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Land mark initiative to enhance the cotton productivity in Bhavnagar district

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Abstract
The field trial entitled "To enhance the cotton productivity in Bhavnagar district" during 2022-23 was conducted at field of Center of Agri-horticulture development (CAHD), Manar, different cluster of Triveni Kalyan Foundation (TKF) & Gram Nirman Samaj (GNS) field during monsoon season 2022-23 which all are financially managed by Pidilite industries Ltd (PIL). The pathbreaking results revealed that highest production of cotton (1267 kg/acre) per unit area is obtained in PIL – CSR field with increase cotton productivity of 134.60% in comparison with national average (540 kg/acre), 77.68% from Gujarat state average (713 kg/acre) and 50.81% from Mahuva taluka (840 kg/acre) average. Major interventions implemented were high density planting at a distance of 4 x 1 feet and 3 x 1 feet, use of mulching materials, Drip irrigation, Pheromone trap installation, detopping and standard package of practices (PoP) for cotton.

Keywords: Cotton, productivity, drip irrigation, mulching, intercropping, high density planting

1. Introduction
Cotton (*Gossypium* sp.) is one of the most important fibre and cash crop in India belongs to *Malvaceae* family and known as *"King of Fiber"* and *"White gold"* plays a prominent role in the rural, national and international economy. It is grown mostly for fibre used in the manufacture of cloths for mankind. In recent years, cotton apparels are being preferred to the synthetic ones due to the increasing the health consciousness among the people. Besides fibre, cotton is also valued for its oil (15 - 20%) which are used as vegetable oil and soap industries and cotton seed cake is very protein rich used as cattle feed and as manure which contain 6.4, 2.9 and 2.2 percent N, P and K, respectively. India is a major producer of cotton. India stands first position in area and third in its production. In India it is grown over an area of 122.38 lakh hectares with production of 361.00 lakh bales and productivity of 501 kg/ha (Anon., 2018) [1]. Cotton is grown chiefly for its fibers, which are used in manufacturing of cloth for the mankind. It is also used for several other purposes like making threads, for mixing in other fibers and for extraction of oil from cottonseed. The oil content in the cottonseed ranges from 15-25% depending on the varieties. Cotton seed cake after extraction of oil is good organic manure and contains about 6% N, 3% P_2O_5 and 2% K_2O. Cottonseed and cotton meal are good concentrated feed for cattle. It is also considered as a "cash crop" since past…
Last year (2021-22) we studied the trend for decrease in yield of cotton crop in India and developed a strategy after discussion with various experts on how to address the same. We decided to develop 7 demo plots in each cluster of CAHD, TKF & GNS and show farmers that by following scientific recommendations the yield can be increased by manifold. For the years 21-22 our target was to achieve an increase in yield by 50% whereas we have achieved yield by 134.60%. The national average for cotton production is 540 Kgs, whereas we have achieved on an average 1267 Kgs (Cluster wise progress attached as Table 3).
In the Current Intervention, we recommended farmers to adopt Drip irrigation, Intercropping, Mulching, High Density Plantation System (HDPS), Pheromone trap installation Package of Practices as per Agriculture Universities, Fertigation through water soluble fertilizer for nutrient management, Low Cost technology for integrated pest and disease management (IPDM), Detopping and others our farmers through which they achieved an average 134.60% yield increase.

For this research work both at our large center and farmers field the entire financial supports was provided by Hon. Chairmen of Pidilite industries Ltd.

2. Materials and Methods

2.1 Drip irrigation

Drip irrigation or trickle irrigation is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. The goal is to place water directly into the root zone and minimize evaporation. Drip irrigation systems distribute water through a network of valves, pipes, tubing, and emitters. Depending on how well designed, installed, maintained, and operated it is, a drip irrigation system can be more efficient than other types of irrigation systems, such as surface irrigation or sprinkler irrigation.

