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Research Article

Supply response of major oilseeds in India: A mix of price and non-price factors

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Abstract
Oilseeds are one of the most important determinants of India's agricultural economy, next only to cereals and pulses. The self-sufficiently in oilseed obtained during the early 1990s could not be sustained sufficiently. Despite, being the fourth largest oilseed crop-producing nation in the world, India is also one of the largest importers of vegetable oils. This study appraises the relationship between price and non-price factors to understand the behaviour of major oilseeds (mustard/rapeseed and groundnut) cultivated in India from 1997-98 to 2019-2020. Supply response is the responsiveness of supply, which can be identified using production response to different determining factors. Mustard/rapeseed and groundnut are the oilseeds that are mainly produced in India. This study specifically attempted to quantify the relationship between oilseed production and different factors, such as annual rainfall, annual temperature, yield, and revenue difference for both crops. The findings suggested that yield and revenue difference of mustard with wheat are the most determining factors for mustard production, whereas annual rainfall, the temperature during the growing season, and revenue difference between groundnut with rice and soyabean are the most significant determinants of groundnut's production response. Crop equivalent productivity further validated that groundnut competed and outperformed the two promising crops (soybean and paddy). The trend analysis (1997-98 to 2019-2020) also indicated that wheat was the dominant crop over mustard from 1997-98 to 2013-14. Afterwards, i.e., from 2014-15 to 2019-20, mustard surpassed wheat productivity (on equivalent terms) and outperformed cereal.

Keywords: Crop equivalent productivity, Oilseeds, Production response, Revenue difference, Supply response

INTRODUCTION

Agriculture, which contributes 2/3rd to the Indian economy, demands modern technological intervention and strategies for smoothening the demand-chain supply to grow. Although the advent of the green revolution undoubtedly made India self-sufficient in producing major cereals followed by pulses, the oilseeds were cornered.

India, the world's largest consumer and importer of vegetable oils, is likely to buy 15.6 million metric tons of cooking oils in the 2023-24 oil year. During 2021-22, domestic edible oil production stood at 116.5 lakh tonnes and imported 145.57 lakh tonnes. The total consumption/ demand was 258.43 lakh tonnes. This shows that almost 56% of the India's edible oil demand is met by import. Among the nine oilseeds commonly grown in the country, mustard/rapeseed and groundnut together contribute nearly 60 % of the total vegetable oil production (MOAFW, 2022). Any alteration in the import directly affects the demand-supply parity, thus affecting normal demand-supply relation (Narayan, 2017).

It has been observed that the farmers are not willing to grow oilseeds. Instead, they are more akin towards staples and pulses. There are various issues, such as the inability to take risks by small and marginal farmers, the breaking down of the supply chain process, decreasing the process of value addition and the absence of appropriate infrastructure, which inhibit production and subsequent marketing of groundnut and mustard in this country. The agricultural sector's supply chain management is a crucial problem. Identifying the price and non-price factors responsible for the oilseeds production and market supply can be an easier way to get authentic estimates of these oilseeds' supply response (Grace *et al.*, 2014). This can be further attended by establishing the relationship between production and its different determinants. To increase oilseed production, robust policy decision making is needed which needs reliable estimates of the supply determinants. Compared to other crops, few attempts have been made to analyse the production and supply response of oilseeds in India. Many of the past supply response studies are based on traditional econometric techniques viz. classic linear regression (Jainuddin *et al*., 2021 and Kumar *et al*., 2023) Results of traditional econometric techniques are reliable when the time series data are stationary. However, there is a possibility that some macroeconomic time series data are non-stationary; therefore, the results and conclusions drawn from using those techniques have the risk of invalidity as they might lead to spurious regression (Bernhard, 2008). In India, the cereal-cereal cropping system is predominant, which can cause severe soil health degradation as both of these are nutrient and moisture-exhaustive. Therefore, diversifying our cropping system with alternative crops like pulses, oilseeds, etc, will be a sustainable option.

