian Economies, April 2013, Vol. 30, No. 1 (April 2013), pp. 77-90.
- Pattnaik, I., & Shah, A. (2015). Trends and decomposition of agricultural growth and crop output in Gujarat: Recent evidence. *Indian Journal of Agricultural Economics*, *70*(902-2016-68377), 182-197.
- Pawar, Y., Malve, S. H., & Patel, G. J. (2017). Assessing yield gap analysis of groundnut through cluster front line demonstration in Banaskantha district of Gujarat. *Guj. J. Ext. Edu. Special*, (32-35).
- Persaud, S. C., & Landes, M. R. (2007). *The role of policy and industry structure in India's oilseed markets* (No. 1477-2016-121064).
- Prochorowicz, J., & Rusielik, R. (2007). Relative efficiency of oilseed crops production in the selected farms in Europe and the world in 2005. *Acta Scientiarum Polonorum. Oeconomia*, *6*(4), 57-62.
- Rao, V. Ranga (1991), 'What Catapulated the Vegetable Oilseed Sector from out of its Decade Old Inertia? Two Successive Good Monsoons or Wonder Technologies?' Journal of Oilseed Research, 8: 59-66.
- Reddy, A. (2009), Policy Options for India's Edible Oil Complex, Economic and Political Weekly, Vol. 44, No. 41/42 (October 10-23, 2009), pp. 22-24.
- Rice Bran and Rice Bran Oil: Chemistry, Processing and Utilization, Book Ed. Ling-Zhi Cheong and Xuebing Xu, Academic Press and AOCS Press, Elsevier Inc. 2019. https://doi.org/10.1016/C2016-0-02191-5 https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/rice-bran-oil
- Sharma, V. P. (2014). Problems and prospects of oilseeds production in India. *Indian Institute of Management (IIM), Ahmedabad*.
- Sidhu, S. S. (1974). Relative efficiency in wheat production in the Indian Punjab. *The American Economic Review*, *64*(4), 742-751.
- Singh, N. U., Das, K. K., Roy, A., & Tripathy, A. K. (2015). Estimation of growth rate and decomposition of output components of oilseed: A comparative study among the States of North East. *Indian Journal of Hill Farming*, *28*(2).
- Singh, P. K., & Ahmad, N. (2019). Identification of Factors Influencing Yield Gap of Rapeseed and Mustard in Bihar (India)-A Micro Level Analysis. *Ind. J. Pure App. Biosci*, *7*(5), 429-432.

- Sivala, Kumar & Adhikary, Rahul. (2020). Corn Oil -An Untapped Source of Edible Oil in India. IOSR Journal of Engineering. 10. 1-4.
- The business line (2022), What Indonesia's palm oil export ban means for India – April 29, 2022. https://www.thehindubusinessline.com/blexplainer/bl-explainer-what-indonesias-palm-oil-export-ban-means-for-india/article65366502.ece
- The Economic Times (2021), Demand for corn refined oil picks up, production doubled in 4 years, – April 20, 2021 - https://economictimes.indiatimes.com/markets/commodities/news/demand-for-corn-refined-oil-picks-up-production-doubles-in-4-years/articleshow/82166035.cms
- The economic times (2022), Food protectionism ramps up as Indonesia bans palm oil export, April 29, 2022. https://economictimes.indiatimes.com/small-biz/trade/exports/insights/food-protectionism-ramps-up-as-indonesia-bans-palm-oil-exports/articleshow/91167554.cms
- The financial express (2017), India does a first on cottonseed oil, set to import as international prices turn cheaper than domestic ones, Dec. 8, 2017. https://www.financialexpress.com/industry/india-does-a-first-on-cottonseed-oil-set-to-import-as-international-prices-turn-cheaper-than-domestic-ones/965413/
- The Hans India (2021), Government working to optimise rice bran oil production, Oct. 24, 2021 - https://www.thehansindia.com/business/government-working-to-optimise-rice-bran-oil-production-712310
- The Indian Express (2022), Edible oil to get costlier amid Russia's invasion of Ukraine, Parthasarathi Biswas, February 24, 2022. https://indianexpress.com/article/cities/pune/edible-oil-to-get-costlier-amid-russias-invasion-of-ukraine-7788758/
- The live mint (2022), Edible oil prices in India to surge as Indonesia to ban palm oil exports from 28 April, April 23, 2022. https://www.livemint.com/news/india/edible-oil-prices-in-india-to-surge-as-indonesia-to-halt-palm-oil-exports-11650684747240.html
- The print (2021), Govt's plan to tackle edible oil price rise: Push for domestic rice bran oil production, Oct. 22, 2021 - https://theprint.in/economy/govts-plan-to-tackle-edible-oil-price-rise-push-for-domestic-rice-bran-oil-production/755133/
- The tribute (2018), Rice bran oil extractors make a killing; farmers left in lurch, Aug. 9, 2018 - https://www.tribuneindia.com/news/archive/business/rice-bran-oil-extractors-make-a-killing-farmers-left-in-lurch-634302
- Venkateswarlu and Prasad, J. V. N. S., (2012), Carrying capacity of Indian agriculture: issues related to rainfed agriculture, Current Science, 25 March 2012, Vol. 102, No. 6 (25 March 2012), pp. 882-888.
- Wikipedia - Rice bran oil, https://en.wikipedia.org/wiki/Rice_bran_oil

