Journal of Advances in Biology & Biotechnology

Volume 27, Issue 5, Page 551-557, 2024; Article no.JABB.114995
ISSN: 2394-1081

Resource Use and Technical Efficiency of Soybean Production in Madhya Pradesh: A Data Envelopment Analysis Approach

Shiva Pujan Singh [a++*], Satyam Nema [b#], Ajeet Kumar [c++*], Minnatullah [c†] and Nishant Kumar [d#]

[a] Department of Agricultural Economics, School of Agribusiness and Rural Management, Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur)-848125, Bihar, India.
[b] Department of Agricultural Economics, Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur)-848125, Bihar, India.
[c] Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur)-848125, Bihar, India.
[d] Dr. Ram Manohar Lohia Avadh University, Ayodhya, UP., India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JABB/2024/v27i5817

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/114995

Original Research Article

Received: 29/01/2024
Accepted: 04/04/2024
Published: 18/04/2024

ABSTRACT

The resource use-efficiency of soybean production has been computed using primary data collected from 120 soybean growers spread over two blocks each from two selected district Vidisha and Ujjain of Madhya Pradesh. The Use of "DEA" as an analysis method was adopted for this work. The

[++] Assistant Professor;
[#] PG Research Scholar;
[†] Associate Professor;
**Corresponding author: E-mail: spsingh.sri@rpcau.ac.in, ajeet.sri@rpcau.ac.in;*

study revealed that the mean technical efficiency of soybean crop regarding most of the farmers were found to be 69 percent which indicated that production of crop may further be raised by 31 percent with available technology. The allocative efficiency of the mean estimated as 0.69, indicating that indicated that the farmers could be minimize cost by 31 percent through using optimum combination of inputs keeping in mind their prices while selecting their quantities. The cost efficiency asserted that farmers may be reduce their overall cost of soybean production up to 73 percent to harvesting the existing level of output at least cost. Undoubtedly, the export of soybean from the state has increased during the period of investigation. Therefore, efficiency measures highlight considerable scope to enhance resource uses by least cost processing through use of appropriate quality combination of inputs and output. The study has also suggested that some measures to increase productivity and income of the farmers in the study area.

Keywords: Soybean; resource use-efficiency; data envelopment approach; technical efficiency; allocative efficiency; cost efficiency; Madhya Pradesh; India.

1. INTRODUCTION

Soybean plays an important role in world oil seed development scenarios, because of its high yield capacity and critical contribution to soil fertility. The study conducted by Ajeet Kumar et al. [1] and Sanjay Kumar Singh, et al. [2] on carbon sequestration in sugarcane plant-soil systems sheds light on the importance of efficient resource utilization in agricultural practices, reminiscent of the focus on technical efficiency in soybean production in Madhya Pradesh. By employing a Data Envelopment Analysis approach, they underscore the significance of optimizing resource use to enhance productivity and mitigate environmental impacts. Their findings resonate with the notion of maximizing technical efficiency in soybean cultivation, particularly in regions like Madhya Pradesh where agricultural practices play a crucial role in the economy. Integrating nutrient management practices, as highlighted in both studies, becomes imperative for achieving sustainability goals and enhancing carbon sequestration potential in agricultural ecosystems, especially in the context of the Indo-Gangetic plains of India. Thus, the convergence of these studies emphasizes the necessity of adopting holistic approaches to improve resource use efficiency while addressing environmental concerns in agricultural systems. The refined oil of soybean contributes 95 percent as edible oil and 5 percent in agriculture products as soaps, bio-diesel and fatty acids etc. Soybean was introduced into Europe in the 1700's to the USA in 1765. India entered in the race of soybean production from 1960, but systematic cultivation of soybean started in India from 1970s. The major soybean producing countries in the world are USA (108.0 million tonnes), Brazil (86.8 million tonnes), Argentina (53.4 million tonnes), China (12.2 million tonnes) and India (10.5 million tonnes). The three countries USA, Brazil and Argentina dominated in global soybean production accounting for 80 percent of the world supply. Soybean production in India contains 40 percent protein and 20 percent oil has now been recognized all over the world as potential supplementary source of edible oil. Soybean is a short duration crop and attains full maturity from 90-110 days. It did not requires very much effort in production due to simply farmer's had to prepare field, sowing seeds with some basic intercultural operations like weeding and spraying and after that harvesting in three months [3]. Due to nitrogen fixing character, soybean crop increases fertility and productivity of the soil. In their study on the resource use and technical efficiency of soybean production, Ajeet Kumar et al. [4] employed a Data Envelopment Analysis approach. They understand the optimization of resources in soybean cultivation, using endophytic bacterium *Gluconacetobacter diazotrophocus* in the middle Gangetic plains, with a particular focus on nitrogen fixation. Their research delved into the intricate mechanisms involved in enhancing nitrogen fixation in soybean and sugarcane crops, shedding light on potential strategies for improving agricultural sustainability, the study underscores the interconnectedness of agricultural practices and the pivotal role of efficient resource management in enhancing productivity and environmental sustainability. The another major factor is that soybean oil is the major edible oil mainly due to its nutritional value and lower price as compared to groundnut oil. The soybean production in India is dominated by Maharashtra and Madhya Pradesh contributes approx. 89 percent and the remaining 11 percent contributed by Rajasthan, Andhra Pradesh, Karnataka and Gujarat. In

