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Impact assessment of BBF technology adoption in soybean production using probit regression

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Abstract
This study assesses the impact of the Broad Bed and Furrow (BBF) system on soybean farming in Latur, Maharashtra. Originally developed by ICRISAT for vertisols and tested for eight years in Medak, the BBF method proved effective in improving drainage, reducing soil erosion, and enhancing yields, which led to its widespread adoption across Marathwada's rainfed regions with strong support from Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani. Soybean, often referred to as a "miracle crop," is one of India's major oilseeds known for its economic and nutritional value. It plays a significant role in uplifting the socio-economic status of farmers, especially in rainfed areas like Marathwada. Latur, being a key soybean-growing district, was purposively selected for this study. A multistage sampling technique was employed for selecting respondents. Primary data was collected for the year 2023-2024 through personal interviews using a pre-tested schedule. A total of 120 farmers were selected, equally divided between 60 adopters and 60 non-adopters of BBF technology. To evaluate the economic impact of BBF adoption, a probit regression model was applied, as it is well-suited for binary outcomes such as adoption (1) and non-adoption (0). The explanatory variables considered in the model included age, education level, family size, annual income, and source of information. The analysis revealed that source of information and family size significantly influenced adoption, at the 1 per cent and 10 per cent levels respectively, with the source of information emerging as the most influential factor. To enhance BBF adoption, it is essential to strengthen extension services, increase farmer awareness through demonstrations, and promote family involvement by emphasizing the benefits of labour sharing and collaborative decision-making.

Keywords: BBF technology, soybean, probit regression, impact

Introduction
The Broad Bed and Furrow (BBF) system is an innovative farming technique developed to tackle water scarcity and soil erosion in semi-arid and rainfed regions. It consists of raised beds 90-95 cm wide, separated by 45-55 cm wide and 15 cm deep furrows, with 30 cm row spacing for sowing. Initially designed for deep black soils (vertisols), BBF has proven effective in improving water-use efficiency, minimizing moisture stress, and boosting crop productivity, particularly in soybean cultivation. It enables farmers to reduce seed rates, lower pest and disease incidence and protect crops during dry spells, resulting in up to a 35 per cent increase in yields. The system is particularly beneficial when combined with appropriate nutrient management, improving soil health and supporting crop growth under changing climate conditions. The Broad Bed and Furrow (BBF) system was initially developed by ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) as a land management technique tailored for black soils in semi-arid areas. Acknowledging its advantages, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani, further promoted and adapted the technology.

The BBF system helps prevent waterlogging, supports double cropping, and is ideal for areas receiving over 750 mm of rainfall. VNMKV Parbhani enhanced the technology by introducing a lightweight, foldable BBF machine compatible with low-horsepower tractors and effective in handling crop residues. Equipped with multipurpose attachments, it offers a practical and affordable solution for small farmers in Marathwada. Overall, BBF promotes resilient, sustainable, and efficient rainfed agriculture. For soybean, BBF allows a seed rate reduction

from the conventional 20-22 kg per acre, offering notable input savings.

Soybean is an important legume crop known for its high protein and oil content, widely used in food, feed, and industry. In India, it supports soil health through nitrogen fixation and serves as a key cash crop in rainfed regions like Maharashtra. To improve its productivity in such areas, the Broad Bed and Furrow (BBF) system has emerged as a sustainable land configuration technique. Assessing the impact of BBF adoption in soybean cultivation is essential to understand its effectiveness in enhancing farm performance and farmer livelihoods under challenging agro-climatic conditions.

Methodology

The study was carried out in Latur district of Maharashtra, a major soybean-growing area. A multistage sampling method was followed for the selection of farmers. In the first step, Latur district was purposively selected due to its significant role in soybean cultivation. Then, two tehsils Latur and Ahmadpur were randomly chosen from the district. From each tehsil, five villages were selected at random, making a total of ten villages. In the final stage, six BBF adopters and six non-adopters were selected randomly from each village. This resulted in a total sample size of 120 farmers, which included 60 BBF adopters and 60 non-adopters. The study was based on primary data collected from these respondents using a pre-tested interview schedule. Information was gathered for the agricultural year 2023-24, focusing on socio-economic characteristics such as age, education, family size, annual income and source of information.

