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Assessing the Impact of Natural Farming Practices on Quality Parameters of Cotton (*Gossypium hirsutum*)

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ABSTRACT

Background: Cotton, a popular fiber crop, is in high demand for textiles due to its natural properties. It plays a vital role in biological cycles and sustainable yield. A field experiment to compare natural, organic farming and integrated crop management to assess cotton fiber qualities was conducted in Tamil Nadu Agricultural University, Coimbatore, for two years (2021-22 and 2022-23) in Cotton cv. CO 17.

Methods: The experiment had nine treatments, arranged in a Randomized Block Design and replicated thrice. A complete Zero Budget Natural Farming Practices were used, including *Ghanajeevamirit* as Basal, seed treatment with *Beejamirit*, *Jeevamirit* applied twice a month through irrigation, intercropping, mulching and Whapasa (Alternate Furrow irrigation). Organic and Integrated plots were also included.

Result: The use of *beejamirit, jeevamirit* and *ghanajeevamirit* in natural farming led to substantial seed cotton yield of 1287 kg ha^{-1} in 2021-22 and 1364 kg ha^{-1} in 2022-23, comparable to organic plots of 1695 kg ha^{-1} in 2021-22 and 1768 kg ha^{-1} in 2022-23, while improving soil health, biodiversity and pest management. Quality characteristics did not significantly differ among the different farming practices.

Key words: Natural farming, Organic cotton, Quality parameters.

INTRODUCTION

Cotton plays a vital role in agriculture and the textile industry and secures livelihoods of over 250 million people. In India, cotton cultivation occupies the largest area globally, accounting for 25% of cotton area (Muthukrishnan *et al.*, 2017). During 2022-23, India's cotton production spanned about 130.49 lakh ha, yielding 337 lakh bales with a productivity of 439 kg ha^{-1} (Indiastat, 2023). Though the adoption of synthetic agrochemicals and high-yielding varieties during the green revolution increased cotton production but resulted in soil degradation, reduced water systems and fertility decline in traditionally cotton-growing regions (Kumar *et al.*, 2022). As people become more aware of the dangers of pesticides and hazardous chemicals, there is a rising demand for organic products. Green manures and organic additions should be used to promote long-term soil health. India takes the lead in organic cotton cultivation, emphasizing diverse and sustainable ecosystems. Key practices include the use of organic manures, *Beejamirit, Ghanajeevamirit, Jeevamirit*, vermicompost, intercropping with green manures, crop rotation, bio-fertilizers, bio-pesticides and botanicals. Global organic cotton production in 2015-16 reached 1.08 lakh tonnes, with India, China, Kyrgyzstan, Turkey and the United States as the top five producers, yielding 60184, 14187, 7981, 7577 and 4524 tonnes respectively (Mageshwaran *et al.*, 2019).

Since 2016, the US, India and Brazil dominated global cotton production and exports, with respective exports of 3.8, 1 and 2.1 Mt in 2020. Conversely, China, Vietnam and Bangladesh were top importers, with imports of around 2.2, 1.4 and 1.2 Mt in the same year. Europe and the US anticipate a post-COVID sustainable clothing surge, while India witnesses growing demand for eco-friendly cotton. The projected worldwide cotton production aims for 13 Mt by 2025. In 2020, 11% of the textile industry incorporated certified organic cotton, with leading firms using 0.84 Mt of cotton lint. About 85% (0.72 Mt) of total cotton consumed was sustainably sourced, influenced by the rising trend of sustainable cotton sourcing (Voora *et al.*, 2020). Scientists

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globally study cotton to develop high-yield, quality varieties for the textile industry. In this article, organic, natural and integrated agricultural practices are examined in relation to the important fiber quality metrics of length, strength, fineness, uniformity ratio and micronaire value.

MATERIALS AND METHODS

The field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore (11°N latitude, 77°E longitude, 426.7 m altitude) in sandy clay loam soil. Initial soil analysis showed low available nitrogen (213 kg ha^{-1}), medium available phosphorus (16 kg ha^{-1}) and high available potassium (886 kg ha^{-1}). Cotton variety CO 17 was chosen and its quality was evaluated for two years (2021-22 and 2022-23). The experiment was set up in a randomized complete block design with 9 treatments and 3 replications. The treatments are as follows.