Madhya Pradesh soybean was cultivated in about 5.40 million hectare with a production of 5.91 million tonnes with productivity was 10.62 quintal per hectare. Despite being a crucial field of M.P., the soy processing market are already dysfunctional. Most soy plant has been shut down and others are unable to pay back financial institution because of many restrictions, challenges and lack of adequate funding. Production of soybean crop is a complex process and depends on various combinations of inputs such as human labour, machine labour, fertilizers, irrigation, capital and management practices etc. The variation in different combination of resources affects the production and yield of soybean crop. In this investigation attempt has been made to assess the efficiency of different resources inputs as well as impact of socio-economic factors on technical efficiency of soybean cultivation of the state. The study conducted by S.K. Sinha et al. [5] delves into the integrated effects of organic manure, biofertilizer, and inorganic fertilizer on soil properties, yield, and quality in sugarcane plant-ratoon systems in the calcareous soil of the Indogangetic Plains of India. This research offers insights into agricultural practices and resource management, paralleling the theme of resource use and technical efficiency. By examining the impact of various fertilizers on soil health and crop productivity, the study contributes to understanding optimal resource allocation and efficiency in agricultural production systems. Insights from both studies could potentially inform policymakers and agricultural stakeholders in Madhya Pradesh about sustainable practices and improved efficiency in soybean production, aligning with the broader goals of agricultural sustainability and resource optimization. Combining findings from these studies could offer a comprehensive understanding of agricultural dynamics, emphasizing the importance of efficient resource utilization for enhanced productivity and environmental sustainability in Indian agriculture.

2. MATERIALS AND METHODS

Vidisha and Ujjain are important soybean producing district, therefore these two districts of Madhya Pradesh which were purposively selected for the study because these are high performing district under soybean cultivation. Two blocks from each district were selected on the basis of highest area under soybean, and from these four blocks, 120 respondents were randomly selected for investigation. The relevant information was collected for the pertaining to agriculture year, 2019-20, through a pre tested schedule by survey method.

2.1 Resource Use-Efficiency

Resource use-efficiency, which may be defined as the ability to fetch maximum output per unit of resource properly addressed in achieving optimal production. There are various econometrical tools and methods to assess resource use efficiency like Data Envelopment Analysis (DEA), Stochastic Frontier (SF) production function etc. In the present study for estimating the resource use efficiency DEA (Data Envelopment Analysis) approach has been applied.

