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Assessment of Yield and Economics under High Density Planting System in Cotton in Kachchh District of Gujarat, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Cotton (*Gossypium hirsutum* L.) possesses a position of major fiber and cash crop, which plays vital role to sustain national economy. It provides the basic raw material (cotton fiber) to cotton textile industry. Gujarat contributes substantially to the national cotton area (24%) and productions (37%). A field experiment was carried out during the *kharif* seasons from 2017-18 to 2019-20 at

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farmers' fields through ICAR-CAZRI Krishi Vigyan Kendra Kachchh-II to evaluate the impact of frontline demonstrations (FLDs) on cotton productivity and profitability. During the experiment period, a total of 30 FLDs on high density planting system (HDPS) in cotton with the high-yielding variety GTHH-49 were demonstrated in a 12-hectare area across 6 villages in the Bhuj, and Nakhatrana talukas of Kachchh district. The improved variety GTHH-49 with a full package of practices was demonstrated in the plots, while existing technology was treated as the local check. Based on three years of data, the improved practice (IP) resulted in an average seed yield of 2868 kg ha^{-1}, which was an increase of 13.35% compared to the local check yield of 2530 kg ha^{-1}. The demonstrated technology showed an average extension gap, technology gap, and technology index of 338.33 kg ha^{-1}, 631.67 kg ha^{-1}, and 18.05%, respectively. The economic analysis of the demonstrations revealed the viability of the improved technology, with a net return of 101670.3 Rs. ha-1 and a benefit-cost ratio (BCR) of 3.24, compared to 84964.67 Rs. ha-1 and a BCR of 3.02 for local check. A wide range of extension and technology gaps had a detrimental influence on crop output and net returns in general. 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: Analysis; cotton; FLDs; net return; technology index; technology gap; yield.

1. INTRODUCTION

"Cotton (*Gossypium hirsutum* L.) is one of the most important commercial crops cultivated in India and accounts for around 23% of the total global cotton production", Anonymous [1]. "It plays a major role in sustaining the livelihood of an estimated 6 million cotton farmers and 40-50 million people engaged in related activity such as cotton processing & trade. Cotton is an International crop grown by about 80 countries across the world. On an average, cotton is planted in an area of 329.49 lakh hectares. India is at top with 1st rank by contribution of 33.23 % in total area of the world". Anonymous [2] "India is the only country which grows all four species of cotton *Gossypium arboreum* & *Gossypium herbaceum* (Asian cotton), *Gossypium barbadense* (Egyptian cotton) and *Gossypium hirsutum* (American Upland cotton) comprising Andhra Pradesh, Telengana, Karnataka and Tamil Nadu. Gujarat is the largest producer of cotton having 2.60 million ha under cotton cultivation, producing 9.50 million bales and ranks first in production". Anonymous, [1]. "For cotton crop, 21-27 ºC temperature is required for proper vegetative growth. Temperature significantly effects leaf expansion, internodes elongation, dry matter production and partitioning of assimilate to different plant parts" [3]. "Gujarat cotton crop yield is expected to rise by 32.97% and crop is expected to increase by 30.83% even today, it occupies an outstanding position in the textile industry despite pressure of manmade fibers and blended fabrics. Gujarat is one of the leading cotton producing state in the country. Hirsutum represents 90% of the hybrid cotton production in India and all the current Bt cotton hybrids are G. Hirsutuim. In India, there are ten major cotton growing states which are divided into three zones, viz. north zone, central zone and south zone. North zone consists of Punjab, Haryana, and Rajasthan. Central zone includes Madhya Pradesh, Maharashtra and Gujarat. South zone. The high density planting system (HDPS) is a method where planting is done very closely per unit area. 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. A high density planting system (HDPS) leading to more rapid canopy closure and decreased soil water evaporation is becoming popular to address water scarcity challenges". Kumar et al. [4]. Gujarat account for more than 30 per cent of the total cotton production in the country and has more than 30 Lakh hectares under cotton. The presence of black soils and annual rainfall of 80-100 cm, make Gujarat a favorable region for cotton production. Some of the major cotton producing regions of Gujarat are Bharuch, Vadodra, Panchmahal, Mehsana, Ahmedabad, Kachchh and Surendernagar [5].