Treatment details

T_1: Control (No input addition except manual weeding).

T_2: Complete natural farming (NF) practices (*Bijamirit* + *Ghanajeevamirth* + *Jeevamirth* + mulching + Intercropping + Whapasa)

T_3: Natural farming practices 1 (without *Bijamirt* + *Ghana jeevamirth* + *Jeevamirth*)

T_4: Natural farming practices 2 (without crop residue mulching)

T_5: Natural farming 3 (without intercropping)

T_6: Natural farming 4 (without whapasa)

T_7: Organic farming (OF) practices (5 t ha^{-1} FYM + 2.5 t ha^{-1} Vermicompost)

T_8: Integrated crop management (ICM) (50 % organic + 50 % inorganic with bio-pesticide)

T_9: Integrated crop management (ICM) (50 % organic + 50 % inorganic with chemical pesticide).

The treatments T_8 and T_9 were maintained separately, adjacent to the Organic and Natural farming area, with a plot size of 12 m × 8.4 m. Table 1 displays the nutrient content and applied quantity of manures.

Crop cultivation practices

Natural farming

According to Palekar (2006), cow-based organic formulations (*Beejamirit*, *Ghanjeevamrit* and *Jeevamirit*) were used in Natural farming plots. *Ghanjeevamrit* was incorporated before sowing at a rate of 250 kg ha^{-1}. *Jeevamrit* was applied twice a month at a rate of 500 l ha^{-1} through irrigation water. *Beejamirit* was used for seed treatment. Green gram (cv. DGGV 2) intercrop sown between cotton rows. No weeding in natural farming plots. Mulching @ 5 t ha^{-1} with millet straw was done immediately after sowing. Alternate row and furrow irrigation (Whapasa) method was adopted. Ecological engineering method used for plant protection, including cowpea as border/trap crop and Organic pesticide (3 G) applied as a foliar spray.

Organic farming and integrated crop management

Seeds treated with *Trichoderma viride* (5 g kg^{-1}) and *Bacillus subtilis* (5 g kg^{-1}). Cotton seeds were dibbled with specific spacing (60 × 15 cm) and seed rate (15 kg ha^{-1}). Pre-emergence herbicide of pendimethalin @ 1.0 kg ha^{-1} was applied in an integrated plot followed by hand weeding @ 40 DAS. Manual weeding was done twice on 20 and 40 DAS was performed as per treatments. Irrigation was given at intervals with a withholding period. Cowpea was used as a trap crop for T_7 and T_8. Pest repellent (3G extract spray) was used for T_8. Yellow sticky traps, Pheromone traps (12 No's ha^{-1}) and neem oil (3%) was sprayed to control pests and TNAU Panchagavya (3%) spray was used for growth promotion in organic farming plots. Seed cotton yield was determined by weighing mature *kapas* collected plot-wise. All these practices were followed for two years.

Data collection and fiber quality analysis

Kapas sample were collected from each plot, weighing 100 seed cotton. Laboratory gin was used to separate seeds and lint. Seed yield and lint yield were determined. According to Santhanam (1976), Ginning percentage was calculated.

$$\text{Ginning percentage} = \frac{\text{Weight of the lint}}{\text{Weight of the seed cotton}} \times 100$$

The cotton fiber analyzer available at the Department of Cotton, TNAU, Coimbatore was used for cotton quality analysis and a 100 g fiber sample was enough to generate reports on various quality parameters. A single operator can finish testing in a matter of seconds. The data were statistically analyzed using R Software (Gopinath *et al.*, 2021) with the grapesAgri1 package, Version 1.0.0.

RESULTS AND DISCUSSION

The data collected from the two years of research on assessing the impact of natural farming practices on quality parameters of cotton were presented and discussed on aspects like cotton yield and quality parameters.

