Economic Affairs, Vol. **69**(02), pp. 791-797, June 2024
DOI: 10.46852/0424-2513.3.2024.2

AESSRA

RESEARCH PAPER

The Miracle Bean: Tapping Unrealized Potential

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Received: 23-02-2024 **Revised:** 21-05-2024 **Accepted:** 02-06-2024

ABSTRACT

The study attempts to assess the extent of yield gap in soybean crop over time and changes in the same at district as well as at farm level in Maharashtra. The study uses two types of yield gaps. Yield gap I compares check plot yield and district average yield, whereas yield gap II compares demo plot with that of district average yield. It also assesses yield gap at farm level vis-à-vis demo plot yield for various varieties of soybean. Although the study shows significant yield gap of soybean with respect to check and demo plot yield, a reduction in this gap is also noticed over the last one decade, especially in major soybean cultivating districts of Maharashtra. The major soybean cultivating districts show 15-20 per cent decline in yield gap during this period. The efforts initiated by agricultural extension network in the form of scientific methods of farming with emphasis on adoption of HYVs of seeds and improved cultivation practices have significantly contributed towards the decline in yield gaps.

HIGHLIGHTS

- Assessment of yield gap changes in soybean.
- Assessment of different types of yield gaps in soybean.
- Identifying factors affecting yield gap.

Keywords: Check/demo Plot Yield, Farm Yield, Yield Gap, Soybean, Oilseed Production

Although various programme initiatives undertaken in the past have led to rise in yield and area under oilseed crops, India still imports a significant proportion of its requirement of edible oil. The demand for both edible and non-edible oils is growing fast on account of rise in income, population and urbanization, resulting in decline in per capita availability of edible oils. The lack of technological breakthrough in developing high-yielding varieties (HYVs) of oilseeds is on account of lack of supply of quality seeds, which has hindered large-scale production of oilseeds. It has been observed that farmers hesitate to adopt improved varieties of seeds since it involves huge investment due to higher doses of fertilizers and pesticides, resulting in virtual stagnation in the yield levels of most oilseed crops cultivated in India (Jha *et al.* 2012). This has resulted in significant yield gap of majority of oilseeds cultivated in India. The studies conducted in the past by Mattigatti *et al.* (2009), Kumar *et al.* (2015), Raghuwanshi *et al.* (2018), Prasad *et al.* (2019), NABARD (2020), etc. have estimated different types of yield gaps for oilseed crops depending upon availability of data. The study conducted by Singh *et al.* (2007) used technological and extension yield as a measure to compute yield gap by using frontline demonstrations data (FLD), and observed a positive impact of FLD since farming community were motivated by the new agricultural technologies applied in the FLD plots. Choudhary *et al.* (2009) also focuses upon technology and extension yield gaps in case of oilseeds. Another study conducted by Dhandhalya *et al.* (2009) in Saurashtra region of

How to cite this article: Shah, D. and Shroff, S. (2024). The Miracle Bean: Tapping Unrealized Potential. *Econ. Aff.*, **69**(02): 791-797.

Source of Support: None; **Conflict of Interest:** None

Gujarat found a wide yield gap. The study revealed that the reduction in the production of groundnut and sesame was on account of biotic, abiotic and socio-economic constraints. In case of soybean, the highest yield was observed through application of improved technology (Billore *et al.* 2009).

The domestic production of oilseeds suffer from some major constraints like small sizes of farm, low productivity, shifting of acreage from oilseeds to other crops, losses due to pests and diseases, vagaries of nature, lack of varietal replacement, etc. Since bridging yield gaps for oilseeds has become a major cause of concern, there is a need to ascertain ways and means to bridge such gaps.

Among various oilseeds, though soybean shows significant growth in its production over time, there has also been lack of technological breakthrough to improve yield at farm level. The demand for soybean is rapidly growing in domestic and international market due to changes in consumption habits of urban population. Despite the fact that Madhya Pradesh is the leading producer of Soybean, Maharashtra has a substantial share in India's total soybean production. The State has witnessed perceptible increase in area as well as production of soybean over time. However, farm yield of soybean is still much lower as against frontline demonstration yield, resulting in significant yield gap. Therefore, the present study attempts to assess the extent of yield gap in soybean crop over time and changes in the same at district as well as farm level.

