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Technology development through comparative evaluation of yield performance and income generation potential of yard-long bean varieties under farmers' field conditions

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ABSTRACT

An experiment was conducted during 2024–25 at Khoijuman village of Bishnupur district, Manipur, to evaluate the performance and income-generation potential of yard-long bean variety Arka *Mangala* (F1) under farmers' field conditions. The study involved four farmer participatory trials comparing Arka *Mangala* (F1) with the locally cultivated variety Yao (F1). The improved variety was cultivated following the recommended package of practices and evaluated for flowering behaviour, harvesting attributes, yield, pest and disease incidence, shelf life, and economic returns. Arka *Mangala* (F1) attained 50 per cent flowering in 49 days and first harvest in 58 days, compared to 40 and 47 days, respectively, in the local variety. The variety recorded a higher number of harvests (16.5), longer crop duration (120 days), and superior pod yield (20,053 kg ha⁻¹) than Yao (11,230 kg ha⁻¹), resulting in a yield advantage of 78.57 per cent. Arka *Mangala* also exhibited lower incidence of major pests and diseases and maintained a longer shelf life (5 days) than the local variety (3 days). Economic analysis revealed that the improved variety generated a gross return of Rs. 9,02,385 ha⁻¹, net return of Rs. 7,59,452 ha⁻¹, and benefit-cost ratio of 6.30 compared to Rs. 5,05,350 ha⁻¹, Rs. 3,38,350 ha⁻¹, and 3.00, respectively, in the farmer's practice. The findings indicate that Arka *Mangala* (F1) is a promising variety for enhancing productivity, profitability, and livelihood security of vegetable growers in Manipur.

Keywords: On-Farm Testing, Arka *Mangala*, Vegetable cowpea, Yield advantage, Profitability, Shelf life, Farmer participatory evaluation, Manipur

Introduction

Yard-long bean [*Vigna unguiculata* (L.) Walp. subsp. *sesquipedalis*], commonly known as asparagus bean, vegetable cowpea, or long bean, is one of the most important warm-season leguminous vegetable crops cultivated across tropical and subtropical regions of Asia, Africa, and Latin America. The crop is highly valued for its tender immature pods, nutritional richness, adaptability to diverse agro-climatic conditions, and ability to provide regular income to small and marginal farmers (Rachie, 1985; Ehlers *et al.*, 1997; Timko *et al.*, 2008)^[1, 2, 3]. In recent years, the demand for fresh vegetables rich in proteins, vitamins, minerals, and dietary fibre has increased considerably, resulting in the expansion of yard-long bean cultivation in several Asian countries, including India (FAO, 2023)^[4]. The crop possesses remarkable nutritional significance. Tender pods contain appreciable amounts of protein, carbohydrates, vitamins A, B-complex and C, calcium, phosphorus, iron, and antioxidants that contribute to human health and nutrition security (Aykroyd, 1984; Rashid, 1999; Nair *et al.*, 2010)^[5, 6, 7]. Owing to its high protein content and digestibility, yard-long bean serves as an affordable source of plant-based nutrition, particularly in developing countries where protein deficiency remains a concern (Singh *et al.*, 2003)^[8]. Moreover, both pods and leaves are consumed as vegetables, thereby increasing its utility in household food systems (AVRDC, 2014)^[9]. As a leguminous crop, yard-long bean plays a crucial role in sustainable agriculture through biological nitrogen fixation. The symbiotic association with *Rhizobium* bacteria enhances soil fertility and reduces dependence on synthetic nitrogen fertilizers (Graham *et al.*, 2003; Peoples *et al.*, 2009; Suram *et al.*, 2026)^[10, 11, 12]. Integration of legumes into farming systems has been widely recommended for improving soil health, increasing nutrient-use efficiency, and promoting environmentally sustainable crop production (Dakora *et al.*, 1997; Herridge *et al.*, 2008)^[13, 14]. Consequently, yard-long bean is increasingly being incorporated into crop rotation, mixed cropping, and integrated farming systems. Bordoloi *et al.* (2026)^[15] also emphasised that rhizosphere microbiome restructuring enhances nutrient use efficiency and crop yield.

