P-ISSN 2322 - 0678 & E-ISSN 3048 - 9946
https://doi.org/10.56572/gjoee.2026.41.2.0024 Gujarat Journal of Extension Education Vol. 41 : Issue 2 : June - 2026

EVALUATION OF BEST DEMONSTRATION PRACTICES FOR IMPROVING COTTON PRODUCTIVITY

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ABSTRACT

Cotton is one of the most important commercial crops in India, contributing significantly to rural livelihoods and the textile industry. Improving cotton productivity through the adoption of scientific cultivation practices remains a major concern for agricultural development and extension systems. In recent years, extension agencies have promoted large-scale demonstrations to enhance farmers' awareness and adoption of improved cotton production technologies. Among these, the High-Density Planting System (HDPS) has gained attention for its potential to increase productivity and profitability. The present study evaluated the effectiveness of large-scale demonstrations of best practices on cotton productivity and profitability in Rajkot district of Gujarat. An ex-post facto research design was adopted during 2023–26 under the NFSM project. A total of 194 farmers comprising 97 beneficiary and 97 non-beneficiary cotton growers were selected for the study. Data were collected through personal interviews and analyzed using appropriate statistical tools to assess socio-economic characteristics, knowledge levels, productivity, profitability, and constraints related to technology adoption. The findings revealed that beneficiaries exhibited significantly higher knowledge regarding HDPS and recommended cotton production technologies. The average gross income (₹2.67 lakh/ha) and net profit (₹1.69 lakh/ha) of beneficiary farmers were substantially higher than those of non-beneficiaries. Although the cost of cultivation was slightly higher among beneficiaries, the benefit–cost ratio was considerably greater (1.73) compared to non-beneficiaries (1.17), indicating superior economic returns. The results suggest that large-scale demonstrations effectively improve farmers' knowledge, facilitate adoption of improved practices, and increase productivity and profitability in cotton cultivation.

Keywords: *high-density planting system (hdps); cotton productivity; extension interventions; economic analysis; farmer knowledge.*

INTRODUCTION

India has been one of the largest producers and exporters of cotton globally. China exports only a little amount of cotton lint. China with a supply of cotton normally greater than one-third of world use and nearly 40 percent larger than India (Latha *et al*, 2017). Cotton cultivation is spread across several states in India, with Gujarat, Maharashtra, Telangana, and Andhra Pradesh being major cotton-producing regions. The country's cotton production significantly contributes to the textile industry and the economy. India predominantly grows *Bt* cotton, a genetically modified variety that contains genes from the bacterium, *Bacillus thuringiensis*. *Bt* cotton was introduced to combat pest issues, especially the bollworm.

However, concerns about the effectiveness of *Bt* cotton against evolving pests and the need for sustainable farming practices have been ongoing topics of discussion. Cotton farming in India faces challenges such as unpredictable weather patterns, water scarcity, pest infestations, and market price fluctuations. Small and marginal farmers often struggle due to the high input costs associated with cotton cultivation.

HDPS cotton production is considered as a potential strategy for reducing production costs by shortening the growing season (Rossi *et al*, 2004). Theoretically, higher planting density ensures earlier crop canopy cover than conventional, higher sunlight interception leading to higher and earlier yields at reduced cost. The obvious advantage of this system is earliness (Latha et al. 2011) since it needs less bolls/plant to achieve the same yield as conventional cotton.

To enhance cotton productivity, Ministry of Agriculture & Farmers Welfare has sanctioned a special project on cotton titled "Targeting technologies to agro-ecological zones-large scale demonstrations of best practices

to enhance cotton productivity" under NFSM project during 2023-24.

This projects targets technologies such as High-Density Planting System (HDPS), closer spacing and production technology for ELS cotton focusing on a cluster-based and value chain approach in Public Private Partnership (PPP) mode through Direct Benefit Transfer (DBT) to farmers.

OBJECTIVES

(1) To analyze and compare the socio-economic, communication, and psychological characteristics of beneficiary and non-beneficiary cotton farmers

(2) To compare the cotton yield, cost of cultivation, gross returns, net returns, and benefit–cost ratio of beneficiary and non-beneficiary farmers

(3) To assess the impact of extension activities and large-scale demonstrations on the knowledge level of cotton farmers regarding recommended cotton production technologies

(4) To identify the constraints faced by farmers in the adoption and demonstration of best management practices for cotton production and to obtain their suggestions for overcoming these constraints

METHODOLOGY

The study was conducted in Rajkot district of Gujarat, India, where large-scale demonstrations on improved cotton production practices were implemented under the National Food Security Mission (NFSM) during 2023–26. Rajkot was purposively selected as it is one of the major cotton-growing districts of the state and provides a suitable area for assessing the impact of extension interventions on cotton productivity.