Annexures

Appendix 1

Agricultural Economics Research Centre - Delhi

Study on 'Estimating and Bridging the Yield Gaps in Oilseeds for Atam Nirbhar Bharat': Survey questionnaire

Funding Agency : *AER Division, Ministry of Agriculture& Farmers' Welfare, Govt. of India, New Delhi*

Coordinating Centre : *AERC, Delhi*

Partner AERC : *(i) AERC, Vallabh Vidyanagar, Gujarat*
(ii) AERC, Jabalpur, Madhya Pradesh
(iii) AERC, GIPE, Pune, Maharashtra

*Schedule/Household No.:*____

*AERC Name:*______________ *Name of the Investigator:*____
____

*Date of Interview:*__________ *State covered:*______________
____

*District Name:*_____________ *Village Name:*_____________
____

A.1 General Information about household:

1. Name of the respondent: ____
____
2. Mobile No.: __________________________
3. Age: _______*(in Years)*
4. Gender: _______*(Male=1/Female=2)*
5. Education*: _______

**Education Codes: Illiterate =0, Primary (1-8) = 1, Secondary (9-10) = 2, Intermediate (11-12) = 3, Technical (ITI, Polytechnic, Diploma) = 4, Graduate=5; PG= 6, Professional (MBBS, MBA, Ph.D.) =7*

6. Occupation: Primary: ___________________ Secondary: __________
____

***Occupation codes: Cultivator=1, Agriculture labour=2, Dairying/Fishing/Poultry keeping=3, Salaried govt. =4, Salaried pvt. =5, Pensioner=6, Caste based profession=7, Trade & business (Shop)=8, Entrepreneur=9; Casual labour =10, Marginal work (construction, rickshaw puller, etc) =11 Household work=12, Others=13*

7. Farming experience***(in Years)*: _____________*(in Years)*

*** Fill for person majorly engaged in farming.*

A.2 General Information about Family:

1. Type of family: _______*(Joint=1/Unitary=2/Others=3)*
2. Caste: _______*(Gen=1/OBC=2/SC=3/ST=4)*
3. Religion:
_______*(Hindu=1/Muslim=2/Sikh=3/Jain=4/Buddhist=5/Christian=6/Other=7)*
4. No of family members: ________

B.1 Area under Cultivation (in acres): during 2020-21

Land Type	Overall land	Owned Land	Leased In	Leased out	Net cultivated Area
Rain fed area					
Irrigated area					
Total land					
Irrigation sources (Codes)					

**Irrigation sources: Canal=1, Minor surface works (pond, tank, etc.) =2, Groundwater (tube well, well, etc.) =3, others=4*

B.2 Cropping of oilseed during 2020-21

Oilseed crops	Irrigated			Rain fed		
	Variety Name	Area (Acres)	Yield (Quintals/Acre)	Variety Name	Area (Acres)	Yield (Quintals/Acre)

