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Technology assessment and development of commercial marigold (*Tagetes erecta* L.) Cultivation: Insights from adoption and gap analysis in Northeast India

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Abstract

The present study entitled “Adoption and gap analysis of commercial marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda cultivation for livelihood enhancement in Tripura” was conducted during 2021–22 and 2022–23 to assess the extent of adoption, technological gaps and economic viability among farmers. The study was carried out in Panisagar block of North Tripura and Salema block of Dhalai district, covering 120 marigold growers selected through proportionate random sampling. The findings revealed that the majority of respondents (63.34%) exhibited a medium level of adoption with a mean adoption quotient of 42.15, while 18.33% each belonged to low and high adoption categories. Practice-wise analysis indicated higher adoption of nipping/tipping (70.83), transplanting (68.75) and use of improved variety (62.50), whereas plant protection measures (28.33) and micronutrient application (36.67) showed lower adoption, indicating significant technological gaps. District-wise comparison revealed significantly higher adoption in North Tripura (43.20) than Dhalai (31.75). Economic analysis showed higher profitability of marigold cultivation with a net return of ₹4,22,625 per acre and a benefit–cost ratio of 4.60 compared to conventional vegetable cultivation. Yield gap analysis indicated a technology gap of 20 q ha⁻¹, extension gap of 45 q ha⁻¹ and technology index of 10%. The study concludes that commercial marigold cultivation is a viable livelihood diversification option in Tripura; however, strengthening extension services, capacity building and timely input supply are essential to bridge the existing adoption gaps and enhance productivity.

Keywords: Marigold (*Tagetes erecta* L.), Pusa Narangi Gaiinda, adoption, gap analysis, extension gap, livelihood

Introduction

Agricultural diversification towards high-value crops has gained considerable importance in recent years due to its potential for enhancing farmers’ income, generating employment and improving nutritional security. Among horticultural enterprises, floriculture has emerged as a rapidly expanding sector owing to increasing domestic demand, export potential and higher economic returns compared to traditional crops (Chadha, 2001; Singh *et al.*, 2017) ^[2, 15]. India is one of the leading producers of flowers, with a substantial area under floriculture and increasing production of loose and cut flowers (NHB, 2023–24) ^[11].

Marigold (*Tagetes erecta* L.) is one of the most important loose flower crops cultivated in India due to its wide adaptability, short duration and year-round demand for religious, social and decorative purposes. It is extensively grown in several states and is preferred by farmers because of its relatively low cost of cultivation and assured market demand. In addition to ornamental value, marigold has industrial importance in the extraction of carotenoids and natural dyes (Arora and Khanna, 2014; Venkatesan *et al.*, 2025) ^[1, 16]. The crop has also been recognized as a profitable enterprise offering higher net returns compared to conventional field crops and vegetables (Kaur, 2022; Singh

and Ramachandran, 2002)^[9, 14].

Despite its potential, adoption of floriculture, particularly marigold cultivation, remains limited in the North Eastern region of India. Tripura possesses favourable agro-climatic conditions such as high humidity, moderate temperature and suitable soil types for floriculture crops. However, the farming system is still dominated by paddy and seasonal vegetables, and the adoption of improved floricultural practices remains low to moderate (Govt. of Tripura, 2020)^[8]. Although there is increasing market demand for flowers in local markets and nearby urban centres, expansion of marigold cultivation is constrained by lack of awareness, inadequate technical knowledge, limited access to quality inputs and weak market linkages.

Krishi Vigyan Kendras (KVKs) and the State Department of Horticulture have been promoting scientific marigold cultivation practices through Front Line Demonstrations (FLDs), On-Farm Trials (OFTs) and capacity building programmes. However, the adoption of recommended technologies varies among farmers due to socio-economic and institutional factors. Previous studies have indicated that variables such as education, land holding, income, extension contact and input availability significantly influence adoption behaviour of farmers (Chandawat *et al.*, 2009; Gedam and Singh, 2012; Chouhan *et al.*, 2013)^[3, 7, 5].