Yield

Natural farming practices significantly affected seed cotton yield (Fig 1a and 1b). Integrated Crop management (T_8) practice showed the highest yields of 2178 and 2232 kg ha^{-1} in 2021-22 and 2022-23, respectively. These treatments outperformed effects of organic and natural farming inputs like *jeevamirit, beejamirit* and *ghanajeevamirit*. Organic farming practices achieved yields of 1695 and 1768 kg ha^{-1} in 2021-22 and 2022-23, respectively, next to ICM practices. Complete natural farming (T_2) consistently achieved the highest seed cotton yield in both years. The trend was also observed in seed yield and lint yield, as shown in Table 2. Previous studies (Sahito *et al.*, 2016; Yaqoob *et al.*, 2016) indicated that a strong positive correlation between lint yield and fiber fineness and Velmurugan *et al.* (2022) found that Panchagavya, *Trichoderma viride* and water (control) treatments influenced SVPR 2 cotton seed yield and quality and improved lint quality. As regards ICM, it combines inorganic fertilizer and organic manures to enhance yield and synchronizes crop nutrient demand with soil nutrient release, minimizing losses through leaching, runoff, volatilization and immobilization (Tarfeen *et al.*, 2023) while lower yields in recommended dose nutrient application with organic manure compared to ICM and OF due to slow nutrient release was reported by (Mishra and Chaturvedi, 2023). The yield gap between chemical fertilizers, organic manures and natural farming practices decreased from the second year onwards which may be attributed to gradual nutrient release from organic manures, as seed cotton yield was strongly correlated with lint yield, while lint yield showed a strong positive correlation with lint percentage (Desalegn *et al.*, 2009).

Quality characters

Fiber quality is crucial to technology acceptance. Considering all parameters is essential to ensure fiber quality as it affects prices apart from Productivity. However, farming practices showed no significant variations in fibre qualities of cotton (Table 2 and 4).

Ginning percentage

Natural farming methods did not significantly differ in the ginning percentage, according to the experiments (Table 2). Bharathi *et al.* (2018) and Muthukrishnan *et al.* (2017) made comparable observations, finding that the ginning percentage values were marginally higher with fertilizer management approaches than the no manure treatment in both years. According to earlier studies (Monicaa *et al.*, 2020; Tariq *et al.*, 2018), fertilizer amounts did not affect the proportion of cotton that was ginned.

Upper half mean length

The UHML is a crucial quality parameter in cotton fiber that determines the spinning value. Cotton fiber development occurs in four phases: initiation, elongation, secondary deposition and maturation. There was no significant difference in UHML among different farming practices (Fig 2). The UHML values ranged from 25.50 to 28.89 mm for 2021-22 and 23.6 to 26.9 mm for 2022-23 (Table 4). Barotova *et al.* (2023), UHML had classified 9 types (1a, 1b, 1, 2, 3, 4, 5, 6, 7) as depicted in Table 3. The CO 17 variety falls under types 4 to 7, indicating it is a medium staple length and it was confirmed by Gunasekaran *et al.* (2020) with recorded values of 26.9 and 27.6 g/tex. Different fertilizer levels had no impact on fiber quality, consistent with findings by Bharathi *et al.* (2018); Tariq *et al.* (2018). Sankaranarayanan *et al.* (2018) observed that varying fertilizer levels and planting systems did not significantly affect fiber length. Since quality parameters are primarily determined by genetics and minimally influenced by management practices, there were no significant differences, as supported by Gacche and Gokhale (2018); Xu *et al.* (2023).