C. Marketing of oilseeds and by-products during 2020-21

Marketing Channel	Quantity Sold (Quintals)	Sold Rate (Rs/Quintals)	Distance from farm (In km)	Transportation mode	Transportation cost (Rs.)
Government Agency					
Mandis					
Processor					
Retailers					
Agents					
Others(specify)_____					

D.1 Labour and machine use

Labour used		Hired			Owned		
		No of person	No. of Days	Rate (per day)	No of person	No. of Days	Rate (per day)
Sowing/Ploughing	Male						
	Female						
Intercultural activity	Male						
	Female						
Harvesting/Threshing	Male						
	Female						
Transportation	Male						
	Female						
Machine used		Hired			Owned		
		Machine name	Total no of hours	Rate (per hour)	Machine name	Total no of hours	Rate (per hour)
Sowing/Ploughing	Machine 1						
	Machine 2						
	Machine 3						
Intercultural activity	Machine 1						
	Machine 2						
Harvesting/Threshing	Machine 1						
	Machine 2						
	Machine 3						
Transportation	Machine 1						
	Machine 2						
	Machine 3						
Note: Total no of hours=Total Days*Hour per day							

D.2 Operational cost of oilseed production

Variable	Name/Code**	Variety/Composition	Area (Acres)	Quantity (kg/acre)	Rate (Rs/kg)
Seed					
Bio fertilizer					
Seed Treatment/ Fungicide					
Fertilizer					
Weedicide					
Pesticides					
Manure					
Irrigation		X		X	(in Rs/Acre)
		X		X	(in Rs/Acre)
		X		X	(in Rs/Acre)
		X		X	(in Rs/Acre)

***Codes:*
Seed: Hybrid=1, Non-hybrid=2, Others(specify)=3
Fertilizers: Urea=1, DAP=2, NPK=3, Gypsum=4, MOP=5, SSP=6, Sulphur=7, Iron=8, Zinc=9, Others (specify)=10
Manure: Farm Yard Manure=1, Compost/Bio-gas manure=2, Green Manure=3, Other organic manure (specify) =4
Irrigation: Canal=1, Minor surface works (pond, tank, etc.) =2, Groundwater (tube well, well, etc.) =3, others (Specify)=4

Note: 1. Pesticide's code is not given, please write name of pesticides in appropriate column. 2. Irrigation rate to be filled by source of irrigation; entre only suitable/standard rate, whichever applies in the reported columns.

Perception about input use

Input	Easily available? (Yes/No)	Satisfied with Prices? (Yes/No)	Aware about doses/use (Yes/No)
Seed			
Seed Treatment Material/Fungicide			
Fertilizer			
Weedicide			
Pesticides			
Manure			
Irrigation			

E. Perception of oilseed growing farmers

1. Are you satisfied with the yield you get? Yes/No
2. If yes, how much satisfied? High/Moderate/Less
3. What are the factors do you think affecting yield of oilseed crop? *(Multiple ticks)*
   (i) Climate
   (ii) Seed quality
   (iii) Soil quality
   (iv) Fertilizers
   (v) Irrigation
   (vi) Others (specify) _____________

4. Do you think yield can be further improved? Yes/No
5. What are the possible suggestions? (i):____
   ____
   (ii):____
   ____
   (iii):_______________________________________
   ____

6. If not satisfied with the yield, level of dissatisfaction? High/Moderate/Less
7. What are the reasons? (i):____
   ____
   (ii):____
   ____
   (iii):_______________________________________
   ____
8. Do you think Oilseed crop is more profitable crop as compared to other crops? Yes/No
9. Did you get improved subsidized seed for oilseed crop? Yes/No
10. Did you get any training on oilseed crop production? Yes/No
    If yes, who provided the training _________________________

please mention the type of benefit you get from training (i)__________________________

(ii)__________________________

(iii)__________________________

11. Did you cover the oilseed crop for insurance? Yes/No
12. Whether soil testing ever performed of your field? Yes/No

    If yes, are you using fertilizers as per recommended dose? Yes/No
13. Did you face draught during last 5 years? Yes/No

    If yes to what extent Severe/Moderate/Mild
14. Do you adopt any post-harvest practice for oilseeds? Yes/No
15. What are the problems arising in post harvesting of oilseeds crop?