Methodology and Analytical Framework

In order to estimate and bridge yield gaps in soybean crop in Maharashtra, two sampled districts namely Nanded and Latur were selected on the basis of highest area under soybean crop from the State. The multi-stage stratified sampling approach was used to select the final sample for collecting the primary data. Initially, the State was categorized as into four strata of districts based on area allocation and yield of soybean crop with the 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. In the second stage, only two criteria were considered from the two categories, namely high yield-high area, and low yield-high area, for selecting the districts. The districts of Nanded and Latur belonging to Marathwada region of Maharashtra fulfilled the criteria of high yield-high area and low yield-high area, respectively, for the reference year 2018-19. Therefore, the districts of Nanded and Latur were finally selected for the present study.

From each of these districts, a sample of three villages was selected randomly. 30 soybean crop growing farmers were selected for the survey from each of the selected villages. Thus, the study covered 90 farmers from Nanded and another 90 from the district of Latur to make a total of 180 soybean crop growing farmers. The selected 90 soybean crop growers from each of the selected districts were further categorized as marginal (less than 1 hectare), small (1 to 2 hectares), semi-medium (2-4 hectares), medium (4-10 hectares) and large (above 10 hectares) using probability proportion to land holding size criteria. The number of soybean growing farmers selected from both the districts put together encompassed 84 in marginal, 60 in small, 30 in semi-medium and 6 in medium category. The survey could not come across large soybean crop growing farmers.

Yield Gap Analysis

The study makes use of both secondary and primary data for estimating the yield gaps. The secondary data was used to examine inter-district comparison of yields with that of demonstration yields, and reasons for their differences. The primary data was used to measure the yield gaps for major varieties of soybean at farm level and analyze constraints in harnessing the potential yields.

Yield Gap at District Level

In order estimate yield at district level, two different types yield gaps were computed. The yield gap I was computed by comparing check plot yield and district average yield for the period TE 2010-11 and TE 2020-21, whereas yield gap II referred to comparison of demo plot and district average yield. The check and demo plot yield estimates were obtained from recently published report of the ICAR-Agricultural Technology Application Research Institute (ATARI), Zone-X, Hyderabad 'Bridging Yield Gaps in Oilseeds - Experiences of KVKs under NMOOP Cluster Frontline Demonstrations', 2009.

The following procedure was adopted to estimate yield gap:

Yield Gap I = [(Check Plot Yield – Dist. Avg. Yield) / Check Plot Yield] × 100

Yield Gap II = [(Demo Plot Yield – Dist. Avg. Yield) / Demo Plot Yield] × 100

The change in yield gap of soybean (+/-) in TE 2020-21 was computed over base period TE 2010-11 for the districts with respect to Demo Plot Yield.

Yield Gap at Farm Level

In order to assess yield gap at farm level, the demo plot yields of selected soybean varieties were compared with average check plot yield at farm level for various categories of farmers. The Demo Plot Average Yields for various varieties of soybean are based on figures/estimates obtained from Prasad *et al.* (2019).

Yield Gap = [(Demo Plot Yield – Avg. Yield at Farm Level) / Demo Plot Yield] × 100

Thus, the above procedures to examine yield gaps at district level as well as at farm level encompassed mixed outcomes with respect to yield gaps since the yield gaps estimated through comparison of check and demo plot yields of ICAR report (Prasad *et al.* 2019) with that of district average yield varied significantly when compared at farm level for the selected districts using empirical study.

RESULTS AND DISCUSSION

In order to enhance production of oilseeds, the front line demonstrations were initiated by the Government of India under National Mission on Oilseeds and Oil Palm (NMOOP), which led the ICAR- Division of Agricultural Extension to plan FLDs on oilseeds during *rabi* 2015-16 through *Krishi Vigyan Kendras* in select states in the country. It has been reported by Prasad *et al.* (2019) that 2,850 FLDs were allotted to 41 KVKs in Andhra Pradesh, Telangana and Maharashtra states, which covered an area of 804 hectares under groundnut, soybean, sunflower and sesame crops during *kharif* 2016-17. The information relating to technologies of soybean demonstrated during *Kharif* 2016 in Maharashtra is provided in Table 1.