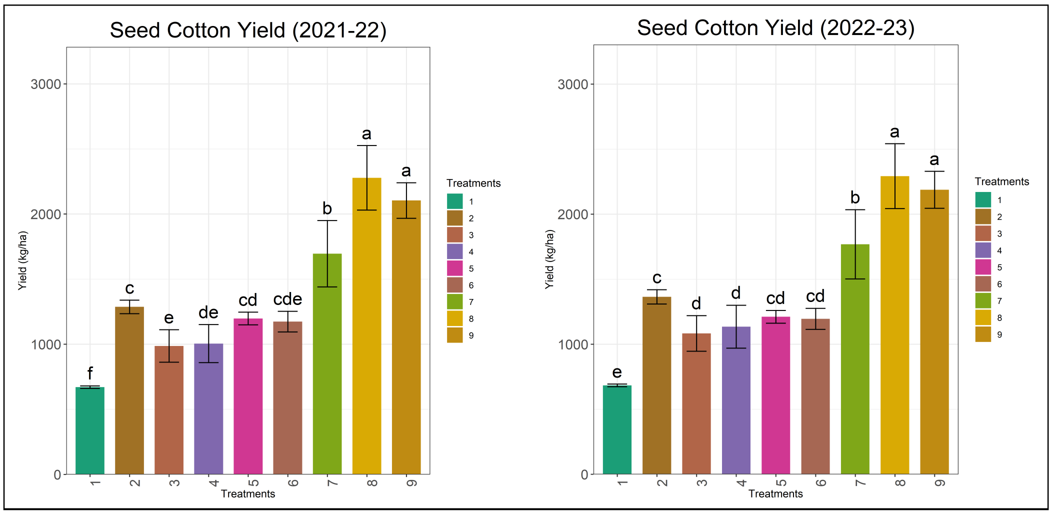

Fig 1a and 1b: Effect of natural farming practices on seed cotton yield (kg ha^{-1}) of Cotton during 2021-22 and 2022-23.

Table 1: Nutrient content and the quantity of manures applied in both years.

Manure	Nutrient concentration (%)			Quantity applied	Nutrients applied in kg/ha		
	N	P	K		N	P	K
Ghanajeevamirit	1.5	0.32	0.21	250 kg ha^{-1}	3.75	0.8	0.53
Beejamirit	2.1	0.26	0.34	1 kg^{-1} of seeds	0.32	0.04	0.05
Jeevamirit	1.7	0.28	0.88	500 l ha^{-1}	51	8.4	26.4
FYM	0.43	0.21	0.41	12.5 t ha^{-1}	53.75	26.25	51.25
Vermicompost	2.4	0.63	0.96	2.5 t ha^{-1}	60	15.75	24

Fiber strength (Str)

Fiber strength plays a crucial role in determining the durability and resilience of cotton textiles during processing. It remained unaffected by organic, natural and integrated farming practices in both years (Fig 2). The values ranged from 22.1 to 27.1 g/tex for 2021-22 and 23.0 to 29.5 g/tex for 2022-23, as shown in Table 4. Similar findings were reported by Gunasekaran *et al.* (2020); Velmurugan *et al.* (2022). Fiber strength was not influenced by different nutrient doses, as supported by Bharathi *et al.* (2018); Tariq *et al.* (2018) ; Gacche and Gokhale (2018); Sankaranarayanan *et al.* (2018). Strong cotton fibers yield robust yarns and fabrics, enhancing spinning efficiency. Longer and finer fibers generally result in stronger yarns, whereas shorter and coarser fibers are weaker and prone to breakage. Hence, cotton fibers with higher strength are deemed superior in quality and preferred for textile manufacturing (Desalegn *et al.*, 2009).

Uniformity index (Unf)

Uniformity Index is vital for assessing cotton fiber quality as it indicates the consistency of fiber length within a sample. Length uniformity directly influences spinning efficiency, yarn uniformity and yarn strength, reflecting the level of consistency within a sample (Desalegn *et al.*, 2009). However, in this study, there were no significant differences observed in the Uniformity Index among the treatments for both years (Table 4). A higher uniformity index ensures consistency in yarns and fabrics during textile production. Varying nutrient doses did not impact the quality parameter of uniformity ratio, which is consistent with findings reported by Bharathi *et al.* (2018); Sankaranarayanan *et al.* (2018); Tariq *et al.* (2018).

Fiber elongation (Elg)

Factors like fiber maturity, fineness and moisture content play a role in cotton fiber elongation, but it was not influenced by different management practices. The values for elongation remained consistent between 5.5% and 6.1% in both years (Table 4). Higher fiber maturity typically leads to lower elongation, while finer fibers exhibit higher elongation. Moisture content also affects elongation, with dry fibers having lower elongation compared to moist fibers. Hulihalli and Patil (2008) found that different fertilizer levels did not significantly affect fiber elongation.