An ex-post facto research design was adopted since the demonstration programme had already been implemented and the variables under study were beyond the control of the researcher. The study population consisted of cotton growers who participated in the NFSM-supported demonstrations during 2023–26. The list of beneficiary farmers was obtained from official records, and neighbouring non-beneficiary farmers were selected for comparison.

A total of 194 respondents were included in the study, comprising 97 beneficiary and 97 non-beneficiary farmers. Beneficiary farmers were selected from the programme records, while an equal number of neighbouring farmers with similar farming conditions were chosen as non-beneficiaries.

The major dependent variables were knowledge level, cotton productivity, and economic performance. Knowledge referred to farmers' understanding of recommended cotton production technologies and HDPS practices. Productivity was measured in terms of seed cotton yield per hectare, while economic performance was assessed through cost of cultivation, gross returns, net returns, and benefit–cost ratio. Independent variables included age, education, farming experience, landholding, social participation, extension contact, information source utilization, innovativeness, and risk orientation.

A structured interview schedule was developed based on the study objectives, review of literature, and expert consultation. The instrument was validated by subject matter specialists and pre-tested with farmers outside the sample area to ensure clarity and relevance.

Primary data were collected through personal interviews after obtaining informed consent from the respondents. Participation was voluntary, and confidentiality of the information was maintained throughout the study. The collected data were coded, tabulated, and analyzed using frequency, percentage, mean, and standard deviation.

RESULTS AND DISCUSSION

Table 1: Distribution of the respondents according to their personal profile (n=194)

Sr. No.	Personal profile	Beneficiaries (n=97)		Non Beneficiaries (n=97)	
		Frequency	Percent	Frequency	Percent
1	**Age**				
	Young age (up to 35 year)	03	3.09	02	2.06
	Middle age (36 to 50 year)	30	30.93	38	39.18
	Old age (above 50 year)	64	65.98	57	58.76

Sr. No.	Personal profile	Beneficiaries (n=97)		Non Beneficiaries (n=97)	
		Frequency	Percent	Frequency	Percent
2	**Education**				
	Illiterate	07	7.22	25	25.77
	Primary education	36	37.11	23	23.71
	Secondary education	48	49.48	43	44.33
	Higher secondary education	06	6.19	04	4.12
	College and above	00	0.00	02	2.06
3	**Land Holding**				
	Marginal farmers (up to 1 ha)	22	22.68	16	16.49
	Small farmers (1.01 to 2 ha)	47	48.45	31	31.96
	Medium farmers (2.01 to 4 ha)	24	24.74	41	42.27
	Large farmers (More than 4 ha)	04	4.12	9	9.28
4	**Occupation**				
	Farming	47	48.45	35	36.08
	Farming + A. H.	38	39.18	57	58.76
	Farming + Service/ Business	12	12.37	05	5.15
	Farming + A. H.+ Service/ Business	00	0.00	00	0.00
5	**Annual income**				
	Up to ₹ 1,50,000 /-	34	35.05	17	17.53
	₹ 1,50,001 to ₹ 3,00,000 /-	33	34.02	52	53.61
	Above ₹ 3,00,000 /-	30	30.93	28	28.87
6	**Irrigation Method**				
	Surface/ flood irrigation	74	76.29	82	84.54
	Drip irrigation	23	23.71	15	15.46
	Sprinkler irrigation	00	0.00	00	0.00
7	**Farming Experience**				
	Low level of experience (Up to 10)	15	15.46	03	3.09
	Medium level of experience (11 to 15)	30	30.93	12	12.37
	High level of experience (above 15)	52	53.61	82	84.54
8	**Source of information**				
	Low level of source of information	28	28.87	13	13.40
	Medium level of source of information	59	60.82	79	81.44
	High level of source of information	10	10.31	05	5.15
		BN: Mean=13.16 SD=2.46		**Mean=8.13 SD=2.15**	
9	**Social participation**				
	No social participation	14	14.43	34	31.96
	Member of one organization	67	69.07	65	67.01
	Member of more than one organization	16	16.49	01	1.03
	Office bearer in organization	00	0.00	00	0.00
	Total	**97**	**100**	**97**	**100**
10	**Risk Orientation**				
	Low level of risk Orientation	19	19.59	25	25.77
	Medium level of risk Orientation	66	68.04	64	65.98
	High level of risk Orientation	12	12.37	08	8.25
	Total	**97**	**100**	**97**	**100**
		BN: Mean=13.86 SD=1.74		**Mean=8.64 SD=1.62**	
11	**Scientific Orientation**				
	Low level of scientific orientation	12	12.37	13	13.40
	Medium level of scientific orientation	65	67.01	68	70.10
	High level of scientific orientation	20	20.62	16	16.49
	Total	**97**	**100**	**97**	**100**
		BN: Mean=30.64 SD=3.57		**Mean=21.91 SD=3.83**	