The application of HYVs of soybean coupled with seed, weed, fertilizer, nutrient, insect pest and disease management practices resulted in significantly high yield of soybean on demo plots as against check plots. The check and demo plot yield estimates along with district average yields for various varieties of soybean have been made use of to ascertain yield gaps of the crop with respect to two time periods for various districts of Maharashtra, and these estimates are brought out in Table 2 and Table 3.

There was a distinct difference between check/demo and district average yield of soybean. While check/demo yields of soybean were with respect to particular HYVs, the district average yield of soybean resulted from application of all the varieties, including both local and HYVs. Therefore, though demo yields were invariably higher than district average yield, the check yield in many cases turned out to be lower than average yield of soybean in the district. The estimates presented in Table 3 show two types of yield gaps. The Yield Gap-I estimates for TE 2010-11 and TE 2020-21 were corresponding

Table 1: Technologies of Soybean demonstrated during *Kharif* 2016 in Maharashtra

Variety	Seed Treatment	Weed Management	Fertilizer/ Nutrient Management	Insect Pest and Disease Management
MAUS-162, 9560, Phule Agrani, MAUS-71, MACS 1188, JS-9305, JS-NRC-37, MAUS 158	PSB, Trichoderma, Rhizobium	Spraying of Imazethapyr 10% SL at 15-20 DAS. pendimethalin 30 EC, Hoeing and Hand weeding @ 25 and 45 DAS.	NPK: 30:75:30 as Basal application with seed cum fertilizer drill, FYM: 5 ton at preparatory tillage	Spodoptera: Carbendazim + Mancozeb 20g /10 l water, Pheromone trap (Spodo lure). Girdle beetle, stem borer and hairy caterpillar: Triazophos 16ml or Chlorpyriphos 20ml or Emamectin Benzoate 4g/10l water

Source: *Prasad et al. (2019).*

Table 2: District Average, Check Plot and Demo Plot Yield of Soybean in Maharashtra (Yield in qtl Ha^{-1})

Major District	Dist. Avg. Yield		Average Yield		
	TE 2010-11	TE 2020-21	Variety	Check Plot	Demo Plot
Jalna	11.33	15.38	MAUS-158	16.93	21.88
Beed	6.97	9.99	MAUS-158	16.93	21.88
Latur	11.02	12.92	MAUS-158	16.93	21.88
Osmanabad	8.21	11.47	MAUS-158	16.93	21.88
Nanded	9.11	13.74	MAUS-71	10.74	18.13
Nanded	9.11	13.74	JS-9560	12.92	16.87
Parbhani	10.65	11.71	MAUS-158	16.93	21.88
Hingoli	10.30	14.85	MAUS-158	16.93	21.88
Buldana	9.56	13.78	MAUS-158	16.93	21.88
Buldana	9.56	13.78	KDS-344	16.09	24.31
Akola	10.20	11.79	MAUS-158	16.93	21.88
Washim	7.10	14.04	MAUS-162	19.23	21.80
Amravati	9.23	9.87	JS-9560	12.92	16.87
Amravati	9.23	9.87	KDS-344	16.09	24.31
Yavatmal	7.05	10.01	NRC-37	13.52	22.00
Wardha	7.55	10.52	MAUS-162	19.23	21.80
Nagpur	9.35	9.62	JS-9560	12.92	16.87

Note: *1) TE 2000-01 = 1998-99– 2000-01 (Avg.); TE 2010-11 = 2008-09– 2010-11 (avg.); TE 2020-21 = 2018-19– 2020-21 (Avg.)*

Source: *(1) District Average Yield computations are based on figures obtained from the 'Statistical Division, Commissionerate of Agriculture, Government of Maharashtra, Central Building, Pune'.*

(2) Check/ Demo Plot Yield are based on estimates obtained from Prasad et al. (2019).