Oilseed crops have traditionally played significant roles in the food chain, human consumption, and other businesses. The disparity between supply and demand, middlemen's meddling, disregard for oilseed crops, and a greater reliance on imports to satisfy domestic needs are some of the main causes of the high market price of edible oils (Lakshman and Sadakshari, 2018). Oilseed production needs to be redesigned immediately to meet the low-priced oilseed supply in the context of the shrinking agricultural land of today (Das and Biswas, 2021). Therefore, studying the supply response by addressing the production response of oilseeds can give a vivid picture. With this view, the present study aimed to quantify the relationship between groundnut and mustard production and price and non-price factors.

MATERIALS AND METHODS

Data collection and methodology

Several price and non-price determinants are responsible for oilseed production, which ultimately steer the domestic supply-demand equation. Thus, estimating the production response would help understand the supply response due to price and non-price variables. Time series annual mustard/rapeseed and groundnut data were collected from 1997-98 to 2019-20, accounting for nearly 65% of the total oilseed production. In India, mustard/rapeseed is grown as *Rabi* crop and sowing is done in November-December. Groundnut is a *kharif* crop sown from June to July with the onset of monsoon season. Many national and international studies establish the link between the supply response and production function (Mythili, 2006). Production is a function of area and yield. Thus, production response is preferred to know the contribution of oilseed productivity as well as the influence of price and non-price variable. In this study, production (in million tonnes) was considered as dependent on annual average rainfall (in mm), net irrigated area (in percentage) and yield (kg/ha) of the studied crops as non-price factors, whereas revenue difference with its competitive crops was considered to be the price factor. Area, production, yield and area under irrigation of oilseed and their respective competitive crops were obtained from various Ministry of Agriculture & Farmers Welfare, Government of India (GOI) publications (MoAFW, 2022).

Studied variables were further tested for understanding their stationarity pattern or tested for presence of unit root using Augmented Dickey Fuller (ADF) test (Granger and Newbold (1974). Akaike information criterion (AIC) was employed to select the appropriate lag in the model. For testing stationarity, Augmented Dickey-Fuller method was applied, in which study variable Y_t was expressed in the following manner:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \delta Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \epsilon_t \quad (1)$$

In this above equation, $\Delta Y_t = Y_t - Y_{t-1}$ was a vector to be tested for cointegration; α_0 was the intercept of the model; α_1 was the coefficient associated with time or trend variable t; ε_t was a white noise error term. The null hypothesis was $\delta = 0$ signifying presence of unit root, *i.e.*, the time series was non-stationary, and the alternative hypothesis was $\delta < 0$, signifying the time series was stationary (therefore, rejecting the null hypothesis). The required test statistics were:

$$DF_{\tau} = \frac{\delta - 1}{SE(\delta)} \quad (2)$$

The value of the test statistic was computed and compared with relevant critical values for Dickey-Fuller test statistic (τ). Variables which were identified with unit root were transformed into annual growth rate (Klein and Kosobud,1961; Bernhard, 2008) and all other variables were log transferred as studied variables carried different unit of measurements.

Assuming there were several price, yield and environmental factors, the hypothesized production response was expressed as:

$$P_i = \beta_0 + \beta_1 Y + \beta_2 RF + \beta_3 IA + \beta_4 T\, \beta_3\, RD \quad (3)$$

Where,

P_i = Production of i^{th} oilseed crop (mustard/rapeseed & groundnut)

Y =Yield of i^{th} oilseed crop

RF = Average annual rainfall

IA = Irrigated area under i^{th} oilseed crop

T = Average temperature during the growing season of i^{th} oilseed crop

RD = Revenue difference between i^{th} oilseed and its competing crops.

As production was a major determinant of supply, studying the production response based on the selected variables would give a more comprehensive perspective. Economic theory suggests that the supply response equation is mainly expressed in terms of the price of one's own commodity and price of substitute/ competitive and complementary commodities and other significant variables. However, in this study, prices of own and competitive commodities were expressed implicitly rather than explicitly in the variable called revenue difference. Thus, revenue difference was considered the sole price factor and various non-price variables for determining the production response of the studied oilseeds.

