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# Economic Feasibility and Nutritional Security of Tribal Farmers through Grow Bag-based Organic Vegetables Production in Chhattisgarh Plain Agro-climatic Zone, Madhya Pradesh

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## ABSTRACT

The present study was conducted in January-December, 2023 under the ICAR-supported Tribal Sub Plan (TSP) at 150 tribal farmers across the Baihar, Paraswada, and Birsa developmental blocks of the Balaghat district, Madhya Pradesh, India to assess the impact of grow bag-based organic vegetable cultivation on productivity, profitability, and nutritional well-being among tribal communities in the Chhattisgarh Plain Agro-climatic Zone of Madhya Pradesh. Farmers were provided with complete input kits, including grow bags, drip irrigation setups, enriched organic nutrients, and seedlings of four vegetable crops i.e. tomato, brinjal, cabbage, and chili. In comparison to traditional farming, the grow bag system showed marked improvements. Average yields per 25 bags reached 356 kg for tomato, 230 kg for brinjal, 40 kg for cabbage, and 33 kg for chili, nearly doubling the output from existing conventional methods. Economic analysis revealed a sharp rise in the benefit–cost ratio from 1.40 (farmers' practice) to 2.88 under the improved package. Extension and technology gap studies highlighted critical knowledge shortfalls, emphasizing the value of focused capacity-building. Beyond yield and income, the initiative enhanced household dietary diversity and vegetable intake frequency. Largely, the intervention demonstrated high adaptability and scalability, offering a sustainable, space-efficient model for year-round vegetable cultivation, improved nutrition, and livelihood security in resource-poor tribal settings. Thus, the grow bag based organic vegetable production technology significantly superior from the traditional methods.

**KEYWORDS:** Grow bag, tribal farmers, extension and technology gap

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***Data Availability Statement:*** Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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## 1. INTRODUCTION

India, as one of the world's leading vegetable producers, is experiencing a transformation in horticultural practices, with the adoption of resource-efficient technologies such as grow bag cultivation and overhead irrigation. Crops like tomato (*Solanum lycopersicum*), brinjal (*Solanum melongena*), chilli (*Capsicum* spp.), and cauliflower (*Brassica oleracea var. botrytis*) have emerged as cornerstone vegetables, contributing significantly to dietary diversity, farmer income, and rural employment (Anonymous, 2023). In this context, the integration of grow bags and overhead irrigation presents a dual advantage, facilitating high-density vegetable cultivation while conserving water and optimizing space, especially in small and fragmented landholdings. In Madhya Pradesh, especially Balaghat district, government schemes like PMKSY and MIDH are promoting grow bag cultivation with micro-irrigation technologies such as overhead sprinklers and drip lines, offering efficient, climate-suited solutions for enhancing vegetable production in water-deficient areas (Anonymous, 2022). In Balaghat, where mono-cropping and fallow seasons limit income and drive migration, grow bag cultivation with overhead irrigation offers a sustainable solution by transforming unused spaces into year-round, diversified production zones for enhanced livelihoods and food security (Thakur et al., 2021). Adopting grow bag technology at the household level offers a strategic advantage it is low-cost, requires minimal space, and aligns well with recycling of organic kitchen waste. Coupled with overhead irrigation, which ensures uniform water distribution and reduces manual labor, this method maximizes water-use efficiency and crop performance. Anonymous (2021) highlights that grow bag cultivation of tomato, brinjal, and chili with controlled irrigation boosts yield and resilience, offering a space-efficient, nutrient-rich solution ideal for smallholder and tribal farmers. Integrated Nutrient Management (INM) in grow bags involves a balanced combination of organic compost, bio-fertilizers, and minimal chemical inputs to sustain plant health and productivity (Sarvade et al., 2014; Patel et al., 2018; Tiwari et al., 2024; Sarvade et al., 2025). This approach ensures optimal nutrient availability, enhances microbial activity, and improves the quality of produce. INM in grow bags not only supports efficient resource use but also promotes eco-friendly and sustainable home-based farming. The economic and nutritional importance of vegetables like cauliflower, brinjal, and chilli goes beyond just regional relevance. These crops are key sources of micronutrients, and their rapid growth cycle makes them ideal for short-duration, high-return cultivation. In Madhya Pradesh, the shift toward protected and precision horticulture, supported by government-backed extension services and irrigation infrastructure, is contributing to increased vegetable productivity and profitability (Ganeshamurthy et al., 20216; Lodhi et al., 2024a). With overhead irrigation enabling water delivery even in shallow-rooted vegetables, this technique proves indispensable in areas where uniform water supply is critical for vegetable success (Lodhi et al., 2013; Lodhi et al., 2014). Tribal areas in Madhya Pradesh's Chhattisgarh Plain face irrigation, soil, and nutrition challenges, where grow bag cultivation with overhead irrigation offers a viable solution to improve livelihoods and dietary diversity (Lodhi et al., 2024b). This integrated approach ensures not just sustainability and crop diversification but also fosters self-reliance in food production by enabling families to grow vitamin-rich crops right at their doorstep. With Madhya Pradesh advancing towards intensified agriculture, grow bag systems with overhead irrigation offer a climate-resilient, water-efficient solution for boosting productivity, especially in space-limited peri-urban and tribal areas with high potential for year-round vegetable cultivation (Yadav et al., 20124; Eigenbrod and Gruda, 20215). Against this backdrop, the present study was undertaken across three blocks of Balaghat, Madhya Pradesh, to assess the productivity and economic viability of growing tomato, brinjal, cabbage, and chili using grow bags and overhead irrigation. The study also aimed to identify existing technological and extension gaps among the farmers' practice and technology demonstration.