In North Tripura and Dhalai districts, declining profitability of traditional crops, increasing cost of cultivation and labour scarcity have compelled farmers to explore alternative livelihood options. In this context, commercial cultivation of marigold (cv. Pusa Narangi Gaiinda) has emerged as a promising enterprise. However, a considerable gap exists between recommended production technologies and their actual adoption at the farmer level.

Therefore, the present study was undertaken to analyze the extent of adoption and technological gaps in commercial marigold cultivation and to assess its potential as a livelihood diversification strategy in Tripura.

Materials and Methods

Study area and sampling procedure

The study was conducted during 2021–22 and 2022–23 in North Tripura and Dhalai districts of Tripura, India. Panisagar block (24.27° N, 92.15° E) of North Tripura and Salema block (24.01° N, 91.84° E) of Dhalai district were selected purposively due to active promotion of commercial marigold cultivation by Krishi Vigyan Kendras and greater exposure of farmers to floriculture technologies. From each block, three villages were selected randomly. Accordingly, Panisagar, Agnipasha and Bilthai villages from Panisagar block, and Salema, Dabbari and North Kachucherra villages from Salema block were included. A total of 120 marigold growers were selected using proportionate random sampling technique, comprising 60 respondents from each block.

Research design and variables

The study followed an ex-post facto research design to assess the extent of adoption and technological gaps in recommended practices of marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda cultivation. Thirteen independent variables, namely age, education, land holding, annual income, farming experience, training exposure, extension contact, mass media exposure, labour availability, market

access and input availability, were considered based on their relevance in influencing adoption behaviour.

Data collection

Primary data were collected using a well-structured and pre-tested interview schedule. The schedule was pre-tested with non-sampled respondents to ensure reliability and validity, and necessary modifications were incorporated. Data were collected through personal interview method to ensure accuracy and completeness.

Measurement of adoption

The extent of adoption of recommended marigold cultivation practices was quantified using Adoption Quotient (AQ) by assigning scores to different practices. Based on AQ values, respondents were categorized into low, medium and high adoption groups.

$$AQ = \frac{\text{Total adoption score obtained by the respondent}}{\text{Maximum possible score}} \times 100$$

Yield gap and economic analysis

Yield gap parameters, namely technology gap, extension gap and technology index, were calculated using standard formulae. Economic analysis was carried out by estimating cost of cultivation, net return and benefit–cost ratio of marigold cultivation and comparing it with conventional cropping systems.

Statistical analysis

The collected data were tabulated and analyzed using appropriate statistical tools such as frequency, percentage, mean, standard deviation, chi-square test, t-test, Kruskal–Wallis test and coefficient of correlation to interpret the results.

Results

Adoption level of recommended commercial marigold cultivation practices: The extent of adoption of recommended scientific practices of commercial marigold cultivation was measured through Adoption Quotient (AQ) and the respondents were categorized into low, medium and high adoption groups (Table 1).

Table 1: Categorization of respondents on the basis of their adoption level of recommended scientific practices of commercial marigold cultivation (N=120)

Category	AQ	No.	%
Low	< 30.00	22	18.33
Medium	30.00 – 60.00	76	63.34
High	> 60.00	22	18.33

Mean = 42.15, SD = 15.20

The data indicate that a majority of respondents (63.34%) belonged to the medium adoption category, followed by 18.33% each under low and high adoption categories. The mean adoption quotient was 42.15 with a standard deviation of 15.20.

Practice-wise adoption of recommended commercial marigold production technologies

The practice-wise adoption of recommended scientific

practices of commercial marigold cultivation is presented in Table 2. The results show that nipping/tipping (AQ = 70.83) recorded the highest adoption, followed by land preparation and transplanting (68.75) and improved variety (62.50). Most of the practices such as spacing, irrigation management, harvesting, nutrient management and nursery management were found under medium adoption category. Plant protection measures (28.33) recorded the lowest adoption level.