Revenue difference was more admissible than price ratio of own and substitute/ competitive crop FHP (Farm Harvest Price). Because net revenue (the product of area, land productivity and FHP) or the profitability encompassed a particular agricultural commodity FHP, land productivity (yield), and area. For example, in rice, FHP per quintal was less compared to the FHP of any oilseed. However, due to higher yield and, subsequently area, revenue obtained from rice was greater than the oilseed. Farm Harvest Price (FHP), both state-wise and national average, of these oilseeds, along with their respective competing crops, were obtained from the website of the Directorate of Economics and Statistics (DES) database (MoAFW, 2023).

Based on literature review and crop calendar, competitive crops of oilseed were identified based on prevailing competition for seasonal requirements and resources viz., land, labour, irrigation and other resources (Jainuddin *et al*., 2021). To select Potential competitive crop(s) was/were selected using the Ordinary Least Square (OLS) regression following this specified model:

$$Area_{ki} = \beta_1 Area_{m1} + \beta_2 Area_{m2} + \ldots\ldots + \beta_n Area_{mn} \quad (4)$$

Where,

$Area_{ki}$ = area of i^{th} oilseed crop

$Area_{m1}$= area of m^{th} competitive crop

k = main crop (oilseed crop)

m = competitive crop

The competitive crops would decrease the production of the studied oilseeds compared to their actual potential, and they could be better substituted if these oilseeds showed greater profitability based on the production and bridged the demand-supply gap. This could be achieved through an authentic evaluation of the supply determinants.

Crop equivalent productivity

Crop equivalent productivity is a crop's productivity equivalent to another crop's productivity. Here, yield of one or more crops was converted to the equivalent yield of any one crop based on the market price of their produces. It was calculated as:

$$\text{Crop equivalent productivity} = Y_i{*}P_i / P_j \quad (5)$$

Where,

Y_i = Yield of i^{th} crop

P_i = Market price of i^{th} crop

P_j = Market price of j^{th} crop

RESULTS AND DISCUSSION

Competitive crop selection

The present study quantified the major oilseeds (viz. groundnut and mustard/rapeseed) production response to price and non-price factors such as land productivity, annual rainfall, irrigated area and revenue difference with the competitive crops. Groundnut and mustard/ rapeseed are the major oilseeds of India, accounting for 57% production from 44% acreage during 2020-21 (MoAFW, 2022), where groundnut is cultivated in *kharif* season and mustard/rapeseed is grown as a *rabi* crop. Based on the literature review and crop calendar, a set of major *kharif* crops, viz. rice, maize, soybean and *rabi* crops, viz. wheat, pulses and potato were identified as competitive crops for groundnut and mustard/rapeseed, respectively. But after analysing the data of area under cultivation of all the competitive crops corresponding to groundnut and mustard/rapeseed using ordinary least square (OLS) regression, all three competitive *kharif* crops were found to be significant for groundnut whereas only wheat was found as the most potential competitive crop for mustard (Table 1). Grace *et al.* (2014) similarly opted OLS regression model for the selection of competitive crops of major pulses in India.

Unit root test

Before estimating supply response through production response, the studied variables needed to be tested for possible unit root problems (using ADF test) to avoid spurious relations among the variables while conducting OLS regression. Results of ADF test manifested that except annual rainfall, all the studied variables for both groundnut and mustard/rapeseed had unit root, *i.e.* non-stationary at level [I (1)] (Table 2). It was observed that during the studied period, annual rainfall of India followed a deterministic trend.

Production response

The result presented in Table 3 shows that the production response of groundnut was identified based on all the independent variables viz., average temperature from June to September, land productivity, land area, annual rainfall, revenue difference between groundnut-rice, groundnut-soybean and groundnut-maize. The coefficient of determination (R^2) calculated was 99 per cent, i.e. 99% of variation in the dependent variable explained by chosen independent variables. Significance of each variable in the model was judged by the 't' values. As the studied variables were in different units of measurement, for interpreting the results (in percentage change) the stationary variables were log transformed, whereas the non-stationary variables were transformed to annual growth rate. The results showed that yield or land productivity was the one significant factor, suggesting a 1.07% increase in production with every 1.0 % change in the yield, keeping other variables constant. It signified that production of groundnut is yield responsive i.e. any technological change in production practices will have an impact in production through land productivity. Groundnut is a *kharif* crop; therefore, production heavily depends on rainfall, and merely 36% of cultivated land depends on irrigation (MoAFW, 2022).