## 2. MATERIALS AND METHODS

### 2.1. Description of study site and climatic conditions

The present study was conducted under the ICAR-funded project on grow bag-based vegetable production at tribal farmers of Balaghat district, Madhya Pradesh, India, during January to December, 2023 under TSP. The study was conducted in three tribal-dominated blocks, i.e., Baihar, Birsa and Paraswada of Balaghat district, located in the Chhattisgarh Plain agro-climatic zone of Madhya Pradesh. The Birsa and Baihar share nearly identical coordinates due to their close geographical closeness, both situated around 22.05° N latitude and 80.72° E longitude, while Paraswada lies further east within Balaghat district at approximately 22.18° N, 80.30° E. The study area has a semi-arid and sub-tropical climate with a characteristic feature of dry summer and cold winter. In the winter season, i.e., from November to February, the temperature ranges from 4 to 33°C and the relative humidity varies from 70 to 90%. Dry and warm weather usually prevails during the months of March to June. Monsoon season extends from mid-June to mid-September. The temperature during this period ranges from 25 to 35°C and the relative humidity ranges between 70 to 80%. The total annual rainfall varies from 1400 to 1500 mm, with the mean value of around 1400 mm (Thakur et al., 2021).

### 2.2. Experimental details

#### 2.2.1. Technology intervention

In the present experimental study, grow bag technology (Figure 1) was introduced among farmers possessing a home garden or small land parcel with access to a basic water source for tank refilling. The simplicity and user-friendliness of the system motivated farmers to adopt the method for year-round vegetable cultivation. To support water delivery, a gravity-fed micro-irrigation system was integrated, wherein a water reservoir was positioned at an elevated level relative to the cultivation area. From the base of this tank, water was channeled through a pipeline into the overhead irrigation network, effectively supplying multiple grow bags simultaneously (Suresh, 2009). The system comprised mainlines and lateral pipes fitted with emitters delivering water at a controlled rate of 2-4 liters hour$^{-1}$. This configuration minimized manual labour, ensured uniform moisture distribution, and significantly improved water use efficiency in the grow bags. The synergy between overhead

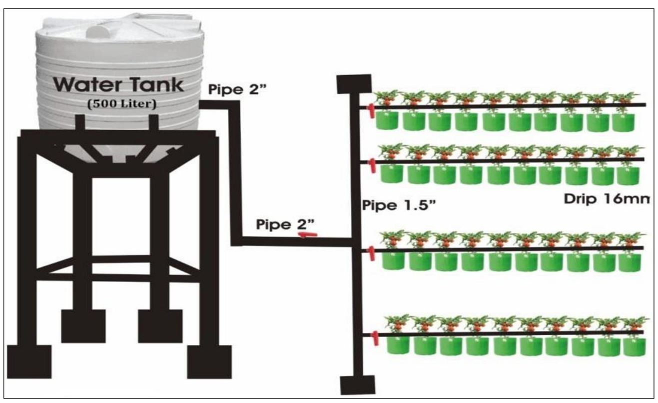


Figure 1: Layout of the technology for grow bag-based vegetable production

irrigation and grow bag cultivation offered an efficient, low-cost solution for producing organic vegetables using minimal space and water, especially beneficial in resource-constrained tribal households.