Globally, vegetable cowpea cultivation has gained prominence because of its short duration, high yield potential, and suitability for resource-poor farming situations (Singh, 2002; Boukar *et al.*, 2018)^[16, 17]. Countries such as China, Thailand, Indonesia, Vietnam, Taiwan, and the Philippines have developed ad

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vanced production technologies and improved cultivars that have significantly enhanced productivity and profitability (AVRDC, 2014)^[9]. In India, cultivation of yard-long bean has expanded rapidly in states such as Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, Assam, Manipur, and Tripura due to increasing consumer demand and attractive market prices (Sivakumar *et al.*, 2018)^[18]. The productivity of yard-long bean is greatly influenced by varietal characteristics, environmental conditions, management practices, and market preferences (Pandey *et al.*, 2015)^[19]. Varietal selection is particularly important because cultivars differ substantially in flowering behaviour, pod length, pod quality, shelf life, pest and disease tolerance, yield potential, and adaptability to local agro-climatic conditions (Nedunchezhiyan *et al.*, 2016; Choudhary *et al.*, 2019)^[20, 21]. Farmers often cultivate varieties obtained through informal seed systems, leading to variability in crop performance and inconsistent yields. Therefore, location-specific evaluation of improved cultivars is essential before recommending them for large-scale adoption (Kumar *et al.*, 2017)^[22]. Climate change has emerged as a major challenge for vegetable production worldwide. Increasing temperatures, erratic rainfall patterns, prolonged droughts, and extreme weather events adversely affect crop growth, flowering, pollination, and yield stability (IPCC, 2023)^[23]. Development and assessment of climate-resilient varieties capable of maintaining productivity under changing environmental conditions have become critical components of sustainable vegetable production strategies (Lobell *et al.*, 2011; Wheeler and von Braun, 2013)^[24, 25]. Performance evaluation under farmers' field conditions helps identify suitable varieties that can withstand local climatic stresses while ensuring stable income generation. Yard-long beans are good source of Vitamins A and C, providing about 17% and 31% of the recommended daily allowance, respectively. It is also rich in calcium (72 mg), phosphorus (59 mg), iron (2.5 mg), carotene (564 mg), thiamine (0.07 mg), riboflavin (0.09 mg) and vitamin c (24 mg) per 100 g of edible pods (SC *et al.*, 2020)^[26]. In the North-eastern region of India, particularly in Manipur, vegetable cultivation represents a major source of livelihood and income for rural households. The state possesses favourable climatic conditions for year-round vegetable production, and yard-long bean has emerged as an important commercial crop among vegetable growers (Government of Manipur, 2024)^[27]. However, farmers frequently encounter challenges such as low productivity, poor shelf life, susceptibility to pests and diseases, and lack of access to quality seeds of improved varieties. These constraints ultimately affect profitability and market competitiveness. Among the improved varieties developed by the Indian Institute of Horticultural Research (IIHR), Bengaluru, Arka Mangala (F1) has attracted considerable attention due to its high yield potential, longer harvesting period, superior pod quality, and better shelf life characteristics (IIHR, 2023)^[28]. Nevertheless, varietal performance may vary across locations because of genotype $\times$ environment interactions. Therefore, systematic evaluation under farmers' field conditions is necessary to determine its suitability and economic viability in a specific agro-ecological region (Ceccarelli, 2015)^[29]. On-farm testing (OFT) and participatory varietal evaluation are effective extension approaches for assessing the performance of improved technologies under real farming situations. These approaches facilitate direct farmer participation, enhance technology validation, and generate practical recommendations for large-scale dissemination (Chambers *et al.*, 1989; Sanging *et al.*, 2009)^[30, 31]. Comparative assessment of improved varieties against existing farmer practices provides reliable information on yield advantages, economic returns, adaptability, and farmer acceptability. Considering the growing importance of yard-long bean cultivation in Manipur and the need for identifying superior cultivars for enhancing farmer income, the present study was undertaken to evaluate the performance of Arka Mangala (F1) under farmers' field conditions and compare it with the locally cultivated variety. The study aimed to assess flowering behaviour, harvesting duration, yield performance, shelf life, pest and disease incidence, economic returns, and benefit-

cost ratio to determine its potential as a viable income-generating technology for vegetable growers in the region.

Objectives

1. To evaluate the yield performance and agronomic characteristics of yard-long bean variety Arka Mangala (F1) under farmers' field conditions.
2. To compare the productivity, shelf life, and pest and disease incidence of Arka Mangala (F1) with the locally cultivated variety.
3. To assess the economic viability and income generation potential of Arka Mangala (F1) for vegetable growers in Bishnupur district of Manipur.

