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Assessment of extension interventions for enhancing cotton productivity through high density planting system among cotton growers in Bhuvanagiri and Jangaon districts of Telangana

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Abstract
Cotton a major fibre and cash crop in the country providing livelihood to the farmers plays a vital role to sustain national economy. The yields in red soils where most of the cotton is cultivated in Telangana are low. To replace this anomaly DAATTC, Bhuvanagiri conducted demonstrations during Kharif from 2022–23 to 2024–25 in different villages of Bhuvanagiri and Jangaon districts. The main objective was to increase productivity and profitability from poor soils by High Density planting system. The average yield recorded was 22.91 q ha^{-1} in demonstration plot, a 33.50% increase over farmer's practice (17.16 q ha^{-1}). The technology gap in the demos was 9.59 q ha^{-1}, extension gap was 5.75 q ha^{-1} with a technology index of 29.49%. The demonstrated plots gave higher gross returns, net return with higher benefit cost ratio when compared to farmer's practice. In present study efforts were also made to study the impact of demonstrations on horizontal spread which increased by 870%. The study also revealed that there was significant increase in knowledge level of the farmers due to the demonstrations. The results revealed that the adoption of the high-yielding variety with a full package of practices significantly increased cotton productivity and reduced both extension and technology gaps.

Keywords: Cotton, technology gap, extension gap, gross returns, net returns

1. Introduction

Cotton (*Gossypium hirustum* L) is the most prominent commercially cultivated fibre crop of India after jute producing natural fibre, fuel and edible oil, playing an important role in Indian economy (Patil 2003; Prasad *et al*., 2018) [23, 25] grown in India under diverse agro climatic conditions, varying from 8°–32° N latitude and 70°–80° E longitude (Ram prasad, 2022) [30]. It is a perennial semi–shrub grown as an annual crop both in tropical and warm temperate regions (Rahman *et al*., 2012; Chakravarthy *et al*., 2012; Sushila *et al*., 2015) [29, 42] for domestic consumption and export needs of 111 countries in the world (Srinivas, 2018) hence called "King of Fibres" or "White Gold". India is the largest producer of cotton in the world accounting for about 22% of the world's production. It is cultivated in an area of 112.94 lakh ha (279.08 lakh acres) in India, with an output of 320.18 lakh bales (170 kg bale^{-1}) and productivity of 443 kg ha^{-1} (lint) against the world average yield of 814 kg ha^{-1}(Anonymous, 2023–24) [2]. The major cotton producing states in our country are Gujarat, Maharashtra, Telangana, Andhra Pradesh, Punjab and Tamil Nadu (Redy *et al*., 2020). Telangana occupies 3rd position among cotton producing states in India with an area of 17.70 lakh ha (43.76 lakh acres), occupying 15.67 per cent of the total area under cotton cultivation in India followed by Maharashtra (36.18%) and Gujarat (20.95%) with a production of 65.87 lakh bales with the productivity of 546 kg ha^{-1} (Anonymous, 2023–24) [2].

In India area under cotton cultivation is more than the world, but productivity is low, major yield–limiting factors for low productivity are attack of insect pests in almost all cotton growing countries (Luttrell *et al*., 1994, Hladik *et al*., 2014) [14, 10], lack of plant population and the use of low potential cultivars (Pradeep *et al*., 2017, Vakudavath, 2018) [24, 43].

The high-density planting system (HDPS) aids farmers in overcoming these obstacles. It is a narrow row spacing system that uses early-maturing semi-compact cotton hybrids. This method restricts the number of bolls per plant but maximizes bolls per unit area, thereby enabling the farmers to achieve high yields (Sam *et al*., 2023) [33]. It is one of the new systems of cultivation of cotton, popularly known as 'Ultra Narrow Row' cotton developed in India by the Central Institute of Cotton Research, Nagpur in 2010. The system is now being conceived as an alternate production system having a potential for improving productivity and profitability, increasing efficiency, reducing input costs and minimizing risks associated with India's cotton production system (Venugopalan, 2019) [44].