Fig 1: General view of the cotton field

2.2 Intercropping

Intensification of cotton based cropping system with intercrops was successful as a component in the system have different nutrient and moisture requirement, varied feeding zones in the soil profile, differential growth duration for enabling the utilization of natural resources optimally (Sankaranarayanan *et al.*, 2012) [7]. Intercropping has been recognized as potentially beneficial and economic system of crop production. Similarly intercropping is one of the ways to increase the cropping intensity and resource utilization (Harisudan *et al*., 2008) [3]. Usually a yield advance occurs as component crop differ in their use of resources when they are grown in combination, they are able to component each other and make better use of resources. Due to slow growing nature of cotton much of the vacant interspaces remains utilized during initial stages of the crop growth. This situation offers ample scope for raising intercrops (Nehra *et al.*, 1990) [5]. Intercropping provides the insurance against the inclement weather situation and consequent crops (Balasubramanian, 1987) [2] observed increase in productivity with higher market value and enhanced profitability, when pulses were intercropped with cotton. Intercropping of legumes is an important aspect for biological farming system not only for weed control, but also in reducing the leaching of nutrients, pest control and in reducing soil erosion (Prabukumar and Uthayakumar, 2006) [6].

Fig 2: Drip irrigation and intercropping of legumes in cotton

2.3 Mulching

A mulch is a layer of material applied to the surface of soil. Reasons for applying mulch include conservation of soil moisture, improving fertility and health of the soil, reducing weed growth and enhancing the visual appeal of the area.

A mulch is usually, but not exclusively, organic in nature. It may be permanent (e.g. plastic sheeting) or temporary (e.g. bark chips). It may be applied to bare soil or around existing plants. Mulches of manure or compost will be incorporated naturally into the soil by the activity of worms and other organisms. The process is used both in commercial crop production and in gardening, and when applied correctly, can improve soil productivity.

2.4 Detopping

Cotton detopping is a manual or mechanical operation that consists of cutting off the top of the plant, *i.e.* the terminal bud of the main stem, which reduces the height of the plant to prevent apical dominance and further vegetative growth of side branches. So increase the number and size of balls per plant of cotton ultimately increase the yield per unit area.

2.5 High density planting

High density planting system (HDPS) is gaining popularity in India to increase cotton yield, particularly in rainfed areas with poor productive soils. In HDPS technology short-duration, semi-compact cotton types are planted at populations ranging from 1.1 lakh to 2.45 lakh plants per hectare, with a distance of 45-90 cm between rows and 10 cm between plants in a row, depending on soil type and growing circumstances (Venugopalan, 2019) [8]. This technology targets establishing 7-8 plants per meter of row length. The goal is to keep the number of bolls per plant to 6-8 and maximize the number of bolls per unit area to achieve a high yield in a comparatively short period. When there are few bolls per plant, the fruiting window (or blooming period) is brief (4-5 weeks) and the plant matures early and yields high-quality fibers (Venugopalan, 2019) [8]. HDPS technology results in rapid canopy closure and reduced soil water evaporation, as well as early maturity in soils that do not support excessive vegetative growth (Jost & Cothern, 2001) [4].

Fig 3: High density planting and Detopping in cotton

2.6 Pheromone trap installation

Pheromone traps are useful tools for monitoring moths. It is an important and major pest of Cotton. Pheromone Traps and Lures 5 No's per acre from 30 day crop stage for effective control of Pink boll worm It is cheaper, simpler, easy to use and maintain.

Fig 4: Pheromone trap installation in cotton

2.7 SPNF (Subhash Palekar Natural Farming) Trial

SPNF or holistic agriculture reduces the commercial input expenditure required for the growth of crop and to supplement the root zone. To eliminate the input cost of fertilizers, pesticides and seeds. To activate already existing nutrients in the soil such as phosphate, potash, zinc and calcium available in absorbable form by the plants. 90 to 98.5% nutrients are taken from air, water & solar energy. Remaining 1.5% nutrients taken from the soil are also available free of cost as it is taken from the soil which is enriched with these nutrients. Farming with dripping minimizes electricity and water consumption. Producing quality, poison & toxin free food. Introduction of multi-crop cultivation for higher net income. Enhance productivity and soil fertility in barren land through SPNF.

Small models which farmers can adopt in their own farms as lowcost technology includes one cow Bio gas model, vermiwash unit, vermi-compost unit, Azola unit has been established at CAHD, Manar.

Table 1: Cost of cultivation of cotton

Sr. No.	Cost of input	Cost of cultivation (Rs.) per Acre
1	Land preparation/Primary tillage	7000
2	Seed material	2420
3	Sowing cost	1000
4	FYM/Fertilizer Cost	10000
5	Intercultural/Weeding/Irrigation	11000
6	Plant Protection	4200
7	Mulching material*	22000
8	Harvesting cost	12000
9	Total Cost	69,620

Note*: Mulching material is used only in Devaliya cluster demo.

