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Estimating the impact of BBF technology adoption in soybean cultivation: A probit regression model

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Abstract
In the present study, the economic impact of BBF technology on soybean cultivation has been assessed. This was based mainly on primary data collected through the personal interview method with the help of pre-tested schedules. Dharashiv district was purposively selected due to its high soybean production. A multistage sampling technique was employed for the selection of the district, tehsils and villages. The total sample size was 120, comprising 60 adopters and 60 non-adopters of soybean growers. A Probit regression model was fitted to assess the impact of BBF technology on adopters and non-adopters among soybean cultivators. Dharashiv falls under the dry zone of western Maharashtra. Given increasing climatic challenges, assessing the real-world impact of such innovations is essential. BBF is a “Four-in-One” planter that performs bed making, seed sowing, fertilizer application and weedicide spraying simultaneously, promoting efficient water use and enhanced crop productivity. Due to time and resource limitations, the study is confined to selected variables which are likely to affect the acceptance of BBF technology by farmers. Independent variables considered are age, level of education, source of information, annual income and family size. The Probit model is a method to perform regression for a binary outcome variable with two possibilities, such as adopters and non-adopters of BBF technology. The analysis indicated that annual income (significant at 1% level) and source of information (significant at 10% level) were the two major factors that significantly influenced the adoption of the technology. The result revealed that helping farmers improve their financial condition and providing them with better access to information can play a key role in encouraging the adoption of BBF technology in the study area.

Keywords: BBF technology, soybean, impact, probit regression

Introduction
Soybean (*Glycine max* (L.) Merrill), often referred to as the "golden bean," is a globally important oilseed crop widely cultivated for its high nutritional value and diverse industrial uses. It contains approximately (40%) protein and (20%) oil, in addition to essential micronutrients such as iron, calcium, zinc and B-complex vitamins. India is 5th largest soybean producer in world. Within India, Maharashtra rank second after Madhya Pradesh. Soybean cultivation has expanded notably in Maharashtra, with Dharashiv district in the Marathwada region emerging as a key producing district with favourable conditions and growing farmers preference. Suitable climate and rising demand for oilseeds have led many farmers to adopt soybean as a main kharif crop. However, issues like uneven rainfall, heavy soils and waterlogging on flat fields continue to limit its productivity. ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) originally developed the Broad Bed and Furrow (BBF) system as a land configuration technique suitable for black soils in semi-arid regions. Recognising its benefits, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani actively worked to promote and popularize the BBF technology across the Marathwada region. The BBF technology is particularly suited for black cotton soils found in regions like Dharashiv, as it improves surface drainage, enhances root aeration and reduces soil erosion. By creating alternate raised beds and furrows, BBF facilitates better moisture conservation and nutrient use efficiency, making it a rewarding intervention for sustainable soybean cultivation, especially in rainfed areas. Many social characteristics of farmer reflect its impact on rate of its adoption, supported by study of Welay and Desalegn (2019) [16], Pachpute *et al*. (2023) [14], Etim *et al*. (2020) [3], Kumar *et al*. (2019) [6],

Kumar *et al*. (2022) [7] and Jaybhay *et al*. (2018) [4]
The advanced "Four-in-One" BBF planter streamlines operations by combining bed formation, sowing, fertilizer application and weedicide spraying, saving time, labour and cost which is ideal for small, rainfed farms. Key benefits include reduced seed rate, lower pest and disease incidence, better water-use efficiency and minimized crop lodging. It also helps relieve water stress, improves soil health and boosts overall yield.
Climate change, marked by erratic rainfall, rising temperatures and droughts, has increased risks in agriculture. In this context, BBF technology plays a crucial role by improving water-use efficiency, reducing crop failure. Its adoption is essential to ensure food security and safeguard rural livelihoods. Many social characteristics of farmer reflect its impact on rate of its adoption such as annual income, farm size, education etc. Similar findigs are observed by

Methodology

The methodology adopted for conducting research where multistage sampling design. Study is based on primary data said by respondent farmers. A multistage sampling technique was employed for the selection of respondents in the present study. In the first stage, Dharashiv district was purposively selected due to its significant soybean production. In the second stage, two tehsils i. e Omerga and Lohara were randomly chosen from the district. At the third stage, five villages from each selected a tehsil were randomly selected. Finally, from each village, six adopters and six non-adopters of BBF technology were randomly chosen. Thus, the total sample comprised 120 respondents, including 60 adopters and 60 non-adopters, covering 1 district, 2 tehsils and 10 villages. The present study is based on primary data collected through the pre tested schedules and interviewing the BBF adopters and non-adopters. Primary data was collected for the year 2023-2024. The data included basic socio-economic details such as age, education, source of information, annual income and family size.

Analytical tools

For assessing the economic impact of BBF technology adoption in soybean cultivation a probit regression model was employed. This model is appropriate when the dependent variable is binary, such as adopter (1) or non-adopter (0) of BBF technology (Undirwade *et al*., 2023) [15]. It estimates the probability of adoption based on various explanatory variables. The model specification is given below:

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

Where,
Y = Dependent variable
X = Independent variable
μi = Error term
β = Coefficient of regression

The independent variables included in the model were age, education level, family size, annual income and source of information. These socio-economic and personal factors are known to influence a farmer's decision-making regarding technology adoption.