To gain in-depth insights into the local context and farming practices, various Participatory Rural Appraisal (PRA) tools were employed for baseline assessment of the study area (refer to Table 1). Alongside the technical intervention, a robust Human Resource Development (HRD) component comprising training programs, field demonstrations, and exposure visits was incorporated to enhance farmer knowledge and practical skills related to the grow bag-based vegetable production system (Table 2). A total of 150 tribal households (50 from each of the three selected blocks) were supported with a comprehensive input package. Each beneficiary received a 500 l water tank mounted on a 72-inch-high iron stand with a 30-inch platform diameter, a complete drip irrigation setup (Figures 1 and 2), and 100 HDPE/UV-stabilized grow bags distributed equally across four crops: tomato, brinjal, cabbage, and chili. The grow bags were filled with a nutrient-rich organic potting mix, fortified with vermicompost and bio-fertilizers, and planted with seasonal vegetable seedlings. For comparative analysis under farmer practice, the same number of seedlings was cultivated directly in traditional kitchen garden soil without grow bags. Additionally, targeted training on organic farming techniques, pest and disease management, and efficient use of drip irrigation was delivered to ensure effective implementation and sustainable adoption of the technology.

#### 2.2.2. Data collection and analysis

For evaluating the impact of the intervention, data on vegetable yield and related agronomic and economic parameters were systematically collected from selected farmer fields. A sample of 30 households randomly chosen, with 10 households from each block, was surveyed using structured interviews designed specifically for this study. Detailed information on input costs, yields, prevailing market prices, and net returns was gathered both before and after the implementation of the grow bag-based cultivation system to facilitate a comprehensive cost-benefit (B:C) ratio analysis (Thakur et al., 2023a). Additionally, changes in nutritional indicators, particularly the frequency of vegetable consumption, were recorded to assess improvements in

Table 1: Information regarding experiment

| Parameters | Details |
|---|---|
| Problem diagnoses | Low yield and less intake by the farmers due to a lack of skill for vegetable production |
| Technology selected for assessment | Grow bag and drip irrigation-based technology for organic vegetable production |
| Thematic area | Grow bag and drip irrigation-based technology |
| Process for farmers' participation | Training, field day, exposure visits, popular article/leaflet and field demonstrations |
| Demonstration input | Drip irrigation system, 100 grow bags, vegetable seedlings (tomato, brinjal, cabbage and chili), organic inputs (enriched vermicompost, bio-inoculants, etc.) |
| Total demonstrations | 150 (50 from each block) |

Figure 2: Glimpses of demonstration on grow bag and drip irrigation-based vegetable production technology

dietary diversity. To assess the effectiveness of knowledge, transfer and technology adoption, extension and technology gaps were also quantified using standard approaches (Dwivedi et al., 2019; Thakur et al., 2021), helping to identify critical areas requiring further capacity-building and support. Yield data was analyzed by using multivariate analysis in SPSS (Ver. 20). And the means were compared by LSD test at 0.05 level of probability.

## 3. RESULTS AND DISCUSSION

### *3.1. Human resource development (HRD)*

Throughout the study period, a strong emphasis was placed on Human Resource Development (HRD) activities to enhance farmers' knowledge and practical skills related to grow bag and drip irrigation-based organic vegetable cultivation (Table 2). A series of capacity-building initiatives, including trainings, field days, focused group discussions, and exposure visits were systematically conducted, complemented by the dissemination of information materials such as leaflets, pamphlets, and popular articles (Table 2). These outreach efforts played a vital role in simplifying technical knowledge and promoting hands-on learning among tribal farmers. Consistent with the observations of Dwivedi et al. (2019) and Rasanjali et al. (2021), the study reaffirmed that regular and targeted training interventions significantly improve farmers' competence and confidence, thereby accelerating the adoption of innovative organic production technologies in rural and tribal settings.

Table 2: Human resource development components

| HRD components | Frequency | Beneficiaries |
|---|---|---|
| Training | 09 | 456 |
| Field day | 14 | 671 |
| Exposure visits only for selected farmers | 06 | 150 |
| Popular article/leaf let/ pamphlets | 05 | Mass |