Table 2: Practice-wise categorization of respondents on the basis of adoption score of recommended scientific practices of commercial marigold cultivation (N=120)

Scientific practices	AQ	AC
Improved variety (<i>Pusa Narangi Gaiinda</i>)	62.50	High
Nursery management	45.00	Medium
Land preparation & transplanting	68.75	High
Spacing & plant population	52.50	Medium
Nutrient management	48.33	Medium
Micronutrient application	36.67	Medium
Irrigation management	50.00	Medium
Nipping/tipping	70.83	High
Plant protection measures	28.33	Low
Harvesting & post-harvest	55.00	Medium
Marketing/value addition	40.00	Medium

Overall, while basic production practices are well adopted, gaps remain in technical and input-intensive components, highlighting the need for targeted extension interventions, skill-based training, and timely input supply.

Distribution of respondents based on adoption of individual practices

The data presented in Table 3 reveal that nipping/tipping recorded the highest adoption among respondents, with 50 per cent fully adopting the practice and only 10 per cent not adopting it, resulting in the highest adoption quotient (AQ = 70.83) and rank I. This was followed by transplanting (AQ = 68.75, rank II) and improved variety (AQ = 62.50, rank III). Practices such as harvesting (AQ = 55.00), spacing (AQ = 52.50) and irrigation (AQ = 50.00) were moderately adopted, with a larger proportion of respondents falling under partially adopted category. On the other hand, plant protection measures showed the lowest adoption (AQ = 28.33, rank X), with more than half of the respondents (55%) not adopting the practice. Similarly, micronutrient application (AQ = 36.67, rank IX) and marketing/value addition (AQ = 40.00, rank VIII) also showed relatively low levels of adoption.

Table 3: Distribution of respondents on the basis of adoption score of recommended scientific packages of commercial marigold cultivation (N=120)

Practice	Fully (%)	Partially (%)	Not adopted (%)	Score	AQ	Rank
Improved variety	30	50	20	150	62.50	III
Nursery management	20	55	25	108	45.00	VII
Transplanting	45	45	10	165	68.75	II
Spacing	30	45	25	126	52.50	V
Nutrient management	25	50	25	116	48.33	VI
Micronutrient application	15	45	40	88	36.67	IX
Irrigation	35	30	35	120	50.00	V
Nipping/tipping	50	40	10	170	70.83	I
Plant protection	10	35	55	68	28.33	X
Harvesting	40	35	25	132	55.00	IV
Marketing	20	40	40	96	40.00	VIII

District-wise difference in extent of adoption of commercial marigold cultivation practices (N=120)

Table 4 shows a significant difference in the adoption of commercial marigold practices between North Tripura district and Dhalai district. The mean adoption score was higher in North Tripura (43.20) than Dhalai (31.75), with a

statistically significant *t*-value (6.95). Practices such as nipping/tipping, transplanting, harvesting, improved variety, irrigation, and nutrient management recorded significantly higher adoption in North Tripura, whereas plant protection showed no significant difference, indicating uniformly low adoption.

Table 4: District-wise difference in extent of adoption of commercial marigold cultivation practices (N=120)

Scientific practices of marigold cultivation	MS of extent of adoption		t-value
	North Tripura (n=60)	Dhalai (n=60)	
Improved variety	0.82	0.56	4.85**
Nursery management	0.74	0.48	3.92**
Transplanting	1.28	0.95	6.15**
Spacing & plant population	0.92	0.66	4.20**
Nutrient management	0.88	0.63	3.76**
Micronutrient application	0.65	0.42	3.10**
Irrigation management	0.96	0.70	4.52**
Nipping/tipping	1.35	1.05	6.80**
Plant protection measures	0.32	0.28	1.12(NS)
Harvesting & post-harvest	1.10	0.78	5.02**
Marketing/value addition	0.72	0.50	3.44**
Overall adoption score	43.20	31.75	6.95

* = Significant at 5% level, ** = Significant at 1% level, NS = Non-significant

Effect of socio-economic variables on adoption level: The effect of socio-economic variables on adoption level was analyzed using Kruskal-Wallis test (Table 5). The results indicate that education, land holding, annual income, farming experience, extension contact, training exposure, market access and input availability showed significant differences among adoption categories. Mass media exposure and labour availability were significant at 5% level, while age showed non-significant effect.