Given the growing global population and the increasing demand for food and clothing (Khan *et al*., 2019) [11], the HDPS has emerged as an alternative strategy to conventional methods, proving to be a well-established agronomic technique for enhancing yield, profitability, input use efficiency, and complete mechanization including mechanical harvesting (Venugopalan, 2019) [44]. Promoting plant density is particularly advantageous for cotton yield in low fertility plots (Dong *et al*., 2010; Sankaranarayanan *et al*., 2018) [8, 35]. Optimizing plant population stands out as a cost-effective practice with the potential to significantly boost cotton production. Large scale demonstrations of best practices to enhance the cotton productivity under NFSM were taken up in Bhuvanagiri and Jangaon districts. The main objective is demonstration of proven crop production technologies (Madhushekar *et al*., 2022b) [17] and to introduce suitable agriculture practices on large–scale under real–farming situations (Patel *et al*., 2013, Kushawah *et al*., 2016, Meena and Singh, 2019) [22, 13, 18] in different agro–climatic regions accompanied with organizing extension programmes for horizontal dissemination of technologies (Madhushekar *et al*., 2021, Singh *et al*., 2018) [16]. In view of above facts, present study was initiated to assess the impact of Extension Interventions for Enhancing Cotton Productivity through HDPS among Cotton farmers of Jangaon district in Telangana state.

2. Materials and Methods

Demonstrations conducted in 30 locations under real farming situations were selected from 2022–23 to 2024–25 during Kharif (June–December) in different villages located in different blocks under DAATTC in Bhuvanagiri and Jangaon districts. Demos were conducted along with check plot and they were taken into consideration for the study to find out the impact of extension interventions for enhancing cotton productivity through High Density Planting System. Each demonstration is conducted in an area of 0.4 ha along with farmer's practice or check consisting of 0.4 ha with improved practices for HDPS in red soils or light soils such as 2 kg seed rate, closer spacing of 60 x 20 cm or 80x20cm or 90 x 20 cm, Timely sowing (Sowing after receiving more than 60 mm rainfall), spraying of growth regulator Meqiquat chloride@ 45, 60 and 75 days after sowing based on plant height and growth. The Demos neighbouring plot acted as farmers practice. The differences in the packages were in line with the findings of Singh *et al*., 2007, Shah *et al*., 2019 [36] and Morwal *et al*., 2018 [19].

Data expenditure incurred by the farmer (Farmer's practice) and expenditure of demonstration plots were collected and analyzed. Gross income was calculated based on local market prices of cotton and net income by subtracting the total cost of cultivation from gross income. B:C ratio was computed by dividing gross returns with cost of cultivation in Cotton. To estimate the technology gap, extension gap and technology index the following formula as mentioned below were used as suggested by Samui *et al*. (2000) [34].

$$\%\ \text{Increase in yield} = \frac{\text{Demonstration yield} - \text{farmers yield}}{\text{Farmers yield}} \times 100 \ldots\ldots\ldots\ldots (1)$$

$$\text{Technology Gap} = \text{Pi (Potential Yield)} - \text{Di (Demonstration Yield)} \ldots\ldots\ldots (2)$$

$$\text{Extension Gap} = \text{Di (Demonstration Yield)} - \text{Fi (Farmers yield)} \ldots\ldots\ldots\ldots (3)$$

$$\text{Technology index} = \frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots (4)$$

The data on adoption and horizontal spread of technologies were collected from selected farmers with the help of schedule. Data were subjected to suitable statistical methods. The following formulae were used to assess the impact on different parameters of cotton.

$$\text{Impact of yield} = \frac{\text{Yield of demonstration plot} - \text{Yield of control plot}}{\text{Yield of control plot}} \times 100 \ldots\ldots\ldots (5)$$

$$\text{Impact on adoption (\% change)} = \frac{\text{Number of adopters after demonstration} - \text{Number of adopters before demonstration}}{\text{Numbers of adopters before demonstration}} \times 100 \ldots\ldots\ldots (6)$$

$$\text{Impact on horizontal Spread (\% change)} = \frac{\text{After area (ha)} - \text{Before area (ha)}}{\text{Before area}} \times 100 \ldots\ldots\ldots (7)$$

2.1 Paired t-test

A paired t-test is used to compare two population means where you have two samples in which observations in one sample can be paired with observations in the other sample.

3. Results and Discussion

3.1 Economic parameters

Economic indicators i.e. gross expenditure; gross returns, net returns and BC ratio of Front Line Demonstrations are presented in Table 1. The data clearly envisages that net returns from the demonstration plot were substantially higher than control plot during all the years of demonstration. Average net returns from demonstration plot were ₹65,794.17 ha^{-1} compared to ₹28,586.25 ha^{-1} in control. The average gross expenditure from the demonstration plot was recorded as ₹98,365.83 ha^{-1} compared to ₹94,229.17 ha^{-1} in control. The average gross returns from the demonstration plot were ₹1,64,160.00 ha^{-1} compared to ₹1,22,815.42 ha^{-1} in control plots. The results are in tune with the findings of Rajib *et al.*, 2022, Singh *et al.*, 2018 observed B:C ratio in groundnut and mustard higher in demo plots than in farmer's practice. Hiremath *et al.*, 2007 observed additional net returns because of Demos in onion.

