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Yield gaps and constraints to improve soybean productivity in Adilabad district of Telangana

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ABSTRACT

The study was based on primary data collected from ninety farmers spread over 6 randomly selected mandals of Adilabad district, constituting 30 farmers each in marginal, small and large farmers categories. In this study we found that 4.55 quintals of Yield Gap II and 6.30 quintals of Yield Gap III were existing. Simulation of gross income indicated that bridging 25, 50 and 100 percent of Yield Gap II would increase the gross income per hectare by Rs.4208, Rs.8417 and Rs.16835, respectively.This study also found that lack of application of recommended dose of nutrients and plant protection chemicals were the major reasons for existing yield gaps. The constraint analysis revealed that lack of high yielding varieties along with incidence of pests were major threat to soybean cultivation.

Keywords : Beta regression, constraints, factors, soybean, Telangana, yield gap

Soybean (*Glycine max)* is one of the pertinent crops in the world which is native to East Asia. Soybean can thrive on rainfed conditions besides its capacity to act as a cheap source of quality protein and oil which made this crop to spread around the world. Currently in 2020, 336.56 million metric tonnes of soybean is produced around the world, of which Brazil and USA accounts for 123 and 96 million metric tonnes respectively, while India accounts for 9 million metric tonnes. However, the productivity in India is very low at 1000 kg per hectare compared to USA, Mexico and Argentina recording more than 3000 kg per hectare and China with 1900 kg per hectare. In India Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Telangana are the major soybean producing states. Though India has an area of around 11 million hectares, low productivity makes India as a smaller producer in the world arena. Less productivity can be due to lack of high yielding varieties or poor management practices or sometimes may be due to both. Studies conducted in Madhya Pradesh estimated overall Yield Gap-I, II, and III as 52.20, 52.96 and 77.09 per cent, respectively.The crop yield realized on the farmers' field were considerably lower than that recorded on the demonstration plot (Datarkar *et al.,*2017). This difference in yield was due to lack of scientific management practices and other socio-economic constraints (Kumar *et al*.,2016). Dissemination of technologies of soybean cultivation and timely input supply can be helpful in bridging the yield gap. Different studies reported that higher incidence of pests, lack of technical knowledge (Deshmukh and Deshmukh, 2013) and occurrence of rainfall during harvest (Sharma, 2016) were major constraints in soybean production in India.

To combat the situation of low yields apart from developing high yielding varieties finding and bridging yield gap will also be essential. Therefore, analysis of yield gap and constraints in soybean production were taken up in the present study.

MATERIALS AND METHODS

For this study Adilabad district of Telangana (prior to district division) had been selected purposively since this district had major share in state's soybean area. Among the 52 mandals of the district, 6 mandals namely Jainad, Tannoor, Utnoor, Mudhole, Gudihathnoor and Neradigonda were selected randomly. Again, in each mandal one village was selected randomly. Then the sampling frame was stratified into marginal, small and large farmers based on their land holdings and from each mandal 5 sample farmers had been selected under each stratum. A sample of 90 farmers, constituting 30 in each category constituted the sample for the study. Apart from this, 6 progressive farmers and two research stations were also surveyed for the study purpose.

Yield gap

Though numerous yield gap concepts are existing in the literatures we had opted for the following to estimate the Yield Gap based on the Reddy (1994) concept with slight modifications:-

Yield Gap I = Agricultural Research Station(ARS) farm yield - Progressive farmer farm yield

Short communication

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Yield Gap II = Progressive farmer farm yield - Sample farmer farm yield

Yield Gap III = Agricultural Research Station (ARS) farm yield - Sample farmer farm yield

Bridging the yield gap

To find the factors that can help in bridging the yield gap, beta regression technique had been used. The nature of dependent variable (0 to 1) demanded the application of beta regression for the robust results. Let $y_1, y_2 \ldots y_n$ be the dependent variable that follows the beta distribution, then the beta regression model can be specified as follows:

$h(\mu_i) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} - + \ldots + \beta_j X_{ij} = \eta_i, \quad i = 1, 2, \ldots, n$

here $X_{i1} \ldots X_{ij}$ are the explanatory variables, β_0 is the intercept, β_1 to β_j are the estimated co-efficient of considered covariates, η_i is the linear predictor of the i-$_{th}$ observation, $h(\mu_i)$ is the link function between linear predictor and response variable (Cepeda-Cuervo, 2015).