Table 5: Kruskal–Wallis test of effect of socio-economic profile of marigold growers (N=120)

SE variables of marigold growers	Mean Rank			Kruskal–Wallis value
	Low (n=22)	Medium (n=76)	High (n=22)	
Age	56.20	60.35	64.10	0.842 (NS)
Education	42.15	59.40	78.75	14.562**
Land holding	38.40	55.60	102.30	58.720**
Annual income	50.25	57.80	82.65	25.810**
Farming experience	44.70	61.25	73.50	12.940**
Extension contact	40.80	58.90	84.10	30.225**
Mass media exposure	48.60	62.75	66.85	8.950*
Training exposure	45.10	57.40	80.30	20.875**
Labour availability	58.40	53.20	86.75	6.820*
Market access	46.35	56.95	87.20	33.415**
Input availability	43.90	60.10	79.85	18.730**

** Significant at 1% level, * Significant at 5% level, NS = Non-significant

Association between adoption and selected independent variables

The relationship between adoption and selected independent variables is presented in Table 6.

The results show that land holding ($r = 0.735$), annual income ($r = 0.602$), extension contact ($r = 0.498$) and input availability ($r = 0.521$) had a strong positive association with adoption. Education and farming experience also showed significant positive relationships, while age had a negative and non-significant relationship.

Table 6: Association of dependent variable (extent of adoption) with selected independent variables (N=120)

SE variables of marigold growers	Correlation coefficient (r)	Chi-square (χ^2)
Age	-0.048	3.105
Education	0.285**	16.420**
Land holding	0.735**	65.780**
Annual income	0.602**	27.350**
Farming experience	0.475**	14.680**
Extension contact	0.498**	35.220**
Mass media exposure	0.415**	9.210*
Training exposure	0.265*	22.450**
Labour availability	0.245*	3.120*
Market access	0.332*	34.880**
Input availability	0.521**	59.640**

** Significant at 1% level, * Significant at 5% level

Comparative economics of commercial marigold and conventional vegetable cultivation: The economic comparison between commercial marigold cultivation and conventional vegetable cultivation is presented in Table 7. The results indicate that commercial marigold cultivation

recorded higher profitability compared to conventional vegetable cultivation. The net return from marigold cultivation was ₹4,22,625 per acre, whereas conventional vegetable cultivation yielded ₹80,000 per acre. Similarly, the benefit–cost ratio was higher in marigold cultivation (4.60) compared to conventional vegetable cultivation (2.33).

Table 7: Comparative economics (per acre basis)

Crop	Yield	Cost (Rs.)	Return (Rs.)	Net Return (Rs.)	B:C Ratio
Marigold (scientific)	18 lakh flowers	1,17,375	5,40,000	4,22,625	4.60
Vegetables (conventional)	20 MT	60,000	1,40,000	80,000	2.33

Cost structure of commercial marigold cultivation: The cost structure of commercial marigold cultivation is presented in Table 8. The results show that major cost components included planting material, labour charges, fertilizers and plant protection measures. Labour constituted the highest share of total cost, followed by planting material and nutrient inputs.

Table 8: Cost components (per acre basis)

Input	Cost (Rs.)
Seedlings	12,000
FYM + Vermicompost	40,000
Fertilizers	6,175
Labour	30,000
PPC	14,200
Others	15,000
Total	1,17,375

Yield gap analysis of commercial marigold cultivation

The yield gap analysis of commercial marigold cultivation is presented in Table 9. The results reveal that the potential yield was 200 q ha⁻¹, demonstration yield was 180 q ha⁻¹ and farmers' yield was 135 q ha⁻¹. The technology gap was 20 q ha⁻¹, extension gap was 45 q ha⁻¹ and technology index was 10%.