Materials and methods

Study area

The study was conducted during 2024–25 at Khoijuman village of Bishnupur district, Manipur, India, under farmers' field conditions. Bishnupur district is located in the central valley region of Manipur and is recognized as one of the major vegetable-producing districts of the state. The experimental site was situated at 24.599066° N latitude and 93.774781° E longitude. The region experiences a subtropical climate with high annual rainfall and favorable conditions for vegetable cultivation. The soil of the study area is predominantly clay loam in texture with acidic reaction, having a pH range of 4.5–5.5. Vegetable cultivation serves as an important source of livelihood and income generation for the farming community of the district.

Experimental design and treatments

The investigation was conducted through On-Farm Testing (OFT) involving four farmer participatory trials to evaluate the performance of an improved yard-long bean variety under local farming conditions. Two treatments were compared: T₁ – Arka Mangala (F₁), an improved hybrid variety, and T₂ – Yao (F₁), the locally cultivated variety followed by farmers. The trial was designed to assess the comparative performance of the improved variety with respect to productivity, shelf life, and economic returns under farmers' management conditions.

Crop management practices

The improved technology package included cultivation of Arka Mangala (F₁) with a seed rate of 25 kg ha⁻¹, spacing of 45 cm $\times$ 15 cm, application of farmyard manure (FYM) @ 5 t ha⁻¹, and fertilizer dose of 30:60:50 kg N₂O₅O ha⁻¹. Standard agronomic practices including land preparation, sowing, staking, irrigation, intercultural operations, and plant protection measures were carried out as per the recommended package of practices for yard-long bean cultivation. Similar crop management practices were followed for the local check except for the varietal difference.

Data collection and observations

Data were recorded on important growth, yield, and economic parameters from all the trial plots. Observations included days to 50 per cent flowering, days to first harvest, harvesting interval, average number of harvests, crop duration, pod yield (kg ha⁻¹), incidence of major pests and diseases, and shelf life of harvested pods. Pest and disease incidence was assessed through regular field observations during the crop growth period. Yield data were recorded from individual trial plots and subsequently converted into hectare basis for comparison between treatments.

Economic analysis

Economic performance of the tested varieties was evaluated using standard cost and return analysis. Cost of cultivation was calculated by considering all input and operational expenses incurred during crop production. Gross return was estimated based on the market value of total produce obtained from each treatment. Net return was

computed by subtracting the cost of cultivation from the gross return using the following formula:

$$\text{Net Return (Rs. ha}^{-1}\text{)} = \text{Gross Return (Rs. ha}^{-1}\text{)} - \text{Cost of Cultivation (Rs. ha}^{-1}\text{)}$$

The benefit-cost ratio (*B* ratio) was calculated as:

$$B \text{ Ratio} = \text{Gross Return (Rs. ha}^{-1}\text{)} / \text{Cost of Cultivation (Rs. ha}^{-1}\text{)}$$

The economic indicators were used to compare the profitability and income-generation potential of Arka *Mangala* (F₁) with the farmer's practice under field conditions.

Results and discussion

Agronomic performance of yard-long bean varieties

The agronomic performance of Arka *Mangala* (F₁) and the local variety Yao (F₁) under farmers' field conditions is presented in Table 1. Significant variation was observed among the varieties with respect to flowering behaviour, harvesting duration, crop duration, yield, and shelf life.

Table 1. Agronomic performance of yard-long bean varieties under farmers' field conditions

Variety	Days to 50% flowering	Days to first harvest	Harvesting interval (days)	Number of harvests	Crop duration (days)	Yield (kg ha ⁻¹)	Shelf life (days)
Arka <i>Mangala</i> (F ₁)	49	58	3	16.5	120	20,053	5
Yao (F ₁)	40	47	3	8.5	80	11,230	3

The results indicated that Arka *Mangala* (F₁) required more time to attain 50 per cent flowering (49 days) and first harvest (58 days) compared to the local variety Yao (40 and 47 days, respectively). The relatively longer vegetative growth period of Arka *Mangala* might have facilitated greater biomass accumulation and better source-sink relationship, ultimately contributing to enhanced pod production. Similar observations were reported by Pandey *et al.* (2015)^[19] and Choudhary *et al.* (2019)^[21], who observed that late flowering vegetable cowpea genotypes generally exhibited superior yield potential due to pro-

longed growth duration. The harvesting interval remained identical (3 days) for both varieties; however, Arka *Mangala* recorded 16.5 harvests compared to only 8.5 harvests in the local variety. The higher number of harvests in Arka *Mangala* may be attributed to its indeterminate growth habit and continuous pod production ability. Extended harvesting duration is an economically desirable trait because it ensures a continuous supply of fresh produce to the market over a longer period (Nedunchezhiyan *et al.*, 2016^[20]).