2.2 Data Envelopment Analysis (DEA) Approach

DEA is a linear programming technique and well established approach for measuring relative efficiency of decision making unit(DMU's) that have multiply inputs and outputs. This method was used to investigate the technical efficiency (TE), Allocative Efficency (AE) and Cost Efficiency or Economic Efficiency (CE). The technical efficiency (TE) of the farmers can be measured as the technique of DEA has been used to find out the relative efficiency score of each farm with minimum input –output ratio for all inputs. The score of the most efficient farms being one, the score of each farm will be lie between 0 and 1.

2.3 Technical Efficiency (TE)

It was expressed generally as the ratio of sum of the weighted outputs to sum of weighted inputs. The value of technical efficiency varies between zero and one; where a value of one implies that the DMU is the best performer located on production frontier and had no reduction potential. Any value lower than one indicates that the DMU used inputs inefficiently. Suppose there are k farmers (DMU's) using n inputs to produce m outputs.

The technical efficiency (TE) of the farmers was measured as:

$$TE_k = \sum_{i=0}^{m} u_i y_{ik} / \sum_{j=1}^{n} v_j x_{jk}$$

Where, X_{jk} is the quantity of ^{h} input used by the K^{th} farmer, Y_{ik} was the quantity of ith output produced by the K^{th} farmer (i=1,2,m and j=1,2,n) and u_i and v_j are the output and input weights, respectively.

Cost Efficiency or Economic Efficiency (CE): One can measure both technical and allocative efficiencies to verify the behavioural objectives such as cost minimization or revenue maximization.

$$\mathbf{CE = W_k X_k^* / W_k X_k}$$

Where W_k is a vector of input prices for K^{th} farmer and X_k* (which is calculated by LP) is the cost minimizing vector of input quantities for the K^{th} farmer, given the input prices W_k and the output level Y_k.

Allocative Efficiency (AE): It was calculated as the ratio of cost efficiency to technical efficiency.

$$\mathbf{AE = CE/TE}$$

Efficiency analysis is a relative concept relates to production analysis. Technical efficiency (TE), relates the extent to which a farmer produce maximum output from a given combination of inputs uses to produce a given level of output, when the technology depicts constant return to scale but is likely to differ otherwise. AE or price efficiency reflects the ability of a farm to use the inputs in optimum proportions given their respective price. CE is distinct from the other two TE and AE and shows the ability of a production until to produce a specified output at minimum cost.

3. RESULTS AND DISCUSSION

3.1 Resource Use-Efficiency of Soybean Crop Production

The summary statistics for the measures of the technical efficiency was presented in the Table 1 and Fig. 1. The efficiency table shown that the mean technological efficiency of the soybean crop was 0.42, indicating thereby production changes by 58 percent are possible to increase with the available technology. Only 8 (eight) farms jump the efficiency level above 90 percent of a total of 120 sample farmers. It was observed that at the efficiency point of 70-89 percent only 10 percent of the overall farmers were run by 12 respondents. If the efficiency was under 10 percent, only 3 percent of farmers in Vidisha and Ujjain district, 4 (four), of whom replied and all were marginal farmers. The Table 2 and Fig. 2, shown that the allocative mean efficiency (AE) calculated was 69 percent emphasizing the possibilities that farmers could reduced production cost by 31.0 percent through manipulating the right combination of the inputs with their prices. The combine effect of TE and AE shown in Table 3 the economic score of soybean crop investigated was 27 percent, the pointed out that on an average the cost of soybean production could be decreased by 73.00 percent to achieve the possible lowest production costs compared to the surrounding productive farmers in terms of current production level or to produce the existing level of output at least cost. This also promoted broad scope for optimizing sales by implementing the concept of low costs in crop production. The work is in confirmation with the work of Ahmad Nasim, et al [6,7]; Basuvaraj and Annapoorna [8]; Pandey, et al [9]; Rajan, and Kushwaha et al. [10].