2. MATERIALS AND METHODS

A field experiment was conducted during the kharif season of 2017 to 2020 at farmer's field of in the adopted villages of Bhuj and Nakhatrana talukas of Kachchh district through ICAR-CAZRI Krishi Vigyan Kachchh-II, Kukma Bhuj to study the yield and economics of high density planting system of cotton. Geographically, this experimental site falls under arid-semi arid, region of Gujarat Plains and Hills Region having soils in the research area were sandy to sandy loam, mostly saline-alkaline, with pH values ranging from 8.5 to 9.2 and EC values from 0.9 to 4.5 dSm-1. The soils were low in available nitrogen, medium in phosphorus, essential micronutrients, and organic carbon, The district lies between the parallels located at latitude 23º24'23.46" N and the Meridians of longitude 69º38'31.58" E on an elevation about 109 meters above mean sea level. A total of six villages were randomly selected for front line demonstrations (FLDs) in the three talukas of Kutch district. Materials and methods adopted for the FLDs are given in Table 1. A total of 30 FLDs were conducted over 12 hectares at different locations, as shown in Table 2.

Before execute the FLDs, basic data on crop production techniques, soil parameters, improved varieties, and the occurrence of insect pests were collected through field PRA surveys and farmer meetings. This data helped determine the current state of cotton production and identify necessary improvements in cultivation practices. Each FLD ranged from 0.4 hectares, and farmers allocated some area for cultivating existing varieties using farmers practices. Improved practices with high-yielding cotton variety GTHH-49 and full of package of practices were demonstrated across 12 hectares.

Table 1. Details of particulars inputs used under improved practice and local check in cotton

S. No.	Operation	Demonstrated improved technology	Farmer’s practice
1.	Variety	GTHH-49 (Agriculture Research Station at Talod, SDAU, Gujarat)	G. Bt. Hy. 6 & 8
2.	Soil & Seed treatment	Seed before one day sowing seed treatment with Thiamethoxam 2.8 g or Imidacloprid 70 FS 7g/kg seed for the control of sucking pests. Seed borne diseases: Delinting with sulphuric acid @100 ml/kg seed	Generally, not practiced
3.	Date of Sowing	onset of monsoon during 15th June to 15th July	Last week of June to 1^{st} week of July
4.	Method of sowing and spacing	Line sowing, 60 x 20 cm	Line sowing 120 x 45 cm
5.	Fertilizer N-P-K-S and Application time	10 tonnes FYM, N-240kg (five equal splits at 30, 60, 75, 90 and 105 DAS) +40kg P^2O^5+40K^2O+S-60kg/ha	5 tonnes N-300kg+P-50kg + K-40kg +S-25kg/ha
6.	Irrigation management	20-25 days interval	10-12 days interval
7.	Weed management	Hand weeding at two hand weeding at 30 & 60 days after sowing (DAS). Weed control by chemical Apply Pendimethalin @ 1 kg a.i./ha as pre-emergence or Fluchloralin @ 1.00 kg a.i./ha pre-emergence, Quizalofop-ethyl @ 0.05 kg a.i./ha at 30 & 60 DAS	Hand weeding at 25-30 days after sowing, Fluchloralin of 1.0 kg a.i. at pre-emergence stage
8.	Plant protection	Installation of pheromone trap @ 5/ha for monitoring bollworms, Install yellow sticky trap @ 20/ha for monitoring white fly, Spotted bollworm, American Bollworm, Pink Bollworm: Cypermethrin 10 EC@ 10 ml or Flubendiamide 480 SC 3ml or Chlorantraniliprole 18.5 SC 3ml /10 liter water, Bacterial blight: Streptomycin sulphate @ 0.005% + copper oxychloride 0.2% spray at appearing the disease.	For Insects: Dimethoate @ 0.05% or Profenophos 35ml/Pump Alternaria leaf spot: Captafol or Mancozeb @ 0.2% spray,