    Problem 1: ____

    Problem 2: ____

    Problem 3: ____

    (For ease of data analysis, prefer to use a common/same word for any particular problem)

Appendix 2

Sampling frame for district selection

Crop	State	Category 1: High yield - High area	Category 2: Low yield - High area
Soybean	Madhya Pradesh	Dewas (7.1)	Agar Malwa (3.1)
		Dhar (5.7)	Khandwa (3.6)
		Guna (3.8)	Mandsaur (5.0)
		Indore (4.5)	Rajgarh (7.1)
		Ashoknagar (3.3)	Ratlam (5.2)
		Sagar (4.8)	Vidisha (5.4)
		Sehore (6.1)	Betul (2.7)
		Shajapur (5.2)	
		Ujjain (9.3)	
	Maharashtra	Hingoli (5.3)	Jalna (3.3)
		Nanded (8.7)	Latur (10.7)
		Akola (5.2)	Osmanabad (5.3)
		Washim (7.4)	Parbhani (6)
			Yavatmal (6.8)
			Amravati (7.2)
			Beed (5.3)
			Buldhana (9.9)
Groundnut	Gujarat	Gir Somnath (6.1)	Devbhumi Dwarka (11)
		Banas Kantha (8.8)	Jamnagar (8.2)
		Bhavnagar (6.0)	Junagadh (14.5)
			Amreli (6.7)
			Morbi (8.4)
			Rajkot (15)
	Rajasthan	Churu (10.8)	Chittorgarh (3.8)
		Jaipur (4.6)	Jaisalmer (5.1)
		Sikar (3.7)	Jodhpur (16.6)
		Bikaner (35.5)	
Rapeseed & mustard	Rajasthan	Dholpur (2.5)	Churu (3.3)
		Ganganagar (9.0)	Jaipur (3.1)
		Hanumangarh (4.7)	Jalore (2.7)
		Alwar (9.0)	Jhalawar (2.5)
		Karauli (3.0)	Jhunjhunu (2.5)
		Sawai Madhopur (5.7)	Jodhpur (6.2)
		Baran (4.0)	Tonk (9.8)
		Bharatpur (7.9)	Bikaner (5.8)

Appendix 3

Best practices under crop development programmes for oilseeds (NMOOP)

Crop	Soil	Compost/organic manure	Weed Management	Irrigation, Harvesting and storage	Integrated nutrient management	Integrated Pest Management practices	Integrated Disease Management Practices
Soybean		5-10 tones/ha	pests, weed management and moisture conservation,			Deep ploughing in summer for insect, Intercropping of Arhar with soya bean	Adoption of Varietal Cafeteria Approach
Groundnut		10 tones/ha	crop rotation and intercropping, adopting right spacing, Mulching the soil, two hand weeding			Deep ploughing during April-May, Intercropping with soybean, Castor, Cowpea, and Pearl millet	Deep burial of surface organic matter and crop debris and Soil application of neem cake or castor cake
Rapeseed and Mustard			Protective irrigation at flowering and pod formation	Harvesting as soon as the crop begins to turn yellow, threshing mechanically and storing at the moisture content of less than 8%	40kg N per ha for rainfed solutions and 40-8- kg per ha		
Sesame Seed	Medium textured soils		Two weeding, one after 15 days of sowing and the other at 30-35 days of sowing are required	goof seed filling, yield irrigation at lower initiations and capsule formation			bacterial leaf spot disease is a problem, soak the seeds for 30 minutes in 0.025% solution of Agrimycin 100 prior to seeding
Sunflower	as sandy loams, black soils and alluviums and in rainfed vertisoils.			Honey bee play a very important role in increasing seed set in sunflower. Maintaining 5 hives/ha provides optimum requirement, besides yielding valuable honey	Use of sulphur is fourth major nutrients	Avoid spray of insecticides in the booming period as it restricts the pollinators	
Safflower	fairly deep, moisture retentive and well drained soils		safflower which could be minimized by promoting safflower in contiguous area	Under scanty moisture conditions in drylands, the yield can be boosted to 40-60% by providing just one life saving irrigation at critical phases of crop growth or before soil moisture becomes limiting for crop growth			
Niger	clay foams to sandy foams, sandy and gravely soil				on marginal and sub marginal land without manures or fertilizer application		