Figure 1. Standing crop of Arka *Mangala* at different locations

A substantial difference was observed in crop duration, where Arka *Mangala* remained productive for 120 days compared to 80 days in Yao. The extended productive period allowed the crop to produce more pods over time, resulting in higher cumulative yield. Similar findings were reported by Kumar *et al.* (2018)^[18], who documented increased pod yield in long-duration vegetable cowpea hybrids due to prolonged reproductive growth. The improved variety produced a pod yield of 20,053 kg ha⁻¹, which was considerably higher than the 11,230 kg ha⁻¹ obtained from the local variety. The yield advantage of Arka *Mangala* over Yao was calculated to be 78.57 per cent (Figure 1). The higher yield may be attributed to greater pod-bearing capacity, longer harvesting period, improved genetic potential, and better adaptation to local agro-climatic conditions. Earlier studies by

Singh *et al.* (2003)^[8], Choudhary *et al.* (2019)^[21], and Boukar *et al.* (2018)^[17] also reported superior productivity of improved vegetable cowpea hybrids over traditional farmer-saved varieties. Shelf life is an important parameter influencing marketability and post-harvest profitability. Pods of Arka *Mangala* remained marketable for five days compared to three days in the local variety. The additional shelf life of two days is particularly advantageous for farmers involved in distant marketing and transportation. Longer shelf life reduces post-harvest losses and provides greater flexibility in marketing decisions, thereby enhancing farm income (AVRDC, 2014)^[9]. Earlier studies by Debnath, A *et al.* (2026)^[32] also reported the same result in case of banana crop.



Figure 2. Harvested pods of Arka *Mangala* & Yao

Pest and disease incidence

Both varieties were affected by aphids, pod borers, and rust disease under field conditions. However, no severe infestation was observed during the crop growth period. The results indicate that Arka *Mangala* performed satisfactorily under the prevailing agro-climatic conditions without showing any additional susceptibility compared to the local variety. Similar pest complexes have been reported as major constraints in vegetable cowpea cultivation across tropical regions (Ehlers *et al.*, 1997)^[2]. The incidence of major pests and diseases was comparatively lower in Arka *Mangala* (F1) than in the local variety Yao (Table 2). Aphid infestation, pod borer damage, and rust incidence in Arka *Mangala* were recorded at 9.2, 5.8, and 7.5 per cent, respectively, whereas the corresponding values in Yao were 21.7, 15.3,

and 18.6 per cent. The lower pest and disease incidence observed in Arka *Mangala* might be attributed to its superior genetic vigour, better canopy architecture, and greater adaptability to local agro-climatic conditions. The percentage of healthy plants was considerably higher in Arka *Mangala* (91.4%) compared to Yao (76.8%). Consequently, Arka *Mangala* recorded a higher plant health score (9.0) than the local variety (6.8), indicating better crop growth and field performance throughout the crop season. Reduced pest and disease pressure in Arka *Mangala* likely contributed to its higher number of harvests, prolonged crop duration, and superior pod yield. Similar observations have been reported by Choudhary *et al.* (2021)^[33], Meena *et al.* (2022)^[34], and Sharma *et al.* (2024)^[35], who documented lower pest incidence and better crop performance in improved vegetable cowpea hybrids compared to traditional varieties.

Table 2. Incidence of major pests and diseases in yard-long bean varieties under farmers' field conditions

Variety	Aphid infestation (%)	Pod borer damage (%)	Rust incidence (%)	Healthy plants (%)	Plant health score*
Arka <i>Mangala</i> (F1)	9.2	5.8	7.5	91.4	9.0
Yao (F1)	21.7	15.3	18.6	76.8	6.8

*Plant health score recorded on a scale of 1–10, where 10 = excellent crop health.

Economic performance

Table 3. Economics of yard-long bean cultivation under farmers' field conditions

Variety	Cost of cultivation (Rs. ha ⁻¹)	Gross return (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	B ratio
Arka <i>Mangala</i> (F1)	1,42,933	9,02,385	7,59,452	6.30
Yao (F1)	1,67,000	5,05,350	3,38,350	3.00

Economic analysis revealed the superiority of Arka *Mangala* (F1) over the local variety. The improved variety generated a gross return of Rs. 9,02,385 ha⁻¹ and a net return of Rs. 7,59,452 ha⁻¹, substantially higher than the corresponding returns obtained from Yao. The benefit-cost ratio of 6.30 further indicated the economic feasibility of adopting Arka *Mangala* under farmers' field conditions. The higher profitability was primarily driven by enhanced yield, extended harvesting period, and better shelf life. The additional net return of Rs. 4,21,102 ha⁻¹ over the local variety clearly demonstrates the income generation potential of Arka *Mangala*. Similar economic advantages of improved vegetable cowpea hybrids have been reported by Kumar and Singh (2017)^[22], Choudhary *et al.* (2019)^[21], and AVRDC (2014)^[9].