### 3.2. *Organic vegetable production*

The yield assessment conducted across the three project blocks, Baihar, Paraswada, and Birsa revealed a clear superiority of grow bag-based organic vegetable cultivation over conventional farmer practices (Table 3). Under traditional methods, the average yield per 25 plants was relatively low: 210 kg for tomato, 100 kg for brinjal, 15 kg for cabbage, and 13 kg for chili, amounting to a total yield of 1,017 kg. In contrast, the grow bag demonstration plots showed a remarkable improvement, with yields reaching 356 kg (tomato), 230 kg (brinjal), 40 kg (cabbage), and 33 kg (chili), collectively yielding 1,974 kg per 25 grow bags. This near two-fold increase in production, especially in tomato and brinjal, underscores the effectiveness of the technology. The enhanced performance is attributed to more controlled and favorable root zone environments, steady nutrient availability, and efficient water use enabled by the grow bag and drip irrigation setup. These results align with previous studies by Eigenbrod and Gruda (2015) and Kurmi et al. (2022), which also reported yield boosts in urban and peri-urban agriculture using container systems. Likewise, findings by Yadav et al. (2024) and Eigenbrod and Gruda (2015) reinforce the benefits of protected cultivation and grow bag systems, particularly in enhancing crop productivity through optimal management of plant-soil-water interactions.

Table 3: Yield performance of vegetables under farmers' practice and demonstrated technology

| Sl. No. | Name of block | Yield per season (kg per 25 plants) | | | |
|---|---|---|---|---|---|
| | | Tomato | Brinjal | Cabbage | Chili |
| Yield in farmers' practice | | | | | |
| 1. | Baihar | 211[a]±6.2 | 101[a]±5.6 | 17[a]±2.8 | 13[a]±1.7 |
| 2. | Pasraswada | 209[a]±5.9 | 99[a]±7.2 | 14[b]±2.4 | 13[a]±1.6 |
| 3. | Birsa | 211[a]±2.7 | 100[a]±3.8 | 15[ab]±1.9 | 13[a]±1.0 |
| Mean | | 210* | 100* | 15* | 13* |
| $p$-value | | 0.96 | 0.82 | 0.004 | 0.88 |
| Sl. No. | Name of block | Yield per season (kg per 25 grow bags) | | | |
| | | Tomato | Brinjal | Cabbage | Chili |
| Yield in demonstrated intervention | | | | | |
| 1. | Baihar | 353[a]±11.7 | 228[a]±12.1 | 39[a]±3.5 | 31[a]±2.2 |
| 2. | Pasraswada | 357[a]±9.2 | 231[a]±11.0 | 41[a]±3.4 | 33[a]±2.6 |
| 3. | Birsa | 357[a]±9.8 | 230[a]±11.6 | 40[a]±3.1 | 33[a]±2.4 |
| Mean | | 356* | 230* | 40* | 33* |
| $p$-value | | 0.93 | 0.98 | 0.64 | 0.71 |

*Showed significant difference between farmers practices and demonstrated intervention; Different alphabet showed significant difference at 0.05 for LSD test

### 3.3. *Extension and technology gap*

The extension gap, representing the yield disparity between the grow bag demonstration plots and traditional farmer practices, was markedly evident across all vegetable crops (Table 4). On average, the gap stood at 145 kg for tomato, 129 kg for brinjal, 25 kg for cabbage, and 20 kg for chili, resulting in a cumulative shortfall of 957 kg. This considerable difference underscores the untapped potential in farm productivity that can be harnessed through the adoption of grow bag-based organic cultivation. The findings highlight the urgent need for enhanced extension outreach and farmer-oriented training, aligning with observations by Balai et al. (2013), who emphasized the pivotal role of on-farm demonstrations in reducing knowledge and yield gaps in organic systems. Similar sentiments were echoed by Thakur et al. (2021, 2022), who stressed the critical influence of extension services in maximizing yield outcomes.

In parallel, the technology gap, defined as the difference

Table 4: Extension gap between farmers' practice and demonstration technology

| Sl. No. | Name of block | Tomato | Brinjal | Cab-bage | Chili | Total |
|---|---|---|---|---|---|---|
| 1. | Baihar | 142 | 127 | 22 | 18 | 309 |
| 2. | Pasraswada | 148 | 131 | 27 | 21 | 327 |
| 3. | Birsa | 146 | 131 | 25 | 20 | 322 |
| | Mean | 145 | 129 | 25 | 20 | |

between actual and potential yields, further illustrates the effectiveness of the intervention (Table 5). Under conventional practices, this gap was significant: 150 kg for tomato, 135 kg for brinjal, 30 kg for cabbage, and 22 kg for chili, amounting to a total of 1,008 kg. However, with the implementation of grow bag technology, this gap was dramatically minimized to just 4 kg (tomato), 5 kg (brinjal), 5 kg (cabbage), and 3 kg (chili), a total of only 51 kg. This stark reduction clearly demonstrates the efficiency of grow bag systems in achieving near-optimal yields, even under organic cultivation. These results resonate with findings from Dixit et al. (2023), who reported similar outcomes in protected and container-based farming models, affirming the suitability of such systems for maximizing productivity in constrained resource environments.