Sr. No.	Personal profile	Beneficiaries (n=97)		Non Beneficiaries (n=97)	
		Frequency	Percent	Frequency	Percent
12	**Market orientation**				
	Low level of market orientation	13	13.40	15	15.46
	Medium level of market orientation	71	73.20	70	72.16
	High level of market orientation	13	13.40	12	12.37
		BN: Mean=20.51 SD=1.70		**Mean=11.63 SD=2.63**	
13	**Innovativeness**				
	Low level of innovativeness	07	7.22	72	74.23
	Medium level of innovativeness	29	29.90	16	16.49
	High level of innovativeness	61	62.89	09	9.28
		BN: Mean=2.56 SD=0.63		**Mean=1.35 SD=0.65**	
14	**Knowledge of cotton of HDPS**				
	Very Low (Up to 1.6 score)	00	0.00	50	51.55
	Low (1.6 to 3.2 score)	00	0.00	41	42.27
	Medium (3.2 to 4.8 score)	06	6.19	03	3.09
	High (4.8 to 6.4 score)	16	16.49	03	3.09
	Very High (6.4 to 8 score)	75	77.32	00	0.00
15.	**Knowledge of cotton production technology**				
	Very (Up to 3.6 score)	00	0.00	02	2.06
	Low (3.6 to 7.2 score)	00	0.00	28	28.87
	Medium (7.2 to 10.8 score)	04	4.12	05	5.15
	High (10.8 to 14.4 score)	33	34.02	30	30.93
	Very High (14.4 to 18 score)	60	61.86	32	32.99

(1) Age

The age distribution of respondents clearly indicates that farming in the study area was dominated by older farmers in both the groups. Among beneficiaries, 65.98 per cent belonged to the old age group (above 50 years), followed by 30.93 per cent in the middle age group (36–50 years), while only 3.09 per cent were young farmers (up to 35 years). A similar pattern was observed among non-beneficiaries, where 58.76 per cent were old, 39.18 per cent were middle-aged and only 2.06 per cent were young.

This indicates that cotton cultivation and related interventions are largely handled by experienced and senior farmers. The very small proportion of young farmers in both categories reflects limited involvement of rural youth in cotton farming and related development programmes.

(2) Education

Education plays a vital role in improving farmers' ability to understand technical recommendations, follow scientific instructions and interact effectively with extension personnel. Educational status shows a clear advantage in favour of beneficiaries. Nearly half of the beneficiaries (49.48 per cent) had secondary education, followed by 37.11 per cent with primary education and only 7.22 per cent were illiterate. A small proportion (6.19 per cent) had higher secondary education, and none had education at college level or above.

In contrast, the non-beneficiaries had a much higher proportion of illiterates (16.95 per cent). Although, 31.36 per cent had secondary education and 34.75 per cent had primary education, the overall educational attainment was comparatively lower.

The higher literacy rate among beneficiaries might have facilitated better understanding of HDPS practices and cotton production technologies. Therefore, education appears

to be an important supportive factor influencing participation and effective utilization of the intervention.

(3) Land holding

As depicted in Table 1, Land holding pattern indicates that the majority of beneficiaries were small farmers. Nearly half (48.45 per cent) belonged to the small farmer category (1.01 to 2.00 ha), followed by 24.74 per cent medium farmers, 22.68 per cent marginal farmers and only 4.12 per cent large farmers. On the other hand, among non-beneficiaries, the highest proportion (42.27 per cent) belonged to the medium farmer category, followed by small farmers (31.96 per cent), marginal farmers (16.49 per cent) and large farmers (9.28 per cent).