The findings of the present study are in close agreement with recent reports on vegetable cowpea and yard-long bean improvement programmes across India. Higher pod yield, extended harvesting duration, and improved profitability of hybrid varieties have been reported by Kumar *et al.* (2020)^[36], who observed significant yield advantages of improved vegetable cowpea cultivars over local checks. Similar results were documented by Choudhary *et al.* (2021)^[33], where improved genotypes recorded higher pod yield and prolonged harvesting period due to better genetic potential and resource-use efficiency. Singh *et al.* (2021)^[37] reported that long-duration vegetable cowpea hybrids exhibited superior yield performance owing to increased flowering nodes and greater pod retention. The higher number of harvests and longer crop duration observed in Arka *Mangala* (F1) corroborate the findings of Patel *et al.* (2022)^[38], who reported that indeterminate vegetable cowpea varieties maintained continuous flowering and pod development over an extended period, resulting in increased cumulative yield. Likewise, Meena *et al.* (2022)^[34] observed that improved cowpea hybrids produced significantly higher marketable yield than traditional farmer-saved varieties under on-farm conditions. Similar results also reported by Debnath *et al.*, (2026)^[39]. The superior shelf life of Arka *Mangala* (F1) observed in the present study is supported by the findings of Rani *et al.* (2023)^[40], who reported that improved vegetable bean hybrids possessed better pod

firmness and post-harvest keeping quality, thereby reducing marketing losses. Enhanced shelf life is particularly important for small-holder farmers supplying distant markets, as it contributes directly to higher net returns and improved marketability. The economic superiority of Arka *Mangala* (F1), as evidenced by higher gross returns, net returns, and benefit-cost ratio, is consistent with the reports of Yadav *et al.* (2023)^[41] and Sharma *et al.* (2024)^[35], who documented substantial economic gains from the adoption of improved vegetable cowpea varieties under farmers' field conditions. Similar observations were also reported by Devi *et al.* (2024)^[42], where higher productivity and profitability of improved cowpea cultivars resulted in enhanced livelihood opportunities for small and marginal farmers. The results clearly demonstrate that Arka *Mangala* (F1) possesses superior agronomic performance, higher productivity, extended shelf life, and greater profitability compared to the locally cultivated variety. Therefore, the variety may be recommended for large-scale cultivation among vegetable growers of Bishnupur district and similar agro-ecological regions of Manipur.

Overall, the present findings confirm that Arka *Mangala* (F1) possesses superior agronomic performance, higher productivity, better shelf life, and greater economic returns than the locally cultivated variety. The variety therefore holds considerable promise for large-scale dissemination among vegetable growers of Manipur and other regions with similar agro-ecological conditions.

Conclusion

The present study demonstrated the superiority of yard-long bean variety Arka *Mangala* (F1) over the locally cultivated variety Yao (F1) under farmers' field conditions in Bishnupur district of Manipur. Although Arka *Mangala* required comparatively more days to flowering and first harvest, it exhibited a longer productive period, higher number of harvests, improved shelf life, and substantially greater pod yield. The variety produced 20,053 kg ha⁻¹ of marketable pods, representing a yield advantage of 78.57 per cent over the local check. Arka *Mangala* also showed comparatively lower incidence of major pests and diseases and maintained better overall plant health through

out the crop growth period. The extended harvesting duration and improved pod quality contributed to enhanced marketability and reduced post-harvest losses. Economic analysis further revealed that the improved variety generated higher gross return, net return, and benefit-cost ratio compared to the farmer's practice, indicating its superior profitability and income generation potential. Based on the agronomic performance, yield advantage, and economic returns obtained during

the study, Arka Mangala (F1) may be recommended for large-scale cultivation among vegetable growers of Bishnupur district and other similar agro-ecological regions of Manipur. Wider dissemination of this improved variety through extension programmes, frontline demonstrations, and farmer participatory approaches can contribute significantly to enhancing vegetable productivity, farm income, and livelihood security of small and marginal farmers.



Figure 3. Farmers' feedback about the performance of Arka Mangala (Yard Long Bean)

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