3. Result and Discussion

Table 2: Country-wise production data (2020)

Sr. No.	Country/ State/District	Production (kg/Acre)	India's yield in comparison to various countries mean [Higher (+) or lower (-)]	PIL Demo's mean yield in comparison to various countries mean [Higher (+) or lower (-)]
1	Australia	2608.24	-2068.24	-1341.24
2	China	2369.41	-1829.41	-1102.41
3	Brazil	2023.53	-1483.53	-756.53
4	PIL-CSR (2022-23)	1267	-727	---
5	United States	1125.88	-585.88	+141.12
6	Gujarat State	636.47	-96.47	+630.53
7	Bhavnagar	653.52	-113.52	+613.48
8	India	540	---	+727
9	Pakistan	523.53	+16.47	+743.47

The perusal of data presented in the Table 2 revealed that the mean yield of our country (540 kg/acre) is much lower than that of Australia (-2068.24 kg/acre), china (-1829.41 kg/acre); Brazil (-1483.53 kg/acre), USA (-585.88 kg/acre) and Pakistan (+16.47 kg/acre). The mean yield of Gujarat state (636.47 kg/acre) is also little bit higher than our national average. Our PIL-CSR demo plots production (1267 kg/acre) has also surpassed yield of USA (+141.12 kg/acre), India (+727 kg/acre) and Pakistan (+743.47 kg/acre).

Table 3: Cotton yield of demo plot in different clusters operating under Pidilite CSR (2022-23)

Sr. No	Cluster	Demo (Kg/Acre)	National Average	% Increase from national average	Gujarat Average	% Increase from Gujarat average	Mahuva avg. as per last year production	% Increase from Mahuva Average
1	Kalsar	1098	540	103.33	713	54	840	30.71
2	Otha	1176	540	117.78	713	64.94	840	40
3	Bagdana	1120	540	107.41	713	57.08	840	33.33
4	Khadasali	1040	540	92.59	713	45.86	840	23.81
5	Devaliya	2054	540	280.37	713	188.08	840	144.52
6	Mota Khutvada	980	540	81.48	713	37.45	840	16.67
7	CAHD, Manar	1400	540	159.25	713	96.35	840	66.66
	Average	1267	540	134.60	713	77.68	840	50.81

The results showed that the yield of cotton varied drastically among different clusters (Table 3). Cotton yield was the highest (2054 kg/acre) in field demo conducted on farmers field in Devaliya cluster (Umaniyavadar), whereas, it was lowest in Mota Khuntavada cluster (980 kg/acre). In CAHD, Manar (1400 kg/acre), Otha cluster (1176 kg/acre), Bagdana cluster (1120 kg/acre), Kalsar cluster (1098 kg/acre) and Khadasali cluster (1040 kg/acre). The average mean of cotton yield is achieved 1267 kg/acre from different 7 cluster demo plot of PIL-CSR. We increase cotton productivity 134.60% from national average, 77.68% from Gujarat state average and 50.81% from Mahuva average.

Table 4: Net profit of cotton (per acre) in different cluster of PIL-CSR year 2022-23

Sr. No	Cluster	No. of farmers covered	Yield (kg/acre)	Cost of cultivation per acre	Rate per 20 kg	Gross income	Net income
1	Kalsar	1	1098	50,116	1850	1,01,565	51,449
2	Otha	1	1176	43,493	1850	1,08,780	65,287
3	Bagdana	1	1120	34,897	1850	1,03,600	68,703
4	Khadasali	1	1040	44,346	1850	96,200	51,854
5	Devaliya	1	2054	68,740	1750	1,79,725	1,10,985
6	Mota Khutvada	1	980	49,045	1730	84,770	35,725
7	CAHD, Manar	At center demo	1400	42,700	1428	99,960	57,260
	Mean		1267	47,620	1758	1,10,657	63,038

We taken an implemented one-acre demo with one farmer in each cluster and one acre at PIL-CAHD, Manar center for this initiative. The entire cost of cultivation was financially supported by Pidilite Industries ltd. We recorded an average production of cotton per acre as 1267 kg/acre from our 7 demo of PIL-CSR. An Average net profit of cotton per acre was recorded as Rs. 63,038. Net income in all cluster varied because of cost of cultivation, yield and rate per 20 kg in APMC. Devaliya cluster cost of production was higher due to implementation of mulching materials, standard POP and thereby recorded increased yield is higher per unit area as compare to other cluster.