Fiber fineness

Fiber fineness refers to the diameter of cotton fibers, which is crucial for determining appearance, strength and

Table 2: Influence of different farming practices on kapas yield, lint yield, seed yield and ginning percentage.

Treatment	Ginning percentage		Lint yield (kg ha^{-1})		Seed yield (kg ha^{-1})	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1- Control	37.66	38.06	253	261	418	426
T_2- Complete Natural Farming	36.90	36.80	475	502	817	865
T_3- NF (except GA, BA, JA)	37.00	36.10	365	391	625	686
T_4- NF (except mulching)	36.30	37.45	365	425	640	723
T_5- NF (except Intercropping)	36.90	37.27	438	447	750	758
T_6- NF 4 (without whapasa)	36.79	36.97	445	455	762	776
T_7- NPOF	35.65	36.48	604	645	1094	1141
T_8- ICM (organic pest management)	37.05	37.56	844	861	1435	1444
T_9- ICM (chemical pest management)	37.34	37.34	786	817	1319	1371
SEd	2.18	2.21	35	37	61	64
CD (p=0.05)	NS	NS	76	80	132	137

Table 3 Classification of cotton fiber based on its length.

Type	UHML (mm)	Str (df/tex)	Staple length
1a	33.7-34.3	30.0-35.0	Long staple fiber
1b	32.9-33.6		
1	32.2-32.8		
2	31.4-32.1		
3	29.9-31.3		
4	28.1-29.8	24.5-28.4	Middle staple fiber
5	26.6-28.0		
6	25.8-26.5		
7	25.1-25.7		

*UHML- Upper half mean length.

*Str- Fiber strength.

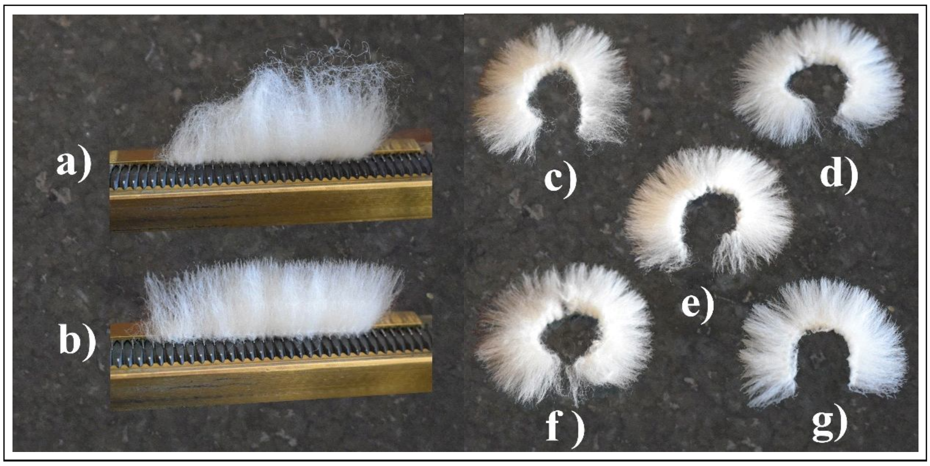

Fig 2: Image (a) depicts the measurement of cotton fiber length and strength before its insertion into the High-Volume Instrument, while image (b) presents the Uniform Transformation of Uneven Cotton fiber after Analysing in High Volume Instrument (HVI), results of the analysis after testing had been generated. Image (c to g): Comparison of Cotton Fiber Strength and Length Analysis After High Volume Instrument Test, c- control, d-Complete Natural farming, e- NPOF, f and g- Integrated crop management.

Table 4: Influence of different farming practices on upper half mean length (UHML), fiber strength (Str), uniformity index, fiber elongation, fiber fineness and micronaire.