Table 5: Technology gap of organic vegetable production

| Sl. No. | Name of block | Tomato | Brinjal | Cabbage | Chili | Total |
|---|---|---|---|---|---|---|
| Farmers' practice | | | | | | |
| 1. | Baihar | 149 | 134 | 28 | 22 | 332 |
| 2. | Pasraswada | 151 | 136 | 31 | 22 | 340 |
| 3. | Birsa | 149 | 135 | 30 | 22 | 336 |
| | Mean | 150 | 135 | 30 | 22 | |
| Demonstrated intervention | | | | | | |
| 1. | Baihar | 7 | 7 | 6 | 4 | 23 |
| 2. | Pasraswada | 3 | 5 | 4 | 2 | 13 |
| 3. | Birsa | 3 | 5 | 5 | 2 | 14 |
| | Mean | 4 | 5 | 5 | 3 | |

### 3.4. *Economic performance of demonstration technologies*

From an economic standpoint, the grow bag-based demonstration technology clearly outperformed conventional farmer practices in terms of profitability (Table 6). In Baihar block, the net return rose sharply from ₹ 7,627 to ₹ 18,056, accompanied by a significant jump in the benefit–cost (B:C) ratio from 1.43 to 2.84. Comparable trends emerged in Paraswada and Birsa, where farmers experienced over 150% increases in net returns, and B:C ratios nearly doubled, rising from approximately 1.4 to 2.9. Although the demonstration plots incurred a slightly higher cultivation cost (₹ 1,000 more), the substantial gains in gross and net income overwhelmingly favored the technology's economic viability. These findings strongly reinforce the economic case for adopting grow bag-based systems, echoing the outcomes reported by Eigenbrod and Gruda (2015), who highlighted the role of controlled environments and container-based organic vegetable cultivation in delivering greater income security and minimizing production risks for smallholder farmers.

### 3.5. *Nutritional improvement*

Prior to the intervention, household vegetable consumption was relatively low, averaging only 2 to 3 days per week. However, following the adoption of grow bag-based vegetable cultivation, the frequency increased significantly to 5 to 6 days per week, reflecting better year-round access to fresh produce. This shift also led to a marked enhancement in dietary diversity scores, particularly through increased intake of leafy greens and nutrient-dense, vitamin-rich vegetables. The improved home-grown availability of vegetables notably benefited women and children, reducing their reliance on irregular market access and ensuring more consistent nutritional intake. These outcomes resonate with the findings of Sithole and Olorunfemi (2024), who emphasized the nutritional advantages of localized vegetable production systems in marginalized communities.

Table 6: Economics of farmers' practice and demonstration technology for organic vegetable production

| Name of block | Farmers' practice | | | | Demonstration | | | |
|---|---|---|---|---|---|---|---|---|
| | Cost of cultivation | Gross income | Net return | B:C ratio | Cost of cultivation | Gross income | Net return | B:C ratio |
| Baihar | 5350 | 12977 | 7627 | 1.43 | 6350 | 24406 | 18056 | 2.84 |
| Pasraswada | 5350 | 12645 | 7295 | 1.36 | 6350 | 24827 | 18477 | 2.91 |
| Birsa | 5350 | 12829 | 7479 | 1.40 | 6350 | 24788 | 18438 | 2.90 |

### 3.6. *Environmental and social impact*

The incorporation of organic inputs in the grow bag cultivation system played a pivotal role in enhancing soil health while minimizing exposure to harmful agrochemicals, contributing to a more sustainable and eco-friendly production environment. Beyond its environmental benefits, the initiative fostered strong community engagement, with a special emphasis on encouraging women's active participation in home gardening activities. This not only supported household nutrition but also catalyzed gender inclusivity and empowerment, enabling women to play a more central role in decision-making and food production at the household level.

## 4. CONCLUSION

Grow bag-based organic vegetable cultivation proved to be a cost-effective and sustainable solution for enhancing the economic and nutritional status of tribal households in Madhya Pradesh's Chhattisgarh Plain region. Utilizing limited space and organic resources, the approach outperformed traditional methods in yield and profitability for vegetables like tomato, brinjal, cabbage, and chili. The study also identified significant extension and technology gaps, highlighting the need for capacity-building. Overall, it demonstrated strong potential for improving rural livelihoods and resource efficiency.

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