Table 1: Cost economics of Demonstrations on High Density planting system in Cotton

Year	Yield ha^{-1} (kg ha^{-1})		Gross expenditure ha^{-1} (₹)		Gross returns ha^{-1} (₹)		Net Returns (₹)		B:C ratio	
	Demo	Check	Demo	Check	Demo	Check	Demo	Check	Demo	Check
2022–23	2225	1675	96282.5	92062.5	155305.00	116915.00	59022.50	24852.50	1.61	1.26
2023–24	2300	1725	98782.5	94687.5	164450.00	122906.25	65667.50	28218.75	1.67	1.29
2024–25	2350	1750	100032.5	95937.5	172725.00	128625.00	72692.50	32687.50	1.72	1.34
Average	2291.67	1716.67	98365.83	94229.17	164160.00	122815.42	65794.17	28586.25	1.67	1.30
Cotton price during 2022-23@6980/q; 2023-24@7150/q and 2024-25@7350/q										

Economic analysis of the yield performance revealed from Table 1 showed that benefit cost ratio of demonstration plots was observed to be significantly higher than farmer's practice. The benefit cost ratio of recommended and control plots were recorded as 1.61, 1.67 and 1.72 and 1.26, 1.29 and 1.34 during 2022–23, 2023–24 and 2024–25 respectively. The cumulative effect of technological interventions over three years, revealed an average benefit cost ratio of 1.67 in demonstration plots compared to 1.30 in control plots. High BC ratio during 2024–25 is due to high procurement price of cotton. The results are in conformity with the findings of Deka *et al.*, 2021 [6], Dhaka *et al.*, 2010 [7], Madhushekar *et al.*, 2021 [16], Rai *et al.*, 2012 [27] and Puniya *et al.*,2021 [26] in Toria, Maize, Paddy, Sesamum and Mustard.

3.2 Technology gap

The technology gap, the difference between potential yield and yield of demonstration plots was 10.25, 9.50 and 9.00 q ha^{-1} during 2022–23, 2023–24 and 2024–25 respectively (Table 2). On an average, technology gap under the demos was 9.59 q ha^{-1}. The technology gap is very wide and this has to be decreased through various extension interventions in crop, nutrient, pest and disease management. This gap may be due to soil fertility status, nutrient management, weather aberrations, market prices, managerial skills of individual farmer's and climatic conditions of the selected area. Hence, location specific recommendations are necessary to bridge these gaps. These findings are similar to findings of Chaturbhuj *et al.*, (2017) [4], Madhushekar *et al.*, (2022a) [15], Shankar *et al.*, (2022) [37], who expressed wide technology gap in groundnut, Cotton and Brinjal.

3.3 Extension gap

The Demo's conducted in cotton on High Density Planting System gave an extension gap of 5.50, 5.75 and 6.00 q ha^{-1} during 2022–23, 2023–24 and 2024–25 respectively. On an average extension gap under three year programme was 5.75 q ha^{-1}. This emphasized the need to educate the farmers on HDPS along with on INM, IPM, ICM, IDM, use of new ICT tools for the adoption of improved agricultural production technologies to reverse this trend of wide extension gap. More and more use of latest production technologies along with high yielding hybrids will subsequently change this trend. Madhushekar *et al.*, 2022b [17], Shankar *et al.*, 2022 [37], Ray *et al.*, 2019, Morwal *et al.*, 2018 [19] and Shah *et al.*, 2019 [36] observed the same findings of wide extension gap in Groundnut, Brinjal, Rice, Cumin and Pulses.