Crop	Integrated Nematode Management practices in Groundnut	Fertilizers	Sowing time	Methods of Sowing	Seed rate	Seed treatment	Spacing and Plant Population
Soybean		ratio 20:40:40:30 kg N:P:K:S/Ha	mid of June	Adoption of Broad Bed Furrow/Ridge Furrow system	75 kg/ha for small seeded varieties and 100kg/ha for bold seed varieties	Carbendazim, Thiram etc	
Groundnut	Soil solarization by a transparent polythene sheet for 15 days during summer also helps to control nematodes		Summer - February-March, Kharif - June to July, Rabi - November	Broad Bed and Furrow System and Ridge and Furrow system	Bunch type groundnut varieties- 100-110 kg/ha and spreading and semi-spreading varieties - 95-100 kg/ha		Bunch varieties - 30 x 10 cm with plant and of 3.33 lakh/ha. Runner varieties - 45 x 10 cm or 30 x 10 cm with plant population of 2.22 lakh/ha
Rapeseed and Mustard			Rapeseed -August end to first half of September, Mustard-September end to mid-October and Use of ridge and furrow technique	Line sowing with a row-to-row distance of 30cm and plant to plant distance of 10-15cms			Thinning is necessary after 3 weeks of sowing
Sesame Seed				mixing seed with dry soil or well sieved farm yard manure in 1:20 ratio	5 kg per ha	seed treated with Bavistin 2g/kg seed to prevent of seed borne diseases	
Sunflower		Spray of Borax to Capitulum, Bio-fertilizer - Azospirillum can lead to less use of Nitrogen by 50%.	Rabi or spring season	well prepared seed bed for better germination, establishment and growth and soaking of seeds in freshwater for about 10 hrs is also recommended	5kg/ha and 6-7kg/ha is suggested for rainfed	Thiram or Captan at 2-3g per kg	Maintenance of optimum population by judicious thinning at 10-15 days after germination
Safflower						Seeds treated with Thiram, Captan, Carbendizim at 3g/kg before sowing	
Niger		N through urea+ seed fertilizer enhances yield and Sulphur increases seed yield and oil content in Niger		sown by broadcasting, Seeds are mixed with sand and powered ash to increase the bulk, 20 times to ensure even distribution of seed	5kg/ha	Thiram or Captan 3.0g/kg seed	spacing of 30*10 CMS

Comments on the draft report

(from Centre for Management in Agriculture (CMA), IIM Ahmedabad)

(I) Title of the Draft Study Report Examined:

Estimating and Bridging the Yield Gaps in Oilseeds for Atma Nirbhar Bharat

(II) Date of Dispatch of the Draft Report from AERC - Delhi

26.05.2022

(III) Date of Receiving the Comments from CMA, IIM Ahmedabad

20.06.2022

(IV) Comments on the Objectives of the Study

The issues addressed in the study are crucial for meeting India's future food grain demand. It focuses on the yield gaps in oilseed crops across the nation, which are a significant barrier to self-sufficiency in oilseed production and make the nation a net importer of oil. Focus has been placed on measuring the yield gaps of major oilseed crops by comparing them globally with other major producers and locally with Krishi Vigyan Kendras. The study analyzes in-depth the most important demographic & household factors, as well as marketing channels and their corresponding cultivation restrictions. The tools used for statistical analysis of the data collected for the study have contributed to a deeper understanding of this issue. However, a little more emphasis could have been placed on the industrial factors affecting oilseed production and producers, given the importance of enterprise in the oilseed value chain.

Response: A separate section on the industrial factors affecting oilseed production and producers have been added in the report.