The present finding showed that production had a positive correlation with rainfall and 1.0% change in rainfall increased production by 0.11%. Contrarily, a unit change in temperature during the growing period decreased the production by 0.83%. Groundnut revenue difference between and competitive crops was one factor contributing negatively to groundnut production. Among the three differences, the one between groundnut-rice and groundnut-soybean was significant. If the revenue difference between groundnut-rice and groundnut-soybean increased by 1.0%, groundnut production would likely to decrease by 0.09% and 0.17%, respectively. These findings established the fact that cereals and pulses are major factors replacing groundnut.

Similarly, the production response model of mustard/ rapeseed based on price and non-price variables like groundnut was based on all the independent variables viz. area under irrigation, average temperature from October to February, annual rainfall and revenue difference between mustard-wheat (Table 3). The coefficient

Table 1. Competitive crop selection for groundnut and rapeseed/mustard (1997-98 to 2019-20)

Crop	Competitive Crop	Coefficients	Standard error	t Stat	P-value
Groundnut	Intercept	5.09	3.02	1.68	0.09
	Paddy	0.21	0.06	3.58	0.00
	Soybean	-0.15	0.07	-2.16	0.03
	Maize	-0.67	0.16	-4.01	0.00
Mustard/Rapeseed	Intercept	1.98	1.30	1.52	0.13
	Wheat	0.15	0.03	4.59	<0.05
	Potato	0.85	0.39	2.16	0.08
	Pulses	-0.07	0.05	-1.31	0.19

Table 2. Results of unit root test (1997-98 to 2019-20)

Crop	Variable name	ADF test Statistics	p-value	Unit Root*
Groundnut	Annual rainfall	-8.15	< 0.05	-
	Area under irrigation	-0.64	0.85	+
	Yield	1.50	0.99	+
	Average temperature (June-sept)	-0.03	0.95	+
	Revenue difference (Groundnut- Rice)	0.75	0.99	+
	Revenue difference (groundnut-soybean)	-0.94	0.75	+
	Revenue difference (groundnut-maize)	-2.57	0.11	+
Mustard/ Rapeseed	Annual rainfall	-7.94	< 0.05	-
	Area under irrigation	-0.90	0.78	+
	Average temperature (annual)	-0.36	0.90	+
	Average temperature (Oct-Feb)	-0.81	0.80	+
	Yield	-0.06	0.95	+
	Revenue difference	2.46	0.99	+

*['-' absence of unit root (stationary); '+' means presence of unit root(non-stationary)

of determination (R^2) calculated was 87%, i.e. 87% of variation in the dependent variable was explained by chosen independent variables. Yield or land productivity was found to be most significant factor, suggesting that everyone 1.0% change in the yield would likely to increase the mustard production by 0.98 %. Next to land productivity, rainfall had a significant but negative impact on mustard production as rainy spell during growing period caused considerable yield losses by physiological disorders such as flower drop, poor pollination, and pest and disease infestations (Boomiraj *et al.*, 2010). Revenue difference between mustard and wheat decreased mustard production by 0.26% for everyone, with a 1.0 % change in the revenue gap between wheat and mustard. Thus, it also confirmed the outcome of groundnuts, which is that cereals are displacing oilseeds.