To identify the constraints faced by the soybean farmers Garret Ranking technique had been employed. As a first step, various constraints faced by the soybean farmers had been identified with the help of preliminary survey and discussing with experts. The listed constraints had been given to the farmers for ranking, then their ranking had been converted into per cent position using the following equation

Per cent position = $100(R_{ij} - 0.5) / N_j$

R_{ij} = Rank provided for the i^{th} constraint by j^{th} person

N_j = No. of constraints ranked by j^{th} person

Once per cent position was estimated then it should be converted into Garret scores with the help of values provided by Garett and Woodworth (1969). Then mean score for every constraint had been calculated and based on the mean score the constraints had been ranked.

RESULTS AND DISCUSSION

Socio-economic profile of the respondents

Creation of awareness among the farmers group is a challenge to the stakeholders, therefore requirement of a thorough understanding of the socio-economic characteristics of the respondents is quite essential. The present survey comprised of around 65 per cent of the respondents falling the range of age group of 30-50 years, whereas just 10 per cent of respondents in the age group of more than 60 years. When it comes to the education around 50 per cent of the respondents had only primary or middle school education and a minimum of 10 per cent respondents had high school education or higher. Among the surveyed farmers around, 40 per cent had their membership in farmers group. Participation in the farmers group could help them in gaining information regarding updated production practices and also market prices.

Table 1: Socio-economic characteristics of the respondents

Characteristics	Classification	Percentage of farmers belong to the Category
Age	21-30	8.88
	31-40	33.33
	41-50	31.11
	51-60	16.66
	>60	10
Education	Illiterate	22.22
	Functionally literate	15.56
	Primary school	30.00
	Middle school	22.22
	High school	6.67
	College level	3.33
Participation in	Yes	38.88
Farmers group	No	61.22

Yield gap analysis

Among the surveyed farmers the average yield was 14.2 quintals per hectare. The popular variety JS 335 was cultivated by the farmers. Though the yield was much higher than national average (10 quintals), there existed huge gap between progressive farmer and the average sample farmer yield. The yield in the progressive farmers farm and research station farm were 18.75 and 20.50 quintals, respectively. The distribution of the sample farmers yield is shown in the box plot. The box plot reveals that majority of the farmers yield lied between median and first quartile and also it is noted that there is no outlier in the yield of sampled farmers.

Table 2: Yields obtained in soybean on different farms

	Yield (q/ha)
Research station farm yield	20.50
Progressive farmers farm yield	18.75
Sample farmers farm yield	14.20

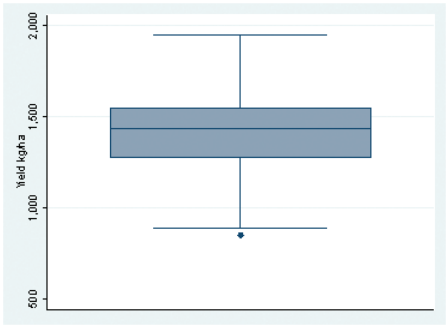

Fig. 1: Box plot representing the distribution of sample farmers' yield

From the Table 3, it is evident that there exists significant amount of yield gap in the soybean production. Among the ARS farm and Progressive farmers farm there existed a productivity difference (Yield Gap I) of 1.75 quintal per hectare. This might occur because of the difference in environmental conditions and also even the progressive farmers might not follows all the scientific production practices precisely as done in the Research station. The recorded Yield Gap II and Yield Gap III were 4.55 q ha^{-1} and 6.30 q ha^{-1} respectively. Lack of proper adoption of package of practices of sample farmers as compared to progressive farmers might be the reason for Yield Gap II.

Table 3: Yield gap in soybean on different farms

Particulars of Yield Gap	Yield Gap (q/ha)
Yield Gap I	1.75
Yield Gap II	4.55
Yield Gap III	6.30

As it is difficult to bridge the Yield gap I, an attempt was made to simulate gross income if the Yield Gap II was bridged. For calculating gross income, Minimum Support Price (MSP) was considered as the price of soybean. The result indicated that bridging 25, 50 and 100 percent of Yield Gap II would increase the per hectare gross income by Rs.4208, Rs.8417 and Rs.16835 respectively. Hence efforts are to be intensified to bridge the Yield gap II to increase the farmers' income, and economic status.