Table 3: Yield Gap Estimates of Soybean in Maharashtra (Yield in qtl Ha^{-1})

District		Yield Gap –I (%) (Check Plot vs. Dist. Avg.)		Yield Gap –II (%) (Demo Plot vs. Dist. Avg.)		
	Variety	TE 2010-11	TE 2020-21	TE 2010-11	TE 2020-21	% Change
Jalna	MAUS-158	33.08	9.16	48.22	29.71	18.51
Beed	MAUS-158	58.83	40.99	68.14	54.34	13.80
Latur	MAUS-158	34.91	23.69	49.63	40.95	8.68
Osmanabad	MAUS-158	51.51	32.25	62.48	47.58	14.90
Nanded	MAUS-71	15.18	-27.93	49.75	24.21	25.54
Nanded	JS-9560	29.49	-6.35	46.00	18.55	27.45
Parbhani	MAUS-158	37.09	30.83	51.33	46.48	4.84
Hingoli	MAUS-158	39.16	12.29	52.93	32.13	20.80
Buldana	MAUS-158	43.53	18.61	56.31	37.02	19.29
Buldana	KDS-344	40.58	14.36	60.67	43.32	17.36
Akola	MAUS-158	39.75	30.36	53.38	46.12	7.27
Washim	MAUS-162	63.08	26.99	67.43	35.60	31.83
Amravati	JS-9560	28.56	23.61	45.29	41.49	3.79
Amravati	KDS-344	42.64	38.66	62.03	59.40	2.63
Yavatmal	NRC-37	47.86	25.96	67.95	54.50	13.45
Wardha	MAUS-162	60.74	45.29	65.37	51.74	13.62
Nagpur	JS-9560	27.63	25.54	44.58	42.98	1.60

Note: *1) Change in yield (+/-) in TE 2020-21 over base period TE 2010-11 for the district with respect to Demo Plot Yield; + denotes decrease in gap and – represents increase in gap.*

Source: *Check/ Demo Plot Yield are based on estimates obtained from Prasad et al. (2019).*

to check plot yield and district average yield, whereas Yield Gap-II estimates correspond to demo plot yield and district average yield.

The major soybean cultivating districts belong to Marathwada and Vidarbha regions since they account for 80-85 per cent of area and production of soybean in the State. The districts of Marathawada region viz. Jalna, Beed, Latur, Osmanabad, Nanded, Parbhani and Hingoli have shown significant yield gap of soybean with respect to both check and demo plot yield with TE 2020-21 sowing lower yield gap as against TE 2010-11. Similarly, the districts of Vidarbha region like Buldana, Akola, Washim, Amravati, Yavatmal, Wardha and Nagpur have also shown perceptible yield gap of soybean with respect to both check and demo plot yield with a reduction in yield gap in TE 2020-21 as against TE 2010-11. For instance, the Yield Gap-II estimates show 26-17 per cent reduction in yield gap of soybean in Nanded district, whereas there is 9 per cent reduction in yield gap in Latur district in TE 2020-21 as against TE 2010-11. The district of Osmanabad showed 15 per cent decline in Yield Gap-II in TE 2020-21.

These estimates were concomitant of the fact that the scientific methods of farming with greater emphasis given on adoption of HYVs of seeds and improved cultivation practices have the potential to significantly increase yield levels of soybean crop, and thereby augmenting its production volume in the State. A sustained increase in production of important oilseed crops through rise in yield is the need of the hour since there is a vast gap in demand and supply of oilseeds in India.

Yield Gap Analysis based on Field Survey

In order to further assess yield gap, the demo plot yields of selected soybean varieties were compared with average check plot yield at farm level. The average yield levels of various varieties of soybean cultivated by various categories of soybean farmers were considered as check plot yield. The estimates related to average yield of soybean crop on sampled farms with all the varieties put together, the demo plot yield of selected varieties, and the proportion of yield gap in this respect are brought out in Table 4.