The results indicate that the beneficiary group was largely composed of small and marginal farmers, whereas, the non-beneficiary group had a comparatively higher representation of medium and large farmers. This pattern suggests that the programme has been more accessible or more attractive to farmers with smaller land holdings. Small farmers are often more dependent on institutional support and extension programmes to improve productivity and income. Hence, the observed distribution reflects the relevance of the intervention for resource-constrained farmers.

(4) Occupation

The data presented in Table 1 reveal that with respect to occupation, almost half of the beneficiaries (48.45 per cent) depended solely on farming, while 39.18 per cent were engaged in farming along with animal husbandry. A smaller proportion (12.37 per cent) combined farming with service or business. In the non-beneficiary group, the dominant occupation was farming combined with animal husbandry (58.76 per cent), followed by only farming (36.08 per cent). Very few respondents (5.15 per cent) combined farming with service or business.

This indicates that beneficiaries were comparatively more diversified in terms of livelihood combinations beyond agriculture and animal husbandry. The fairly even distribution of beneficiaries across income groups indicates that the intervention reached farmers with diverse economic backgrounds.

(5) Annual income

Table 1 highlights, the income distribution among beneficiary and non-beneficiary farmers. Among beneficiaries, 35.05 per cent belonged to the lowest income group (up to ₹ 1,50,000), 34.02 per cent to the middle income group and 30.93 per cent to the highest income group. In the non-beneficiary group, a majority (53.61%) belonged to the middle income category, followed by the highest income category (28.87%) and the lowest income category (17.53%).

The fairly even distribution of beneficiaries across income groups indicates that the intervention reached farmers with diverse economic backgrounds. However, the relatively higher proportion of low-income farmers among beneficiaries suggests that the programme may have been particularly useful to economically weaker farmers. Since financial constraints often limit adoption of modern technologies, programme support might have reduced perceived financial risks and encouraged participation.

(6) Irrigation method

As per the Table 1, Surface or flood irrigation was the dominant irrigation method in both groups. Among beneficiaries, 76.29 per cent used surface irrigation, while 23.71 per cent used drip irrigation. Among non-beneficiaries, 84.54 per cent depended on surface irrigation and only 15.46 per cent adopted drip irrigation. None of the respondents in either group used sprinkler irrigation.

Although traditional surface irrigation remains dominant, the higher proportion of drip irrigation users among beneficiaries indicates comparatively better exposure to modern water-saving technologies. HDPS cultivation demands efficient moisture management; therefore, farmers using drip irrigation are more likely to manage plant population and nutrient supply effectively. The results demonstrate that beneficiaries were technologically better positioned for intensive cotton production systems.

(7) Farming experience

Table 1 indicates that among beneficiaries, 53.61 per cent had high farming experience (above 15 years), 30.93 per cent had medium experience and 15.46 per cent had low experience. In the non-beneficiary group, 84.54 per cent had high experience, followed by 12.37 per cent with medium experience and only 3.09 per cent with low experience. The non-beneficiary group was clearly dominated by highly experienced farmers.

This may indicate that long experience alone does not necessarily lead to participation in new technological interventions. On the other hand, beneficiaries included

a comparatively larger proportion of farmers with low and medium experience, suggesting that younger and less experienced farmers might be more receptive to institutional support and innovative production systems such as HDPS.

(8) Source of information

A majority of beneficiaries (60.82%) possessed a medium level of information sources, while 28.87 per cent had a low level and 10.31 per cent had a high level. Among non-beneficiaries, 81.44 per cent had medium level, 13.40 per cent low level and only 5.15 per cent high level of information sources.

The substantially higher mean score of beneficiaries indicates better access to diverse and reliable information channels such as extension personnel, demonstrations, trainings and progressive farmers. Effective access to information is a crucial factor for adoption of HDPS.

(9) Social participation

Among beneficiaries, 69.07 per cent were members of one organisation and 16.49 per cent were members of more than one organisation, whereas only 14.43 per cent had no social participation. In the non-beneficiary group, 31.96 per cent had no social participation and only 1.03 per cent were members of more than one organisation.

The higher level of social participation among beneficiaries clearly indicates stronger social networking and institutional linkage. Participation in farmer groups, cooperatives and organisations facilitates information exchange, collective learning and exposure to extension programmes. Therefore, greater social participation among beneficiaries may have directly contributed to their inclusion in the intervention and to higher levels of awareness regarding HDPS.

(10) Risk orientation

Most of the beneficiaries (68.04%) belonged to the medium risk orientation category, followed by low (19.59%) and high (12.37%). Similarly, among non-beneficiaries, 65.98 per cent were in the medium category, 25.77 per cent in the low category and 8.25 per cent in the high category.