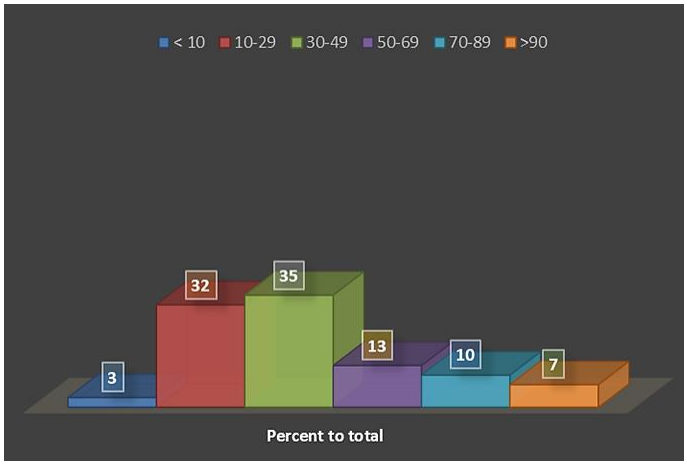

Fig. 1. Frequency Distribution of Technical Efficiency (TE) Scores In Soybean Crop

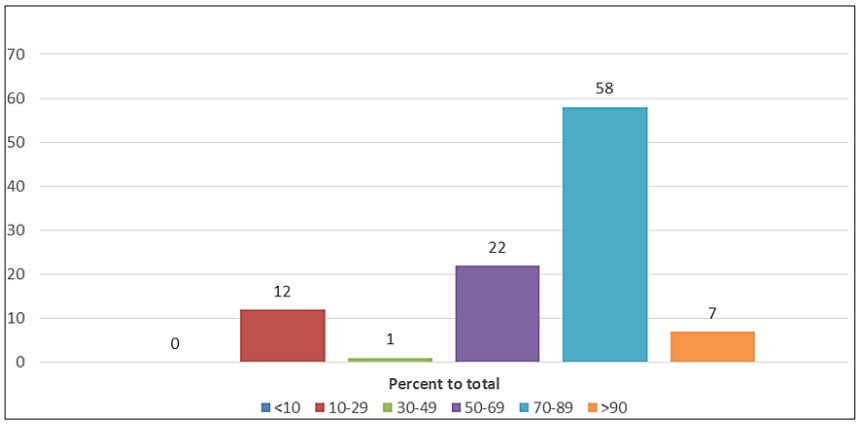

Fig. 2. Frequency distribution of Allocative Efficiency (AE) scores in Soybean crop

Table 1. Distribution of frequently technical efficiency (TE) scores of soybean crop

E.I.	Frequency (no. of farmers)					Percent to total
	Marginal	Small	Medium	Large	Total	
< 10	4	-	-	-	4	3
10-29	18	11	9	-	38	32
30-49	6	10	19	7	42	35
50-69	-	-	3	13	16	13
70-89	2	2	-	8	12	10
>90	1	-	4	3	8	7
Total					**120**	**100**
Mean TE is 0.41						

Table 2. Distribution of allocative efficiency (AE) scores of soybean crop

E.I.	Frequency (no. of farmers)					Percent to total
	Marginal	Small	Medium	Large	Total	
< 10	-	-	-	-	0	0
10-29	9	2	4	-	15	12
30-49	1	-	-	-	1	1
50-69	12	1	11	2	26	22
70-89	9	17	16	28	70	58
>90	-	3	4	1	8	7
Total					**120**	**100**
Mean AE is 0.69						

Table 3. Distribution of cost efficiency (CE) scores of soybean crop

Efficiency interval	Frequency (number of farmers)					Percent to total
	Marginal	Small	Medium	Large	Total	
< 10	14	1	-	-	15	12
10-29	17	22	29	4	72	60
30-49	-	-	6	11	17	14
50-69	-	-	-	13	13	11
70-89	-	-	-	2	2	2
>90	-	-	-	1	1	1
Total					**120**	**100**
Mean cost efficiency is 0.27						