Treatment	UHML (mm)		Str (g/tex)		Uniformity index (%)		Fiber elongation (%)		Fiber fineness (d/tex)		Micronaire (µg/inch)	
	2021-22	2022-23	2021-22	2021-22	2022-23	2021-22	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1	25.50	24.70	25.40	5.80	5.90	153.00	5.80	5.90	153.00	122.00	4.67	4.66
T_2	25.50	26.90	22.30	5.50	6.10	172.00	5.50	6.10	172.00	116.00	5.16	4.69
T_3	28.00	26.90	27.30	6.00	5.90	175.00	6.00	5.90	175.00	115.00	5.27	4.38
T_4	26.90	25.40	24.60	5.70	6.00	155.00	5.70	6.00	155.00	128.00	4.78	5.34
T_5	28.89	24.04	27.37	5.96	5.96	170.69	5.96	5.96	170.69	117.16	5.16	4.68
T_6	26.58	24.25	24.64	5.63	5.63	154.23	5.63	5.63	154.23	110.58	4.75	4.36
T_7	26.90	25.70	23.60	5.60	6.10	182.01	5.60	6.10	182.01	125.00	5.36	5.17
T_8	27.40	23.60	25.20	5.80	6.10	188.00	5.80	6.10	188.00	116.00	5.50	4.59
T_9	27.10	24.80	25.50	5.70	6.00	144.00	5.70	6.00	144.00	108.00	4.52	4.15
SEd	1.70	1.58	1.57	0.36	0.38	10.85	0.36	0.38	10.85	7.55	0.32	0.31
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

processing characteristics as endorsed by Desalegn *et al.* (2009). However, farming practices did not affect fiber diameter. However, the Fineness values ranged from 144 to 188 d/tex in 2021-22 and 108 to 125 d/tex in 2022-23 (Table 4). Finer fibers with smaller diameters are preferred for high-quality apparel and fine fabrics, resulting in softer and more uniform textiles. Coarser fibers with larger diameters are suitable for heavy-duty applications like denim, providing strength. Both planting geometries (Gacche and Gokhale, 2018) and varying nutrient doses (Ahmad and Raza 2014)) had no impact on fiber fineness.

Micronaire (Mic)

Micronaire values can range from 2.5 to 7.5, with lower values indicating finer and more matured fibers, while higher values suggest coarser and less mature fibers. In this study, the Micronaire value ranged from 4.52 to 5.50 µg/inch in 2021-22 and for 2022-23, it was 4.15 to 5.66 µg/inch (Table 4). While, Gunasekaran *et al.* (2020) recorded Micronaire values of 4.3 and 4.4 µg/inch for the Cotton variety (CO 17) from different trial locations. This parameter also did not influence by different nutrient doses as supported by the findings of Bharathi *et al.* (2018); Sankaranarayanan *et al.* (2018); Tariq *et al.* (2018).

Conclusion

Two-year field experiments showed that natural farming, organic farming and integrated crop management had no discernible impact on the quality of cotton fiber. Integrated plots yielded more and had the same fiber quality as that of organic and natural farming, indicating that sustainable production of high-quality fiber is possible.

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Conflict of interest

There will be no conflicts of interest when this article is published.

REFERENCES

Ahmad, S. and Raza, I. (2014). Optimization of management practices to improve cotton fiber quality under irrigated arid environment. Journal of Food Agriculture and Environment. 2(2): 609-613.

Barotova, A., Xurramov, A., Mamadaliyev, A.B. and Jorayev, O. (2023). Fiber length and quality indicators in cotton varieties. Journal of Agriculture and Horticulture. 3(3): 50-53.

Bharathi, S., Sree Lakshmi, B. and Ratna Kumari, S. (2018). Evaluation of compact cultures under high density planting system with different nutrient levels in rainfed vertisols. International Journal of Chemical Studies. 6(5): 3371-3373.

Desalegn, Z., Ratanadilok, N. and Kaveeta, R. (2009). Correlation and heritability for yield and fiber quality parameters of Ethiopian cotton (*Gossypium hirsutum* L.) estimated from 15 (diallel) crosses. Agriculture and Natural Resource. 43(1): 1-11.

Gacche, A. and Gokhale, D. (2018). Nutrient uptake and fibre quality parameters of Bt cotton influenced by planting geometry and integrated nutrient management under rainfed conditions. Journal of Cotton Research and Development. 32(2): 231-235.