Table 2. Effect of frontline demonstration on yield and percentage increase of cotton

Years	No. of Farmers/ Demos	Area in ha	Potential yield (kg/ha)	Demo (kg/ha)	Local (kg/ha)	% Increase in yield
2017-18	10	4.0	3500	3025	2640	14.58
2018-19	10	4.0	3500	2760	2440	13.11
2019-20	10	4.0	3500	2820	2510	12.35
Average	10	4.0	3500	2868	2530	13.35

Every year sowing of cotton was done between mid-June and the second week of July under rainfed conditions, while picking stared from the last first week of January to February. In India, entire cotton is hand picked through human labour when bolls were started open. As showed in Table 1, farmers received essential inputs such as improved seeds, balanced fertilizer use, and plant protection chemicals. Selected farmers for FLDs were motivated and provided with information on how to properly cultivate cotton using the implemented the package of practices. Conversely, farmers were permitted to carry out their own practises in the farmer's practise. Awareness programs on the importance of improved varieties and new production technologies for cotton were conducted by KVK scientist before the season began at adopted villages.

For comparison, data on various parameters such as seed yield and the percentage of insect-pest and disease incidence were collected separately from both improved practice (IP) and farmer's practice (FP). The data were tabulated and analyzed using statistical tools like frequency and percentage. The extension gap, technology gap and technology index were worked out by Samui et al*.* [6] as given below.

Per cent increase in yield = Yield gain in IP plot (kg/ha) – Yield gain in FP plot (kg/ha) x 100 / Yield gain in FP plot (kg/ha)

Technology gap = Potential yield – Demonstration yield

Extension gap = Demonstration yield – Local check

Technology index (%) = [(Potential yield – Demonstration yield)/Potential yield] x 100

3. RESULTS AND DISCUSSION

3.1 Yield Analysis

The yield of cotton was higher in demonstration plot as compared in local practices during the kharif seasons from 207-18 to 2019-20. According to the data shown in Table 2, better technical intervention led to a 13.35% increase in cotton production, with 2868 kg/ha as compared to the local check yield of 2530 kg/ha recorded with existing practice (local check). Similar observations regarding the gap between improved technologies and farmers' practices were also reported by Dahiya et al. [7] and Singh et al. [8]

The average percent increase in yield of improved practices over the local check was higher at 13.35%. The reasons of low yield of local practices in the adopted villages were the use of local variety seeds and traditional cultivation methods, along with imbalanced use of fertilizers and poor weed management practices. However, KVK scientists used high yielding variety seed and adopted improved package of practices such as timely sowing, proper spacing, balanced fertilizers, timely weed control, and Integrated Disease Management (IDM) and Integrated Pest Management (IPM) measures under FLDs, which enhanced the yield of cotton compared to farmers' practices. Kapadia et al. [9]

3.2 Economics Analysis

The economic analysis of cotton cultivation presented in Table 3 showed the viability of scientific technology over local practice, it is the calculated based on the prevailing cost of inputs and economic prices, and represented in terms of the benefit-cost ratio (B:C Ratio). The three-year average cost of cultivation of cotton was Rs. 41966.67/ha for local practices and Rs. 44416.7/ha for demonstrations. The net returns from the demonstrations were Rs. 101670.3/ha, compared to Rs. 84964.67/ha from farmers' practices. The B:C ratio in the demonstrations was calculated as 3.24, compared to 3.02 in farmers' practices.