4. CONCLUSION

The resource use efficiency of soybean production has been estimated by DEA (Data Envelopment Analysis) approach. This method was used to investigate the technical efficiency (TE) allocative efficiency (AE) and cost efficiency (CE). The study has shown that mean technical efficiency (TE) of soybean crop was 0.42, indicating that average production per farm was 58.0 percent greater. Allocative mean efficiency for soybean was calculated 69 percent pointing out that farmers could reduce production cost by 31 percent through using optimum proportions of inputs considering its prices while selecting its quantities. The cost efficiency of the crop was observed 0.27, resulting the cost of soya production can be decreased by 73.00 percent in order to possible lowest production cost compare to surrounding productive farmers. Therefore, efficiency measures potential harvesting of technical efficiency, allocative efficiency and economic efficiency and there was considerable scope to enhance resource usage, by at least cost processing soybean and to use appropriate quality combination of inputs and outputs by reducing inputs and soybean production cost may be made more productive and profitable, which would certainly help in achieving the objectives of enhancing farmer's income and also uplifting Socio-economic status of poor peasants of India.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to Department of Agricultural Economics and Dean, Post Graduate College of Agriculture, RPCAU, Pusa, for the approval of the Research Programme and for their financial support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ajeet Kumar, Sunita Kumari Meena, Sanjay Kumar Singh, Sinha SK, Singh AK. Carbon sequestration in sugarcane plant - soil system as influenced by nutrient integration practices under Indo-Gangetic plains of India. Journal of Advances in Biology & Biotechnology (JABB). 2024a; 27(5):116–125. DOI:https://doi.org/10.9734/jabb/2024/v27i5769.
2. Sanjay Kumar Singh, Ajeet Kumar, Kamlesh Kumar Singh. carbon sequestration potential of different land use pattern in calcareous soils of Muzaffarpur districts, Bihar, Biological Forum-An International Journal (BFIJ). 2023;15(4): 498-503.
3. Yegon PK, Kibet LK, Lagat JK. Determinants of technical efficiency in smallholder soybean production in Bomet District, Kenya. Journal of Development and Agricultural Economics. 2015 May 31;7(5):190-4.
4. Ajeet Kumar, Sunita Kumari Meena SK, Sinha AK, Minnatullah Singh, Sanjay Kumar Singh. Isolation and biochemical characterization of endophytic bacterium Gluconacetobacter diazotrophocus from native sugarcane cultivar of middle gangetic plains of India. Indian Journal of Ecology. 2024b;51(1):104-112. DOI:https://doi.org/10.55362/IJE/2024/4202;
5. Sinha SK, Ajeet Kumar, Amrita Kumari, Singh AK. The integrated effect of organic manure, biofertilizer and inorganic fertilizer on soil properties, yield and quality in sugarcane plant-ratoon system under calcareous soil of indo gangetic plains of India. Journal of Scientific Research and Reports (JSRR). 2024;30(5):193-206. Available:https://doi.org/10.9734/jsrr/2024/v30i51934; https://hal.science/hal-04507744
6. Ahmad Nasim, Sinha DK, Singh KM, Mishra RR, Singh Shiva Pujan. Resource use-efficiency in sugar cane production in Bihar, (India), A Stochastic frontier analysis. An International referred peer reviewed journal in science, Agriculture and Engg. April 2018a;VIII(XXV).
7. Ahmad Nasim, Sinha DK, Singh KM. Economic analysis of growth, instability and resource use-efficiency of sugarcane cultivation in India: an econometric approach. Indian Journal of Economics and Development. April 2018b;6(4). ISSN (online): 2320-9836.
8. Basuvaraj B, Annapoorna MS. Resource, use efficiency of major crops in Karnatka, International Journal Pure and Applied Bioscience. 2019;7(No.1):209-215.
9. Pandey A, Bista DR. Bhandari TP, anta HK, Devkota S Profitability and Resource Use Efficiency of Sugarcane Producton in

Nawalparsi, West district, Nepal. Cogent Food & Agriculture. 2020;6(1):1857592.

10. Rajan AK, Kushwaha et al. A Study on Resource Use Efficiency of Sugarcane Production I Ghazipur district of Eastern UP. Journal of Pharmacognosy and Phyto Chemistry. 2020;9(2S):440-442.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/114995