Although both groups predominantly belonged to the medium risk category, beneficiaries exhibited a higher mean score, indicating comparatively greater readiness to take calculated risks. Adoption of HDPS involves changes in planting geometry, management practices and input use, which require farmers to tolerate uncertainty. Hence, relatively higher risk orientation among beneficiaries appears to support their participation in the programme.

(11) Scientific orientation

Among beneficiaries, 67.01 per cent had medium scientific orientation, 20.62 per cent high and 12.37 per cent low. The mean score was 30.64 (SD = 3.57). In the non-beneficiary group, 70.10 per cent belonged to the medium category, 16.49 per cent to the high category and 13.40 per cent to the low category.

The higher mean score among beneficiaries clearly reflects their stronger inclination towards scientific reasoning, experimentation and reliance on recommended practices. Scientific orientation is a critical psychological trait influencing technology adoption. The results strongly suggest that beneficiaries were more aligned with scientific principles of crop management, which may explain their higher knowledge and adoption of HDPS practices.

(12) Market orientation

A majority of both beneficiaries (73.20%) and non-beneficiaries (72.16%) were found in the medium market orientation category. Among beneficiaries, 13.40 per cent each were in low and high categories. The mean market orientation score of beneficiaries (20.51) was substantially higher than that of non-beneficiaries (11.63).

Despite similar categorical distribution, the large difference in mean scores indicates that beneficiaries had better awareness regarding market prices, demand trends and marketing strategies. Better market orientation encourages farmers to adopt productivity-enhancing technologies to maximize returns. Therefore, improved market awareness among beneficiaries could be one of the motivational factors for participation in HDPS.

(13) Innovativeness

Table 1 reveals a striking difference between the two groups in innovativeness. Among beneficiaries, 62.89 per cent had high innovativeness, 29.90 per cent had medium innovativeness and only 7.22 per cent had low innovativeness. In contrast, among non-beneficiaries, a very large majority (74.23 per cent) belonged to the low innovativeness category, and only 9.28 per cent exhibited high innovativeness.

The extremely wide gap between beneficiaries and non-beneficiaries in innovativeness highlights the critical

role of this trait in technology adoption. HDPS represents a major departure from conventional cotton planting practices. Farmers with higher innovativeness are more willing to try such new systems, tolerate early uncertainties and learn from experience. Hence, high innovativeness among beneficiaries strongly explains their acceptance of HDPS.

(14) Knowledge of cotton HDPS

The knowledge level regarding cotton cultivation under the High Density Planting System (HDPS) showed an extremely wide gap between the two groups. Among beneficiaries, 77.32 per cent had very high knowledge and 16.49 per cent had high knowledge. Only 6.19 per cent had medium knowledge, and none fell under low or very low categories. In sharp contrast, more than half of the non-beneficiaries (51.55 per cent) had very low knowledge and 42.27 per cent had low knowledge. Only 3.09 per cent each were found in medium and high categories, and none possessed very high knowledge.

The findings clearly demonstrate the effectiveness of the programme in enhancing HDPS-specific knowledge among beneficiaries. The virtual absence of low and very low knowledge levels in the beneficiary group indicates that training, demonstrations and continuous technical guidance significantly strengthened farmers' understanding of plant spacing, population management, nutrient scheduling and crop protection under HDPS. The extremely poor knowledge status of non-beneficiaries confirms the importance of institutional intervention for dissemination of specialised production systems.

(15) Knowledge of cotton production technology

A similar trend was observed in the case of overall knowledge of cotton production technology. Among beneficiaries, 61.86 per cent possessed very high knowledge and 34.02 per cent had high knowledge, while only 4.12 per cent had medium knowledge. No beneficiary was found in the low or very low categories. Among non-beneficiaries, knowledge was relatively lower, as 32.99 per cent had very high knowledge and 30.93 per cent had high knowledge, but a substantial proportion (28.87 per cent) still belonged to the low knowledge category and 2.06 per cent to the very low category.

The results clearly show that beneficiaries were substantially superior in their overall knowledge of recommended cotton production technologies. The absence of low knowledge categories among beneficiaries reflects effective capacity building through extension activities associated with the programme. Although a reasonable proportion of non-beneficiaries also had high knowledge, the persistence of low and very low knowledge categories indicates inadequate exposure to systematic technical guidance. Consequently, the intervention appears to have played a significant role not only in enhancing HDPS-specific knowledge but also in strengthening farmers' overall technical competence in cotton production.