The economic analysis indicates that the net returns and B:C ratio were higher in improved practices as compared to local check. The higher

Table 3. Economic comparison between improved practice and farmers practice

Years	Gross Cost (Rs./ha)		Gross Return (Rs./ha)		Net Return (Rs./ha)		BCR	
	IP	FP	IP	FP	IP	FP	IP	FP
2017-18	42000	40000	136125	118800	94125	78800	3.24	2.97
2018-19	45500	42800	150420	132980	104920	90180	3.31	3.11
2019-20	45750	43100	151716	129014	105966	85914	3.17	2.99
Average	44416.7	41966.67	146087.0	126931.3	101670.3	84964.67	3.24	3.02

Table 4. Effect of FLDs on extension gap, technology gap and technology index in cotton

Years	Extension gap kg/ha	Technology gap kg/ha	Technology index %
2017-18	385	475	13.57
2018-19	320	740	21.14
2019-20	310	680	19.43
Average	338.33	631.67	18.05

net returns and B:C ratio in the demonstrations might be due to increased yields and higher market prices because of the better quality of output achieved through the adoption of improved technologies. Similar findings reported by Tetarwal et al. [10] and Patil et al. [11].

3.3 Technological Gap Analysis

The difference between the demonstrated yield and the yield under existing farmers' practices is known as the extension gap. The extension gap indicates increasing trends in each consecutive year of the study (Table 4). The extension gap ranged between 310-385 kg/ha, with an average of 338.33 kg/ha during the experimental period. This emphasizes the need to motivate to farmers through different improved agricultural production technologies to reverse the trend. Similar findings were observed by Singh et al. [12].

The difference between the potential yield of the variety and the yield of demonstration plots is known as the technology gap. The technology gap ranged between 475-740 kg/ha, with an average of 631.67 kg/ha during the experimental period. The wider gaps between farmers' practices and improved practices, with encouraging results in subsequent years, are shown in Table 4. The observed technology gap might be attributed to dissimilarities in poor soil fertility, balanced use of soil nutrients, especially with organic inputs, and the adoption of IPM and IDM practices, as well as climatic conditions such as rainfall and temperature. (Srinivas et al. [13] and Wasnik et al. [14] also opined that depending on the identification and use of farming situation-specific interventions, these may have greater implications in enhancing system productivity.

The results indicated that the cluster front-line demonstrations have positively impacted the farming community in the demonstrated villages, motivating them to adopt improved agricultural practices and realize the gap between these and existing practices in the Kachchh districts. In the case of the technological index, a lower value indicates greater feasibility of the technology. Similar findings were reported by Kumar, et al. [4]

The ratio between the technology gap and potential yield, expressed as a percentage, is known as the technology index. The technology index shows the feasibility of the evolved technology at the farmers' field. A higher technology index reflects insufficient extension services for the transfer of technology. The wide range in the technology index (13.57% to 21.14%) during the study period may be attributed to differences in soil fertility status, weather conditions, non-availability of irrigation water, and insect-pest attacks on the crop. The average technology index was observed to be 18.05% from 2017-18 to 2019-20, as shown in Table 4. Similar findings were reported by Tetarwal at al. [15].

4. CONCLUSIONS

The research findings of the study revealed that wide gap existed in potential and demonstration yield in high yielding cotton varieties due to technology and extension gap in Kachchh District of Gujarat. Through the conducting front line demonstrations of improved high density planting system technologies, yield potential of cotton can be increased to a great extended. This will enhence the income as well as the livelihood of the farming community. There is need to adopt multi-pronged strategy that involves enhancing cotton production through improved technologies in Kachchh district of Gujarat. Horizontal distribution of improved technologies may be achieved by the proper execution of front-line demonstration. This yield gaps and promoting the adoption of improved practices, FLDs can contribute significantly to the agricultural development and economic stability of farmers in the region. The horizontal spread of improved technologies can be facilitated by successfully conducting frontline demonstrations and various extension programme, such as training programs, field visits, kisan gosthis, and exposure visits organized as part of FLDs programs in farmers' fields.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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