Analytical tools

To evaluate the economic impact of BBF technology adoption in soybean cultivation, a probit regression model was used. This statistical technique is suitable when the dependent variable is binary—in this case, indicating whether a farmer is an adopter (1) or non-adopter (0) of BBF technology. The model estimates the likelihood of adoption based on selected explanatory variables. Key independent variables considered in the model included age, education, family size, annual income and source of information. These socio-economic characteristics play a vital role in shaping a farmer's decision to adopt new agricultural technologies.

$$Yit = \beta Xit + (qi + \mu i) + \mu it$$

Where,

Y = Dependent variable

X = Independent variable

μi = Error term

β = Coefficient of regression

Results and Discussion

The Probit regression analysis aimed at identifying the factors influencing the adoption of Broad Bed Furrow (BBF) technology in soybean farming revealed insightful findings. Among the variables studied, family size and source of information emerged as significant contributors to adoption decisions. Source of information showed a strong positive connection at the 1% level of significance with a value of 0.6708 and a Z-value of 5.17. Family size had a positive and statistically meaningful effect at the 10% level, with a value of 0.1231 and a Z-value of 1.796. The analysis showed that larger households were more inclined to adopt BBF, likely due to better availability of labour and the capacity to manage farming risks collectively. Similar findings for some of the significant variables were also reported by Kumar *et al*. (2020) [8], which falls in line with the present study

Farmers who received information through extension services, media, or peer networks were significantly more likely to adopt BBF technology. On the other hand, factors such as education, annual income and age did not show a notable influence on the decision to adopt the technology. While education and income had a slight positive effect and age showed a marginal negative trend, none of these were statistically significant. Education showed a positive coefficient (0.0074), indicating a slight increase in BBF adoption with higher education. Comparable trends were reported by Sharma *et al*. (2018) [13] and Alabi *et al*. (2014) [2], reinforcing the reliability of the current findings. However, the effect was statistically insignificant (Z = 0.30). Field observations still suggested that educated farmers were more receptive to technical guidance and modern practices.

Overall, the findings suggest that enhancing the reach and effectiveness of agricultural extension systems and promoting knowledge-sharing platforms at the village level can substantially drive BBF adoption. Such efforts are vital for improving soybean productivity, especially in regions reliant on rainfed farming. Social factors influences the impact on adoption rate Khandagale *et al*. (2023) [6]

Sr. No.	Variables	Coefficients	Standard Error	Z value
1	Intercept	-1.361	0.886	-1.53
2	Age	-0.01138	0.018	-0.63
3	Education	0.0074	0.025	0.30
4	Family Size	0.1231*	0.069	1.79
5	Annual Income	0.000020	0.00000063	0.32
6	Source of Information	0.6708***	0.129	5.17

Note: ***, and * represent significance at 1% and 10% respectively.

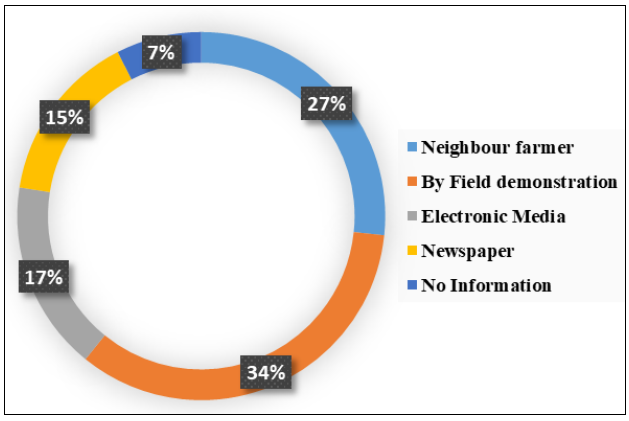

Fig 1: BBF adoption influenced by different information channels

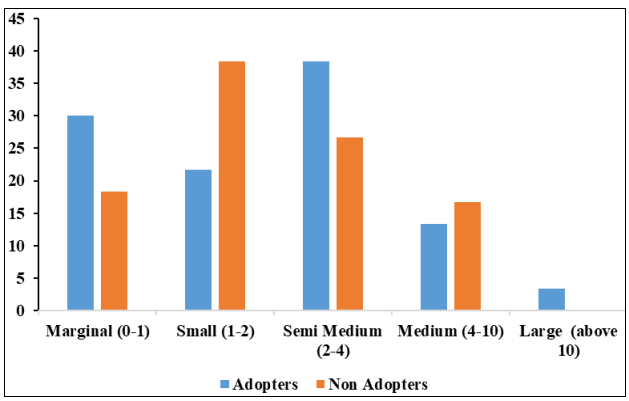

Fig 2: Influence of Family Size on BBF Adoption

Conclusion

The Probit regression analysis indicated that access to information (significant at 1 per cent) and family size (significant at 10 per cent) were the primary factors influencing the adoption of BBF technology. Farmers with reliable information sources such as extension workers, media, or peers were substantially more likely to adopt the practice, while larger households appeared better equipped in terms of labour and risk-sharing capacity. In contrast, age, education, and annual income did not show statistically significant effects, suggesting limited influence on adoption decisions. Although education showed a positive trend (coefficient: 0.0074; Z-value: 0.30), it lacked statistical strength, despite field insights indicating greater openness among literate farmers. These results highlight the importance of strengthening rural information networks and extension outreach to scale up BBF adoption, especially in rainfed areas.

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