Results and discussion

The results are presented in table no. 1. The impact of BBF technology on soybean cultivation was analyzed using a probit regression model. According to the findings, the variable annual income showed a positive and highly significant influence on the adoption of BBF technology, with a coefficient of 0.0042, significant at the 1 per cent level. This implies that farmers with higher income were more likely to adopt BBF, likely due to their stronger financial capacity and greater readiness to invest in improved farming practices. Likewise, the variable source of information had a positive coefficient of 0.5346, which was statistically significant at the 10 per cent level. This indicates that better access to information positively impacted adoption decisions, as farmers with stronger links to extension services or peer groups were more aware of the benefits of BBF technology. Similar finding were reported by Kumar *et al*. (2019) [6] and Kimbi *et al*. (2021) [5].
Although education and family size were not statistically significant, their coefficients reflect meaningful directions. The positive sign for education suggests that more educated farmers may be slightly more open to adopting new practices, while the negative sign for family size may indicate challenges in labour distribution or decision-making in larger households. Similarly, the age variable, though negative and not significant, might be suggesting tendency of older farmers to be less experimental with newer methods. Similar trend realted to education was reported by Wosene and Gobie (2021) [17], Mane *et al*. (2022) [9].
These results suggest that without key influencing factors such as income and access to information, the likelihood of BBF adoption remains low. Therefore, income level and information availability emerge as the most critical factors promoting the adoption of BBF technology in soybean cultivation. This highlights the crucial role of economic stability and effective communication in encouraging technology adoption among farmers. The outcome of the results are supported by findings of Alabi *et al*. (2014) [1] and Welay and Desalegn (2019) [16].

Table 1: Variables influencing BBF technology on soybean cultivation

Sr. no	Variables	Coefficients	Standard Error	Z value
1	Intercept	-12.19	2.90	-4.20
2	Age	-0.0193	0.02	-0.70
3	Education	0.0264	0.05	0.48
4	Source of information	0.5346*	0.29	1.79
5	Annual income	0.0042***	0.0009	4.31
6	Family Size	-0.1327	0.15	-0.86

Note: ***, ** and * represent significance at 0.01, 0.05 and 0.1 respectively.

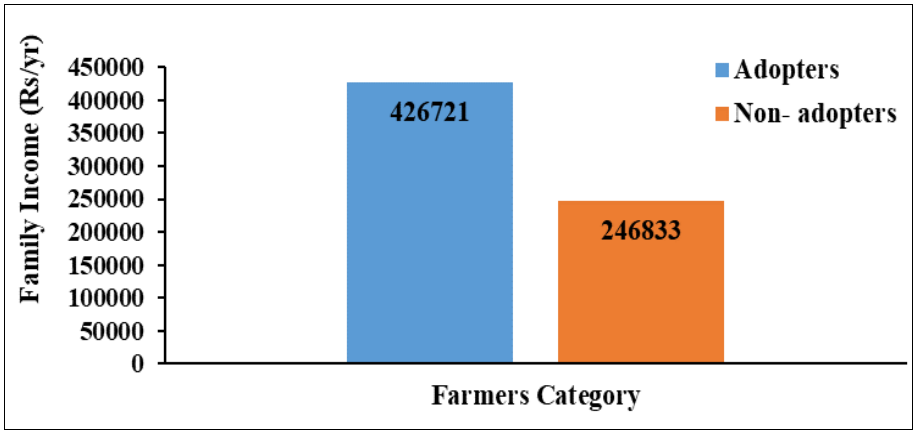

Fig 1: Adoption of BBF technology by Influence of Annual Income

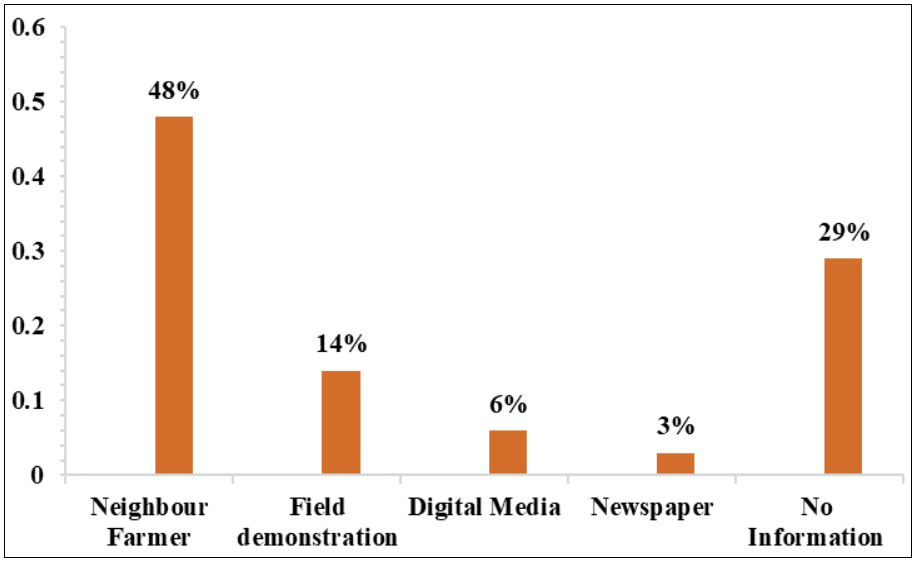

Fig 2: BBF adoption influenced by different information channels

Conclusion

The Probit regression analysis revealed that annual income was significant at 1 per cent and access to information was significant at 10 per cent and these key factors positively influencing BBF adoption. Other variables like age**,** education and family size were statistically insignificant, indicating their low relevance in BBF technology adoption This shows that farmers with better income and information access are more likely to adopt BBF technology, highlighting the need for financial support and awareness programs to boost adoption. Lemma *et al.* (2024) [8]

Financially stronger farmers are more capable of adopting new technologies and timely access to accurate information helps them make informed decisions. Hence, policies aimed at increasing awareness and offering financial support can significantly improve the adoption of BBF technology at the grassroots level.

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