Table 9: Yield gap analysis of commercial marigold cultivation

Parameter	Value
Potential yield (q ha ⁻¹)	200
Demonstration yield (q ha ⁻¹)	180
Farmers' yield (q ha ⁻¹)	135
Technology gap (q ha ⁻¹)	20
Extension gap (q ha ⁻¹)	45
Technology index (%)	10

Livelihood impact of commercial marigold cultivation

The impact of commercial marigold cultivation on livelihood parameters of farmers is presented in Table 10. The results indicate that marigold cultivation contributed significantly to enhancement of income, employment generation and improvement in living standards of the respondents. A majority of farmers reported increased annual income (78.33%), improved employment opportunities (72.50%) and better market linkage (65.83%). Additionally, 60.00% of respondents experienced improvement in their standard of living, while 55.00%

reported diversification of farming systems.

Table 10: Livelihood impact of commercial marigold cultivation (N=120)

Livelihood parameter	No. of respondents	%
Increase in annual income	94	78.33
Employment generation	87	72.50
Improved market linkage	79	65.83
Improvement in standard of living	72	60.00
Farming system diversification	66	55.00
Enhanced input accessibility	58	48.33



The field performance and farmer participation in marigold cultivation are presented in Fig. 1–3

Discussion

The present investigation revealed that the majority of respondents belonged to the medium adoption category, indicating partial adoption of recommended commercial marigold cultivation practices. This suggests that although farmers have been exposed to improved technologies, complete adoption has not yet been achieved. Such a pattern is typical in the diffusion process of agricultural innovations, where farmers gradually adopt technologies based on perceived benefits, risk-bearing ability and resource availability. Similar findings were reported by Chandawat *et al.* (2009) [3] and Gedam and Singh (2012) [7], who observed that most farmers fall under medium adoption categories in crop production technologies due to transitional adoption behaviour. Kumar *et al.* (2018) [10] also reported similar trends in floriculture, indicating gradual acceptance of improved practices among growers (Kumar *et*

al., 2018) [10].

The practice-wise analysis indicated that nipping/tipping, transplanting and use of improved variety (Pusa Narangi Gainda) recorded higher levels of adoption. These practices are relatively simple, less resource-intensive and provide immediate visible benefits such as increased branching, uniform growth and enhanced flower yield. Farmers generally prefer such practices because they are easy to implement and offer quick economic returns. This observation is in line with the findings of Chouhan *et al.* (2013) [5], who reported that farmers tend to adopt practices that are less complex and directly influence productivity. In contrast, practices such as plant protection measures and micronutrient application recorded lower adoption levels. These practices require technical knowledge, timely intervention and higher input costs, which may limit their adoption. Similar constraints were reported by Chanu *et al.* (2014) [4], who identified lack of knowledge and high cost of plant protection inputs as major barriers. Singh *et al.* (2017) [15] also emphasized that micronutrient management is often neglected due to its complexity and uncertain immediate benefits.

The distribution of respondents across individual practices further highlighted that a considerable proportion of farmers either partially adopted or did not adopt several recommended practices. The low adoption of plant protection measures, in particular, indicates a critical technological gap that may lead to yield losses. This reflects inadequate knowledge regarding pest and disease identification, improper use of chemicals and lack of access to quality inputs. Such findings are consistent with earlier studies in horticultural crops, where technical and knowledge-intensive practices showed lower adoption rates compared to general agronomic practices (Gedam and Singh, 2012; Chanu *et al.*, 2014) [7, 4].

The district-wise comparison revealed significantly higher adoption levels in North Tripura compared to Dhalai district. This variation may be attributed to differences in exposure to extension services, training programmes and institutional support. North Tripura has experienced relatively higher intervention by Krishi Vigyan Kendras through Front Line Demonstrations and capacity building programmes, which likely enhanced farmers' knowledge and confidence in adopting improved technologies. These findings are in agreement with Chouhan *et al.* (2013) [5] and Pal *et al.* (2015) [12], who reported that extension contact and training exposure significantly influence adoption behaviour. The non-significant difference observed in plant protection measures across districts suggests that this constraint is widespread and not limited to a particular location.