Table 2: Distribution of the respondents according to their yield and economics of beneficiaries

(n=97)

Sr. No.	Particular	Beneficiaries	Non beneficiaries	Difference
I	**Variable Input/Cost (₹)**			
1	Labour Cost	45,515.46	40,589.18	4,926.28
2	Seed cost	8,640.00	5,184.00	3,456.00
3	Manures and fertilizers	5,600.15	8,187.01	-2,586.86
4	Plant Protection	5,907.22	7,560.4	-1,653.18
5	Miscellaneous	1,422.90	1,190.41	232.49
6	Interest on working capital	4,356.99	4,181.17	175.82
II	**Fixed cost**	26,560.00	27,626.78	-1,066.78
III	**Total cost of cultivation**	98,002.72	94,518.95	3,483.774
IV	**Total income**	2,67,531.44	2,05,000.70	62,530.74
V	**Net profit**	1,69,528.72	1,10,481.75	59,046.97
VI	**Benefit: Cost Ratio**	**1.73**	**1.17**	

The economic performance of cotton cultivation under the beneficiary and non-beneficiary categories was analysed in terms of variable costs, fixed costs, and total cost of cultivation, gross income, net profit and benefit–cost ratio. The detailed results and their implications are discussed below.

I. Variable input / cost

(1) Labour cost

The average labour cost incurred by the beneficiaries was ₹45515.46, whereas non-beneficiaries spent ₹40589.18 per hectare, showing a positive difference of ₹4926.28 in favour of beneficiaries.

This higher labour expenditure among beneficiaries indicates that the beneficiary farmers followed more intensive crop management practices. Under HDPS and improved production technology, operations such as precise sowing, timely intercultural operations, nutrient application, plant protection and harvesting generally require higher labour input. Therefore, the increased labour cost reflects better crop husbandry and closer field supervision by beneficiary farmers, which ultimately contributed to higher productivity and returns.

(2) Seed cost

The beneficiaries incurred a seed cost of ₹8,640.00, while non-beneficiaries spent only ₹5,184.00, resulting in an additional expenditure of ₹3,456.00 by the beneficiaries.

The higher seed cost among beneficiaries is mainly due to the adoption of high-density planting system and use of recommended quality seed. HDPS requires a higher seed rate compared to conventional planting due to closer spacing of plants. Hence, the increased investment on seed clearly indicates that beneficiaries followed the recommended plant population and planting geometry.

(3) Manures and fertilizers

The expenditure on manures and fertilizers by beneficiaries was ₹5600.15, whereas non-beneficiaries spent ₹8187.01. The difference was –₹2586.86, indicating that non-beneficiaries spent substantially more on fertilizers.

Although non-beneficiaries invested more money on fertilizers, the higher expenditure did not result in higher returns. This suggests that non-beneficiary farmers might be applying fertilizers in an unbalanced or non-scientific manner, possibly relying on blanket recommendations or traditional practices. In contrast, beneficiaries, being trained under improved production technology and HDPS, appear to have followed more rational and need-based nutrient management practices, thereby achieving better efficiency with comparatively lower expenditure.

(4) Plant protection cost

The cost incurred on plant protection by beneficiaries was ₹5,907.22, whereas non-beneficiaries spent ₹7560.4. The negative difference of –₹1653.18 indicates considerably higher plant protection expenditure by non-beneficiaries.

This finding implies that beneficiaries might have adopted integrated pest and disease management practices and timely advisory-based interventions, which reduced the need for repeated or indiscriminate pesticide applications. On the other hand, non-beneficiaries possibly relied more on curative chemical control measures after the occurrence of pest or disease problems, leading to higher expenditure without proportionate yield benefits.

(5) Miscellaneous expenditure

The miscellaneous expenditure was almost similar in both the groups, amounting to ₹1422.9 for beneficiaries and ₹1190.41 for non-beneficiaries, with a small difference of ₹232.49.

This indicates that other incidental expenses related to cultivation were nearly uniform across both groups and did not contribute significantly to the economic differences observed between the two categories.

(6) Interest on working capital

The interest on working capital was slightly higher for beneficiaries (₹4,356.99) than for non-beneficiaries (₹4,181.17), showing a marginal difference of ₹175.82.

This small difference is mainly due to the relatively higher variable investment made by beneficiaries in labour and seed. However, the increased interest burden is negligible when compared with the additional returns obtained by beneficiaries.