Table 2: Cotton lint yield, extension gap, technology gap and technology index in demos on HDPS in cotton

Year	Cotton lint yield ha^{-1} (q ha^{-1})		Farmer's practice	(%) increase in productivity	Technology gap (q ha^{-1})	Extension gap (q ha^{-1})	Technology index
	Potential	Demo					
2022–23	32.5	22.25	16.75	32.83	10.25	5.50	31.53
2023–24	32.5	23.00	17.25	33.34	9.50	5.75	29.23
2024–25	32.5	23.50	17.50	34.28	9.00	6.00	27.69
Average	32.5	22.91	17.16	33.50	9.59	5.75	29.49

3.4 Technology Index

The technology index results from Table 2 shows the feasibility of the demonstrated technology at the farmer's field. The technology index varied from 27.69% to 31.53%. On an average, technology index of 29.49% was observed during the three years of the programme, which shows the effectiveness, efficacy and ease of adoption of management practices for control of Pink boll worm in cotton. The results are in unity with the findings of Shankar *et al.*, 2022 [37], Choudhary and Suri 2014 [5], Kumar *et al.*, 2020 and Singh *et al.*, 2024. It was also observed from Table 2 that percent increase in productivity was 32.83, 33.34 and 34.28 during 2022–23, 2023–24 and 2024–25 respectively. The results are in uniformity with the results of Narula *et al.*, 2009 [21], Afzal *et al.*, 2013 [1], Madhushekar *et al.*, 2021 [16], Reddy *et al.*, 2020 [32].

Table 3: Impact on Horizontal spread of HDPS technology in Cotton

Name of the technology	Area (ha)		Change in area	Impact (% change)
	Before demonstration	After demonstration		
HDPS in Cotton	02	19.4	17.4	870.00

In present study, efforts were made to study the impact of HDPS technology Demo's in Cotton and its horizontal spread. It is inferred from Table 3 that Demos organized in the target area helped to increase the area under HDPS in Cotton as the technology was feasible, profitable, easy to adopt, further the yields are low in cotton among non−demo farmers. There was significant increase in area and horizontally spread was observed from 2 to 19.4 ha, the change in area being 17.4 ha and% change observed was 870%. This shows the feasibility of the technology in light soils.

Table 4: Impact on Yield due to HDPS in Cotton

Year	Yield (q ha^{-1})		Change in Yield (q ha^{-1})	Impact (% change)
	Demonstration plot	Control plot		
2022–23	22.25	16.75	5.50	32.83
2023–24	23.00	17.25	5.75	33.34
2024–25	23.50	17.50	6.00	34.28
Average	22.91	17.16	5.75	33.50

It can be noted from Table 4 that yield change noticed due to HDPS Demos in Cotton as 5.50, 5.75 and 6.00 q ha^{-1} during 2022–23, 2023–24 and 2024–25 respectively, the average change in yield was 5.75 q ha$^{-1.}$ The% change in yield observed was 33.50%.

3.5 Increase in knowledge

Knowledge level of respondent farmers on various aspects of High Density planting system interventions in cotton before conducting the demonstrations and after implementation was measured and compared by applying independent 't' test. It could be seen from Table 5 that farmers mean knowledge score on HDPS technology had increased by 42.41 after implementation of demonstrations. The increase in mean knowledge score of farmers observed was significantly higher and the computed value of 't' (5.24) was statistically significant at 5% probability level. The results are at par with Balai *et al*., (2021) [3], Narayanaswamy and Eshwarappa (1998) [20], Singh *et al*., (2007) and Shah *et al*., (2019) [36]. It means there was significant increase in knowledge level of the farmers due to demonstrations on HDPS technology. This shows positive impact of demonstrations on knowledge of the farmers that has resulted in higher adoption of technological interventions. The results so arrived might be due to the concentrated educational efforts in the form of demonstrations, trainings, On−farm trials, method demonstrations and others made by the scientists of DAATTC.

Table 5: Comparison between knowledge levels of the respondent farmers about HDPS technology in cotton

S. no	Mean Score			
	Before implementation	After implementation	Mean difference	Calculated "t" value
1	26.16	68.57	42.41	5.24*
* Significant at 5% probability level				

4. Conclusion

It can be concluded from the results that conducting demonstrations of proven technologies in major crops in the two districts helped to improve productivity potential and profitability. It was also revealed that wide gap existed in potential and demonstration yield in HDPS due to technology and extension gap and this can be reduced by use of proven technologies. This will enhance the income as well as the livelihood of the farming community. There is need to adopt multi-pronged strategy that involves enhancing cotton production and productivity through improved technologies. The impact of Demos was also observed and there was significant increase in area, increase in adoption and increase in knowledge levels of the respondent farmers. The horizontal spread of improved technologies can be facilitated by successfully conducting demonstrations and various extension programmes, such as trainings, field visits, kisan gosthis, and exposure visits organized as part of dissemination and popularization of technology in farmers' fields.

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