Groundnut equivalent productivity

To draw the comparison between kharif crops (like paddy, maize, soybean) and oilseed groundnut, the productivity of those crops over the years was converted to groundnut equivalent productivity, as shown in Fig 1. It was observed from the trend analysis (for the period of 1997-98 to 2019-20) that *kharif* crops showed variable performances when compared with groundnut yield over the years. The results revealed that compared to groundnut yield, the groundnut equivalent productivity of maize was always higher till 2012-13 and remained close to each other. This signified that maize cultivation was always better option than groundnut cultivation during the *kharif* season. The result might be due to higher productivity and farm harvest price of the maize produce. However, when paddy and soybean yields were converted to ground nut equivalent yields and compared with groundnut yield, observations were completely different from those of maize yield.

Trend analysis showed that both soybean and paddy productivities after conversion to groundnut equivalent productivity were less over the years than the groundnut yield. It was also noted that groundnut equivalent paddy yield declined while soybean yield slightly increased over the years. This result indicated that groundnut competed and outperformed the two promising crops (soybean and paddy) and it can be a potential or better alternative to these two crops and, more specifically, rice, as rice is predominantly treated as a major *kharif* crop of India. The Mean productivity of crops from 1997-98 to 2019-20 also showed identical results for individual years where the best-identified crop was maize, sequentially followed by groundnut, paddy, and soybean (Fig. 1). The result was obtained possibly due to the variations in farm harvest price and productivity of different crops for 1997-98 to 2019-20. Additionally, various other factors, as studied here, were also responsible for determining the production response of groundnuts. It revealed that paddy and soybean are the major significant competitive crops of groundnuts besides maize.

Mustard equivalent productivity

During *rabi* season, the two major crops grown in India are cereal crop wheat and oilseed crop mustard. In this study, wheat yield was converted to mustard equivalent productivity and compared with mustard yield from 1997-98 to 2019-20 (Fig 2). The trend analysis indicated wheat was the dominant crop over mustard from 1997-98 to 2013-14. Afterwards, mustard surpassed the wheat productivity (on equivalent terms) and outperformed the cereal. The result also expressed that after 2013-14, mustard productivity steadily increased over mustard equivalent productivity of wheat and reached maximum during 2018-19. The variation in results over the years can be justified by variations in the productivity of these crops as well as the farm harvest price of the nation. Mean productivity analysis for the said period showed that wheat performed compara-

Table 3. Production response coefficients of groundnut and mustard/rapeseed (1997-98 to 2019-20)

Crop	Variable	Coefficients	Standard Error	t Stat	P-value
Groundnut	Intercept	13.29	7.29	1.82	0.09
	Yield	1.07	0.04	25.23	<0.05
	Area Under Irrigation (%)	0.20	0.17	-1.15	0.26
	Annual Rainfall	0.11	0.02	3.87	<0.01
	Temperature (June-sept)	-0.83	0.19	-4.25	<0.05
	Revenue difference (GN-Rice)	-0.09	0.02	-3.64	<0.01
	revenue difference (GN-Soybean)	-0.17	0.06	-2.77	<0.05
	revenue difference (GN-Maize)	-0.003	0.04	-0.80	0.43
Mustard/ Rapeseed	Intercept	36.92	35.61	1.03	0.31
	Yield	0.98	0.32	3.06	< 0.05
	Area Under Irrigation (%)	-0.87	1.07	-0.81	0.42
	Average Temperature (Oct-Feb)	0.55	1.12	0.49	0.62
	Annual Rainfall (mm)	-0.02	0.01	-1.83	0.05
	Revenue difference (Mustard-wheat)	-0.26	0.14	1.89	0.05

[** means significant at 5% level; *** means significant at 1% level]