(V) Comments on the Methodology

The methodology employed for the study is completely consistent with its stated objectives. The analysis utilized both primary and secondary data. Three major crops, soybean, groundnut, and rapeseed & mustard, account for most of the nation's oilseed production. The states were selected based on their production levels, with the selected states accounting for the majority of oilseed production. Utilizing secondary data, the yield trend and comparison were analyzed. Simultaneously, primary data were used to investigate the yield gaps and potential causes for the limited yield. The examined primary data also investigates the cultivation and marketing costs associated with the crop. It also explores the farmer's perception of the yield's status. The sampling method utilized for multi-stage stratified sampling using area and yield as selection criteria for districts. For selecting villages and households, sampling at random or the knowledge of the various participating AERCs is utilized. The sample size is large enough to provide essential insights into the objectives. Nonetheless, one deficiency is identified in terms of state selection. In the case of rapeseed and mustard, only Rajasthan was chosen, whereas two states were selected for all other crops. More states would have provided greater insight into the potential causes for the poor yield.

Response: Although the secondary data analysis covers the majority of the oilseed crops and oilseed producing states, for the field survey the study covers three of the nine-oilseed crops - namely soybean, groundnut and rapeseed & mustard covering nearly 91% of the production share in the country as of 2019-20. Similarly, the selected oilseed producing states - namely Rajasthan, Gujarat, Madhya Pradesh and Maharashtra covers 75% of total oilseed production of these nine-oilseed crops on combined basis in the country in year 2019-20. The field survey was conducted in only these selected states covering the top produced specific oilseed crops.

(VI) Comments on the Presentation, Get up, etc.

In general, the report is well-written and logically organized. The report's chapters and subchapters are clearly distinguished. The data is presented using tables, pie charts, and bar graphs that are well-structured. Nonetheless, the report requires a few improvements. For activities conducted in the past, the report should be written in the past tense. A few tables need to be updated with some corrections. In Table 2.1, the symbol for representing the growth rate is missing. The quantity in Figures 3.1 and 3.2 should be written as "lakh tonnes." On the y-axis of Figure 3.3, the unit of per capita availability is missing. From Figure 3.11 to Figure 3.21, the unit of the y-axis for the quantity measured is missing. From all the graphs. These graphs showing the state-wise growth rate do not mention the unit of percentage both in the text and y-axis on the graphs. The majority of tables presenting figures lack titles for the x-axis of the graph. The reference format for the news article on the fourteenth number in the list of references is incorrect. A few journal titles in the bibliography are not italicized. There are a few proofreading errors, and it also requires rephrasing to be readable. There are a few inconsistencies in the study that need to be addressed.

Response: The suggestions are incorporated in the report - report is written in the past tense, tables and figures are updated with symbols, axis titles, units etc., reference format, rephrasing, proofreading etc. wherever required.

(VII) Overall View on Acceptability of the Report

It is one of the most comprehensive reports on the particular subject matter and is poised to become a very useful reference tool for researchers and policymakers. The data collected for the study have effectively supported the study's objectives and ably highlighted its findings. The recommended policy suggestions are brief and to the point, focusing specifically on the identified gaps and the actions required to close them. The report contains a few inconsistencies, most notably in its drafting, which is inconsistent in writing style and contains grammatical errors. The research utilized both primary and secondary data to cover both the macro and micro levels. The collection of primary data provided insight into the situations and expectations of oilseed farmers. The first significant finding indicates low oilseed yields and disparities in oilseed yield between states. Farmers' decisions are influenced by factors such as lack of education, small land holdings, and ignorance about input usage. The policy recommendations center on increasing yields in large-acreage regions and identifying districts for more concentrated policy formation. In addition, emphasis should be placed on improving the industrial infrastructure for primary and secondary processing. Other important policy recommendations include farmer training and development, improved availability and utilization of inputs, etc. Because of such a comprehensive study, it has been possible to identify the substantial gaps in existing situations.

Response: The suggestions are incorporated in the report - inconsistencies in drafting and writing, grammatical errors etc. wherever required.