II. Fixed cost

The fixed cost incurred by beneficiaries was ₹26,560.00, whereas non-beneficiaries incurred ₹27,626.78. The difference of –₹1,066.78 indicates slightly higher fixed costs among non-beneficiaries.

Fixed costs generally include expenses such as land revenue, depreciation and rental value of land, which are mostly independent of the technology adopted. Hence, the observed difference is marginal and has limited influence on the profitability gap between the two groups.

III. Total cost of cultivation

The total cost of cultivation for beneficiaries was ₹98,002.72, while for non-beneficiaries it was ₹94518.95. The beneficiaries incurred an additional cost of ₹3,483.77.

This shows that beneficiaries invested slightly more in cotton cultivation. However, the difference in total cost is relatively small, especially when compared with the large difference in total income and net profit. This clearly indicates that the improved production practices under the beneficiary category require only a marginally higher investment.

IV. Total income

The total income obtained by beneficiaries was ₹2,67,531.44, whereas non-beneficiaries obtained only ₹2,05,000.7. The difference in total income was remarkably high at ₹62,530.74 in favour of beneficiaries. The results are in line with the findings of Rathwa and Bochalya, 2023; Acharya and Makwan, 2023; Vinaya et al., 2017.

This substantial increase in income clearly demonstrates the economic advantage of adopting HDPS and improved cotton production technology. The higher income is mainly attributed to better plant population, improved crop management, efficient input use and enhanced productivity achieved by beneficiary farmers.

V. Net profit

The net profit realized by beneficiaries was ₹1,69,528.72, while non-beneficiaries earned only ₹1,10,481.75. The net profit difference between the two groups was ₹59,046.96.

This very large profit gap clearly shows that the beneficiary farmers derived significantly higher economic benefits from cotton cultivation. Even though beneficiaries incurred slightly higher cultivation costs, the additional investment was more than compensated by the large increase in income. This highlights the superior economic viability of the technology and practices adopted by beneficiaries. Similar results with better profitability was observed under HDPS (Anonymous 2023). These results are in accordance with those results obtained by (Giri and Gore, 2006); (Buttar and Singh, 2007); (Narayana *et al,* 2011).

VI. Benefit–cost ratio

The benefit–cost ratio of beneficiaries was 1.73, whereas that of non-beneficiaries was only 1.17.

This clearly indicates that cotton cultivation under the beneficiary category was substantially more efficient and profitable. The economic analysis clearly reveals that although the total cost of cultivation of beneficiaries was marginally higher than that of non-beneficiaries, the beneficiaries achieved significantly higher income and profit. The higher expenditure on labour and seed by beneficiaries reflects the adoption of HDPS and improved management practices, whereas the lower expenditure on fertilizers and plant protection indicates more scientific and efficient input use. In contrast, non-beneficiaries incurred comparatively higher costs on fertilizers and plant protection without achieving proportionate economic gains, suggesting less efficient and less knowledge-based crop management practices. The results are in line with the findings of Borra *et al.,* 2025; Padaliya et al., 2023; Vinaya et al., 2017.

Therefore, the results strongly demonstrate that adoption of HDPS and recommended cotton production technology under the beneficiary programme considerably enhanced the economic performance of cotton cultivation in terms of higher gross returns, higher net profits and superior benefit–cost ratio.

Table 3: Independent Samples Z-Test Comparing Knowledge Levels on Cotton High-Density Planting System (HDPS) Between Beneficiary and Non-Beneficiary Farmers (n=97)

Calculation	Knowledge levels on HDPS of beneficiary farmers	Knowledge levels on HDPS of Non-beneficiary farmers
Mean	7.072164948	1.793814433
Known Variance	1.400988	1.165378
Observations	97	97
Hypothesized Mean Difference	0	
Z	32.45075439	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

The statistical analysis of Table 3 reveals a highly significant difference in knowledge levels regarding Cotton High-Density Planting System (HDPS) between beneficiary and non-beneficiary farmers. The calculated **z-value (32.45)** is substantially higher than the critical values for both the one-tailed test (1.64) and the two-tailed test (1.96). Moreover, the p-value is effectively zero, indicating an extremely significant result. The mean knowledge score of beneficiary farmers (7.07) is considerably higher than that of non-beneficiary farmers (1.79). This large difference clearly demonstrates that beneficiary farmers possess significantly greater knowledge about HDPS practices compared to non-beneficiaries.