Table 4: Economics of reducing Yield Gap II

	Increase in yield (kg)	Increase in gross income per hectare (Rs. /ha)
5 per cent bridging of Yield Gap II	22.75	841.75
10 per cent bridging of Yield Gap II	45.5	1683.50
25 per cent bridging of Yield Gap II	113.75	4208.75
50 per cent bridging of Yield Gap II	227.5	8417.50
75 per cent bridging of Yield Gap II	341.25	12626.25
100 per cent bridging of Yield Gap II	455	16835

Factors that can help in increasing the sample farmers yield

While visualizing the data we found that even among the sample farms there existed yield differences. To probe further, a ratio was worked out which represent the proportion of yield that individual farm was getting with respect to the average yield of top ten yielding farms. The results revealed that on an average individual farmer was getting only 75 per cent of the average yield of the top ten higher yielding farms.The yield differences may be attributed to differences in taking up of management practices and application of inputs like chemical fertilizers and plant protection materials. This yield difference can be reduced by identifying the factors responsible and yield can be increased by using them in required quantities. For this purpose, beta regression model was employed and the results are shown below.

Table 5: Summary statistics of variables included in the beta regression model

	Mean	Standard deviation
Individual farmer yield / Average of top ten farm yields	0.76	0.10
Nitrogen (kg/hectare)	43.07	23.10
P (kg/hectare)	34.47	24.76
K (kg/hectare)	16.63	20.97
Plant protection chemicals cost (Rs. /hectare)	2282.34	980.24
Experience in soybean Farming (in years)	9	4

From the Table 5, it is observed that on an average sample farmer had obtained only 75 per cent of the average yield of top ten high yielding farms and also it is evident that average nutrient application of farmers is well below the recommended one. Marginal effects of estimated beta regression model are given in the Table 6. The results are indicating that increasing the use of phosphorus and potassium could improve the sample farmer's yield. These results are in line with the past studies done by Pawar and Tawale, 2011. When it comes to plant protection chemicals cost, for every thousand rupees increase in plant protection chemicals cost can increase the average ratio by 0.03. Earlier studies also support our result that plant protection chemical has significant role in increasing the soybean yield (Pawar and Tawale, 2011; Agarwal and Singh, 2014. Experience also had significant effect in increasing the yield, it might be because of the fact that farmers learned from the practice and also, they might get expertise after cultivating for years. Though trainings may not be a perfect substitute for experience that gained over the years, trainings can be given to improve the technical knowledge of the farmers.

Table 6: Factors contributing for bridging yield difference among farmers

Explanatory Variables	dy/dx	Standard Error	z-score	p>z
Nitrogen	0.000481	0.0003	1.62	0.106
Phosphorus	0.000617	0.00031	1.97	0.049
Potassium	0.001786	0.00044	4.03	0.000
Plant Protection				
Chemical cost	0.000034	0.00001	4.33	0.000
Experience	0.005803	0.00211	2.75	0.006

Table 7 represents the constraints in soybean production. The major constraints were non-availability of high yielding varieties, frequent occurrence of pests and diseases, lack of technical knowledge and untimely rain during harvest time. Lack of high yielding varieties coupled with yield gap of existing varieties was a major threat to soybean farming in India. Lack of technical knowledge emerged as third important constraint which reveals the need for training programs. Past studies also supported our finding that the lack of technical knowledge and occurrence of pests and diseases are the major constraints in soybean production (Desmukh and Desmukh, 2013; Medat *et al.,* 2016). In the present context, climate change and its impacts are faced by all the sectors, agriculture is no exception to that. One of the consequences of climate changes is untimely rainfall and this untimely rain during soybean harvest leading to the pre-harvest sprout which is emerging as serious threat to soybean farming. Earlier study by Sharma (2016) also quoted untimely rain during harvest as one of the major constraints in soybean production, this can be tackled either altering the sowing season or by developing pre-harvest sprout resistant varieties.

Table 7: Constraints in soybean production

Constraint	Garret score	Rank
Non-availability of HYV	74.56	1
Frequent occurrence of pests and diseases	67.65	2
Lack of technical knowledge	67.10	3
Untimely rain during harvest time	53.13	4
High cost of PPC	50.29	5
Seed viability low	41.75	6
Labour scarcity	40.81	7
High cost of fertilizers	39.60	8
Lack of irrigation facility	36.31	9
High cost of seed	35.41	10

From this study it is evident that yield differences existed among the farmers and it was mainly because of lack of adoption of scientific practices. Measures like effective credit facility, arrangement for supply of fertilizers, insecticides and pesticides etc. to farmers on time would be required to increase the yield. As experience has positive effect on yield, farmers also required effective extension services to enable them to use recommended level of inputs. If proper measure would be taken to reduce the yield gap, then definitely soybean cultivation could help in assuring doubling farmers income as well as ensuring protein security in India.

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