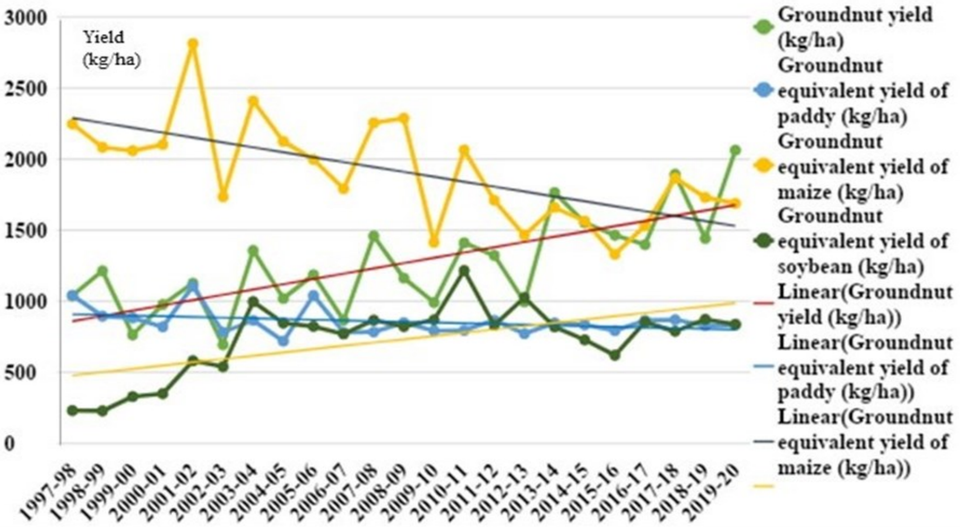

Fig 1. *Trend analysis of groundnut and its equivalent yields of maize, paddy, and soybean for a period of 1997-98 to 2019-20 (Source of data: MoAFW, 2022).*

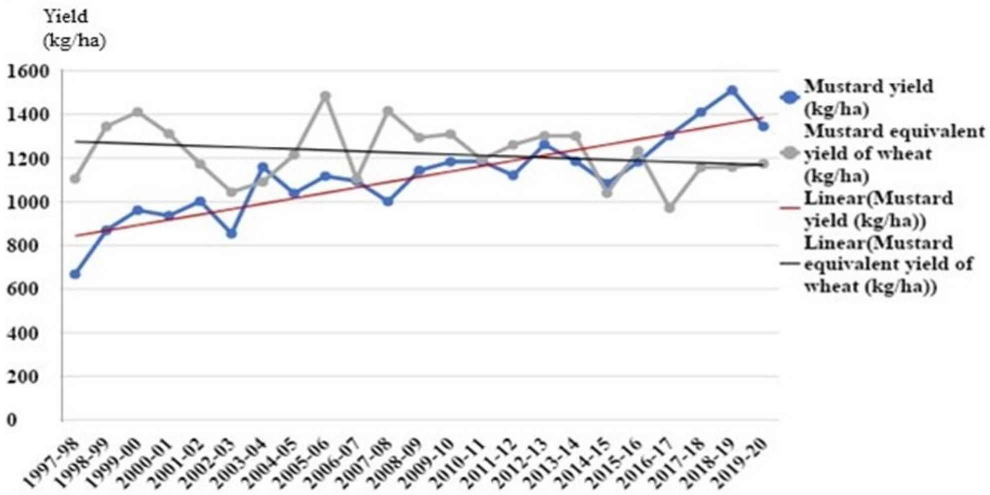

Fig. 2. *Trend analysis of mustard and its equivalent yield of wheat for a period of 1997-98 to 2019-20 (Source of data: MoAFW, 2022)*

tively better than mustard (Fig 2). It might be due to this winter cereal's higher productivity and farm harvest price over the oilseed mustard.

Conclusion

This study mainly focussed on the production response of the two main oilseed crops, mustard/rapeseed and groundnut. In mustard production, wheat was the potential competitive crop. However, the revenue from the wheat crop was found to reduce the mustard production significantly. In the case of groundnuts, rice and soybean revenue growth negatively affected groundnut production. Findings also suggest that yield was a significant variable in the selected oilseed crops, implying that stagnation could be overcome by varietal development and cultivation methods in the long run. There is an argument regarding consistent price rise in oilseeds, which restricts farmers from incorporating oilseeds into their existing cereal-cereal or cereal-pulse cropping system. Crop equivalent productivity further validated that both the studied oilseeds could be a promising alternative for their competing crops. Thus, to increase oilseed production, either technological change or the price of oilseeds has to be increased to an extent such that oilseed revenue is greater than its competing crops.

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Conflict of Interest
The authors declare that they have no conflict of interest.

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