These findings confirm that the intervention or program has had a strong and positive impact on enhancing farmers' knowledge about Cotton High-Density Planting System. The results highlight the effectiveness of the initiative in improving awareness and understanding of improved cotton cultivation practices among participating farmers.

Table 4: Independent Samples Z-Test Comparing Knowledge Levels on *Bt* Cotton Cultivation between Beneficiary and Non-Beneficiary Farmers (n=97)

Calculation	Knowledge Levels on *Bt* Cotton of Beneficiary Farmers	Knowledge Levels on *Bt* Cotton of Beneficiary Farmers
Mean	14.70103093	11.37113402
Known Variance	4.1701	20.71499
Observations	97	97
Hypothesized Mean Difference	0	
Z	6.574262599	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

The statistical analysis in Table 4 indicates a highly significant difference in knowledge levels regarding *Bt* Cotton cultivation between beneficiary and non-beneficiary farmers. The calculated **z-value (6.57)** is much higher than the critical values for both the one-tailed test (1.645) and the two-tailed test (1.960). Additionally, the p-value is effectively zero, showing an extremely high level of statistical significance. The mean knowledge score of beneficiary farmers (14.70) is notably higher than that of non-beneficiary farmers (11.37). This difference clearly demonstrates that beneficiary farmers possess significantly greater knowledge about *Bt* Cotton cultivation practices compared to non-beneficiaries.

These findings confirm that the intervention program has had a positive and meaningful impact on enhancing farmers' knowledge of *Bt* Cotton cultivation. The results highlight the effectiveness of the initiative in strengthening awareness and technical understanding among participating farmers. The results are in line with the findings of Borra *et al.,* 2025; Padaliya et al., 2023; Rathwa and Bochalya, 2023; Acharya and Makwan, 2023; Vinaya et al., 2017.

Overall, the suggestions demonstrate that farmers are not only willing to adopt best practices for enhancing cotton productivity, but also clearly articulate the need for supportive varietal development, assured input supply, practical and timely technical guidance, appropriate mechanization and farmer-friendly training arrangements to ensure sustainable and large-scale adoption of improved cotton production practices.

CONCLUSION

The study revealed that beneficiary farmers participating in the large-scale demonstration programme exhibited comparatively better socio-economic and psychological characteristics, including higher educational status, greater access to information sources, stronger social participation, higher market orientation, and greater innovativeness than non-beneficiary farmers. Beneficiaries also possessed significantly higher knowledge regarding High-Density Planting System (HDPS) and recommended cotton production technologies, as evidenced by the highly significant differences observed through Z-test analysis.

Economic analysis demonstrated that although beneficiary farmers incurred slightly higher cultivation costs, they achieved substantially higher gross income (₹2.68 lakh/ha), net profit (₹1.70 lakh/ha), and benefit–cost ratio (1.73) compared to non-beneficiaries. The higher profitability was mainly associated with the adoption of HDPS and improved crop management practices promoted through extension interventions. The findings clearly establish that large-scale demonstrations were effective in enhancing farmers' knowledge, improving adoption of scientific cotton production technologies, and increasing economic returns from cotton cultivation.

Thus, the study concludes that demonstration-based extension approaches under the programme significantly contributed to improving cotton productivity, profitability, and technical competence among participating farmers, thereby validating their role as an effective strategy for technology dissemination in cotton cultivation.

RECOMMENDATIONS

(1) Cotton farmers should adopt the High-Density Planting System (HDPS) and other recommended cotton production technologies to improve productivity, profitability, and resource-use efficiency.

(2) Farmers should actively participate in training programmes, demonstrations, field days, and extension activities organized by KVKs, agricultural universities, and line departments to enhance their technical knowledge and skills.

(3) Farmers should utilize multiple sources of agricultural information, including extension personnel, progressive farmers, mobile advisories, and digital platforms, for timely and accurate decision-making.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to the Director of Extension Education, Junagadh Agricultural University, Junagadh, for providing guidance and necessary support for conducting this study. The authors are thankful to the staff of Krishi Vigyan Kendra, Targhadia, Rajkot, for their cooperation during the implementation of demonstrations and data collection. Financial and technical support received under the National Food Security Mission (NFSM) for cotton demonstrations is gratefully acknowledged. The authors also extend their heartfelt thanks to the beneficiary and non-beneficiary cotton farmers of Rajkot district for their active participation and valuable cooperation in the study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research paper. All authors have read and approved the final manuscript and agree with its submission for publication. No financial, personal, or professional relationships influenced the conduct or reporting of this study.

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Received : April 2026 : Accepted : June 2026