The estimates presented in Table 4 showed much higher yield of soybean on demo plot as against check plot yield for different categories of soybean farmers, especially in the district of Latur. The

Table 4: Yield Gap of Soybean on Sampled Farms (Yield in qtl Ha^{-1})

District/ HH Category	Average Yield (All Varieties) – Check Plot	Average Yield (Demo Plot)		Yield Gap (%) Demo Plot vs. Check Plot	
		MAUS-158	MAUS-71	MAUS-158	MAUS-71
Latur District					
Marginal	14.83	21.88	—	32.22	—
Small	15.05	21.88	—	31.22	—
Semi-medium	16.53	21.88	—	24.45	—
Medium	18.25	21.88	—	16.59	—
Overall	15.78	21.88	—	27.88	—
Nanded District					
Marginal	19.13	21.88	18.13	12.57	-5.52
Small	18.00	21.88	18.13	17.73	0.72
Semi-medium	22.08	21.88	18.13	-0.91	-21.79
Medium	18.63	21.88	18.13	14.85	-2.76
Overall	19.55	21.88	18.13	10.65	-7.83
Both Districts					
Marginal	16.95	21.88	18.13	22.53	6.51
Small	16.55	21.88	18.13	24.36	8.71
Semi-medium	19.28	21.88	18.13	11.88	-6.34
Medium	18.48	21.88	18.13	15.54	-1.93
Overall	17.73	21.88	18.13	18.97	2.21

Note: *Yield Gap = [(Demo Plot Yield – Avg. Check Plot Yield) / Demo Plot Yield] × 100.*

Source: *Demo Plot Average Yield are based on figures/estimates obtained from Prasad et al. (2019).*

comparison of demo plot yield for MAUS-158 variety of soybean with average check plot yield on sampled farms in Latur district showed an average yield gap of 28 per cent for the average category of farms. However, in the district of Nanded, the yield gap yield for MAUS-158 variety of soybean was lower at 11 per cent for the average category of farms.

It deserves mention that the demo plot yield in Nanded district stood at higher than check plot yield only in case of MAUS-158 variety of soybean. The demo plot yield of soybean for other varieties like MAUS-71 turned out to be lower as against check plot yield. The plausible reason for this phenomenon could be the fact that the check plot yield was based on average yield of three high yielding varieties of soybean viz. JS-335, JS-9305 and PHULE SANGAM (KDS-726), which showed higher yield of soybean as against demo plot yield of MAUS-71 variety of soybean.

In general, the comparison of demo plot yield for MAUS-158 variety of soybean with average check plot yield on sampled farms showed a yield gap of 19 per cent for the average category of farms with both the districts put together. Further, the comparison of demo plot yield for MAUS-71 variety of soybean with average check plot yield on sampled farms hardly showed any yield gap, which on an average was estimated at about 2 per cent. The general trend showed a declining yield gap of soybean with the increase in size of sampled farms since check plot yield was marked with an increase with the increase in farm size as against demo plot yield.

Factors Affecting Soybean Yield- Based on Field Survey

There were large number of factors affecting soybean yield like lack of adoption of technology and extension services, non-availability of quality seeds, seed prices, improper soil and nutrient management, etc. However, the field survey results showed about 90 per cent of soybean farmers holding climatic conditions as the major reason for low yield, whereas about 77 per cent of them identified drought as the most important factor affecting crop yield. The seed and soil quality turned out to be the third major factor affecting crop yield since 57 per cent of farmers showed their concern about it. The major suggestions extended by soybean crop cultivators regarding improvement in crop yield revolved around land preparation and crop management, soil testing, use of quality seeds of improved and recommended varieties, proper and adequate application of fertilizer, insecticides and pesticides, crop management according to rainfall pattern, adaptability to climate, timely availability of institutional credit, water management, etc.

CONCLUSION

Although there has been significant yield gap of soybean with respect to both check and demo plot yield, there was also a reduction in this gap during the last one decade, especially in major soybean cultivating districts of Maharashtra. The major soybean cultivating districts showed 15-20 per cent decline in yield gap during this period. The efforts initiated by agricultural extension network in the form of scientific methods of farming with emphasis on adoption of HYVs of seeds and improved cultivation practices were already paying rich dividends. These initiatives have the potential to raise the farm yields of soybean to match with the demo yield by being scaled up. A sustained increase in oilseed crop production is the need of the hour due to vast gap in demand and supply. The shortage in supply was further accentuated due to pandemic and recent international disturbances. Such factors bring about the need to attain self-sufficiency in edible oils. Therefore, the technological, institutional and policy-based changes coupled with bridging the extension gaps will help in raising the productivity and sustainability of oilseed production.

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