The analysis of socio-economic variables clearly demonstrated that factors such as education, land holding, annual income, extension contact, training exposure, market access and input availability had a significant influence on adoption behaviour. Education enhances farmers' ability to understand and implement improved technologies, while land holding and income determine their capacity to invest in inputs. The strong positive association between land holding and adoption indicates that farmers with larger holdings are more willing to take risks and adopt new practices. This finding corroborates the results of

Chandawat *et al.* (2009) ^[3]. The significant role of extension contact and training exposure underscores the importance of knowledge dissemination and advisory services in promoting adoption, as also reported by Gedam and Singh (2012) ^[7]. Furthermore, the influence of market access and input availability indicates that adoption of commercial crops is closely linked with infrastructural and institutional support systems. Similar observations have been made by Singh *et al.* (2017) ^[15] in floriculture-based farming systems. The economic analysis revealed that commercial marigold cultivation is substantially more profitable than conventional vegetable cultivation, as evidenced by higher net returns and benefit–cost ratio. The higher profitability may be attributed to consistent market demand, better price realization and relatively shorter crop duration. This finding supports earlier reports by Kaur (2022) ^[9], who highlighted the economic superiority of marigold cultivation over traditional crops. The favourable economic returns make marigold cultivation an attractive option for farmers seeking to enhance income and diversify their farming systems. The cost structure analysis indicated that labour, planting material and nutrient inputs constituted major components of the total cost of cultivation. The higher share of labour cost reflects the labour-intensive nature of marigold cultivation, particularly during transplanting, intercultural operations and harvesting. This suggests that labour availability and cost may influence the profitability and adoption of the crop. Similar observations have been reported in horticultural crops where labour constitutes a significant proportion of production cost (Singh *et al.*, 2017) ^[15].

The yield gap analysis revealed a considerable extension gap between demonstration yield and farmers' yield, indicating that the potential of the crop is not fully realized at the farmer level. The technology gap was relatively low, suggesting that the recommended technologies are suitable under local conditions. However, the higher extension gap indicates that productivity losses are primarily due to partial adoption of recommended practices rather than technological limitations. This finding is consistent with Samui *et al.* (2000) ^[13], who emphasized that extension gaps arise due to inadequate transfer of technology and lack of awareness among farmers. The low technology index further confirms the feasibility of the recommended practices under field conditions (Samui *et al.*, 2000; Yadav *et al.*, 2024) ^[13, 17].

The livelihood impact assessment clearly demonstrated that commercial marigold cultivation contributed significantly to improvement in income, employment generation and overall standard of living of the farmers. The crop also facilitated diversification of farming systems and improved market linkage, thereby enhancing economic resilience. These findings are in agreement with the broader perspective of horticultural diversification contributing to livelihood security and rural development (Singh *et al.*, 2017; FAO, 2023; Kumar *et al.*, 2025) ^[15, 6]. The increased employment opportunities associated with marigold cultivation also highlight its potential in addressing rural underemployment. Overall, the findings of the present study emphasize that while commercial marigold cultivation holds significant potential for income enhancement and livelihood diversification, its success largely depends on effective

extension support, capacity building and timely availability of inputs. Strengthening these aspects will help bridge the existing adoption gaps and improve productivity at the farmer level.

Conclusion

The study revealed that the majority of marigold growers in Tripura exhibited a medium level of adoption of recommended cultivation practices, indicating partial utilization of available technologies. While basic agronomic practices such as transplanting and nipping/tipping were widely adopted, significant gaps persist in critical areas like plant protection, micronutrient application and market-oriented practices. The presence of a considerable extension gap highlights that the yield potential of marigold is not fully realized at the farmer level, primarily due to inadequate technology dissemination and limited access to quality inputs.

Economic analysis clearly demonstrated that commercial cultivation of marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda is a highly profitable enterprise compared to conventional crops, offering substantial scope for income enhancement and livelihood diversification. Socio-economic factors such as land holding, income, extension contact and input availability were found to significantly influence adoption behaviour.

Therefore, strengthening extension services, ensuring timely availability of inputs, promoting skill-based training and improving market linkages are essential to bridge the existing technological gaps. With appropriate institutional support and capacity building, commercial marigold cultivation can serve as a sustainable and viable livelihood option for farmers in Tripura.

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