Table 5: Average production of India, Gujarat, Bhavnagar, Mahuva and PIL – CSR

Sr. No.	Region	Production (Kg/acre)
1	India	540
2	Gujarat	636.47
3	Bhavnagar	653.52
4	Mahuva	840
5	PIL - CSR	1267

The data presented in table 5 revealed that the average production of cotton per acre is 540 kg/acre (India), 636.47 kg/acre (Gujarat), 653.52 kg/acre (Bhavnagar), 840 kg/acre (Mahuva) and obtained 1267 kg/acre in PIL-CSR. Graphically data presented cotton production (Kg/acre) in figure 5.

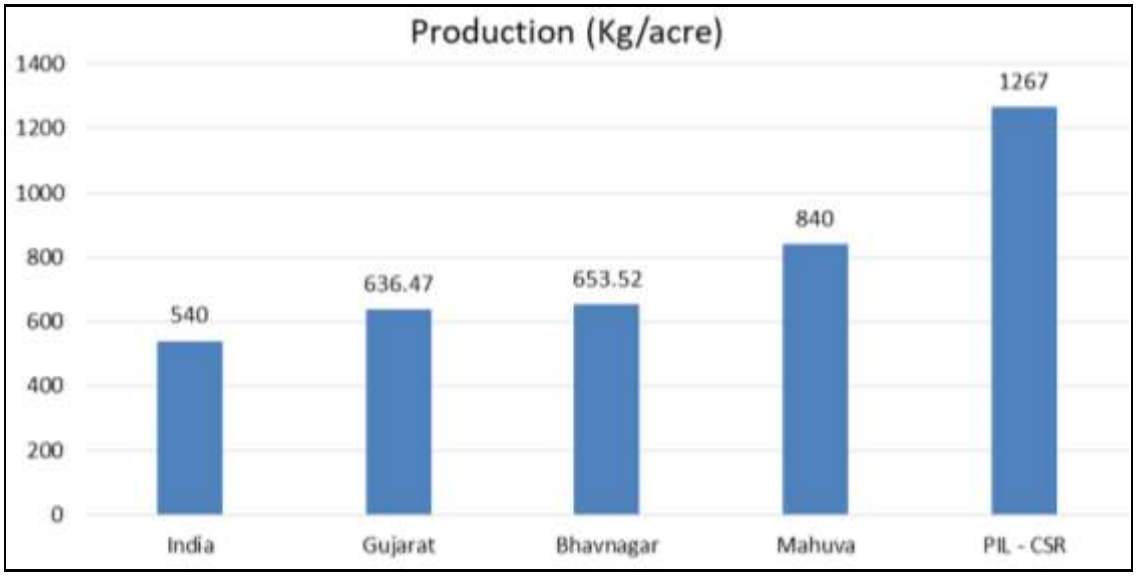

Fig 5: Graphically data presented cotton production (Kg/acre)

4. Conclusion

The results revealed that higher cotton yield of 1267 kg/acre was achieved which is higher than the mean yield of Bhavnagar District, Gujarat State, Country national average & our neighboring Asian country- Pakistan (+743.47 kg/acre) and United states (+141.12 kg/acre). It can be inferred that to achieve higher cotton yield a spacing of 4 X 1 feet or 3 X 1 feet should be followed because higher plant population plays key role in increasing cotton yield per unit area. Timely installation of Pheromone traps (5 no./acre- at square formation stage) and preventive spraying of insecticides immediately when pink bollworm moths are found in these traps to protect the first flush of flowers/bolls which count for 30% of total yield. Drip irrigation, Intercropping, Mulching, High density planting, SPNF system and Detopping at 70-75 days after sowing boost at least 250 to 350 kg cotton yield/acre.

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6. Abbreviation

- **PIL-CSR:** Pidilite Industries Pvt Ltd – Corporate Social Responsibility.
- **CAHD:** Center for Agriculture-Horticulture Development - Financially supported by Pidilite industries Ltd.
- **TKF:** Triveni Kalyan Foundation - Financially supported by Pidilite industries Ltd.
- **GNS:** Gram Nirman Samaj - Financially supported by Pidilite industries Ltd.
- **PoP:** Package of Practices
- **HDPS:** High Density Planting System
- **IPDM:** Integrated Pest and Disease Management

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