Gopinath, P.P., Parsad, R., Joseph, B. and Adarsh, V. (2021). grapes Agri1: collection of shiny apps for data analysis in agriculture. Journal of Open Source Software. 6(63): 3437. doi: https://doi.org/10.21105/joss.03437.

Gunasekaran, M., Premalatha, N., Kumar, M., Mahalingam, L., Sakthivel, N., Senguttuvan, K., Latha, P., Meenakhshiganesan, N., Rajeswari, S. and Geetha, S. (2020). Cotton CO17-A short duration, high yielding compact variety suitable for high density planting system. Electronic Journal of Plant Breeding. 11(04): 993-1000. doi: https://doi.org/10.37992/2020.1104.162.

Hulihalli, U. and Patil, V. (2008). Yield and fiber quality of cotton as influenced by fertilizer levels and organic manure. Annals of Arid Zone. 47(2): 201-204.

Indiastat. (2023). Area, production and yield of principal crops, Directorate of Economics and Statistics. Available from Department of Agriculture and Cooperation report Area, Production and yield of Principal crops, Directorate of Economics and Statistics Retrieved 20/06/2023, from Department of Agriculture and Cooperation report www.indiastat.com.

Kumar, B.V., Mahesh, B., Rajesh, C., Surendra, G., Kumar, P.M. and Meenendranath, K. (2022). An Importance of Sustainable Improvement on Organic Forming in India. International Journal of Research Publication and Reviews. 3(11): 278-286.

Mageshwaran, V., Satankar, V., Shukla, S. and Kairon, M. (2019). Current status of organic cotton production. Indian Farming. 69(02): 09-14.

Mishra, S.K. and Chaturvedi, P.K. (2023). Effect of integrated nutrient management on growth and yield of green gram (*Vigna radiation* L.). The Pharma Innovation Journal. 12(1): 671-673.

Monicaa, M., Vaiyapuri, K., Kamalakannan, A. and Sakthivel, N. (2020). Growth and yield of ELS cotton as influenced by method of planting, intercrops and fertilizer management in summer season. Journal of Pharmacognosy and Phytochemistry. 9(4): 1973-1977. doi: DOI: 10.22271/phyto.2020.v9.i4aa.12043.

Muthukrishnan, P., Thavaprakaash, N. and Srinivasan, K. (2017). Effect of organic nutrient management practices in comparison with conventional method on performance of cotton in Tamil Nadu. Madras Agricultural Journal. 104(2): 15-22.

Palekar, S. (2006). Text book on shoonya bandovalada naisargika krushi, published by swamy anand (Vol. 67).

Sahito, J.H., Gao, S., Nie, Z., Abro, S., Channa, S. A. and Wahocho, N.A. (2016). Correlation Analysis of yield and fiber traits in upland cotton (*Gossypium hirsutum* L.). American-Eurasian Journal of Agricultural and Environmental Sciences. 16(7): 1358-1361. doi: DOI: 10.5829/idosi.aejaes. 2016. 16.7.12960.

Sankaranarayanan, K., Singh, J. and Rajendran, K. (2018). Identification of suitable high density planting system genotypes its response to different levels of fertilizers compared with Bt cotton. Journal Cotton Research and Development. 32(1): 84-96.

Santhanam, V. (1976). Cotton:(taxonomy, agronomy, breeding, physiology). ICAR, New Delhi.

Tarfeen, N., Hassan, S., Manzoor, A. and Sultan, Z. (2023). Integrated nutrient management strategies for improving crop yield [Press release].

Tariq, M., Afzal, M.N., Muhammad, D., Ahmad, S., Shahzad, A.N., Kiran, A. and Wakeel, A. (2018). Relationship of tissue potassium content with yield and fiber quality components of Bt cotton as influenced by potassium application methods. Field Crops Research. 229: 37-43. doi: https://doi.org/10.1016/j.fcr.2018.09.012.

Velmurugan, L., Kanagaraj, J., Kanagaraj, R. and Pandian, K.D. (2022). Research Article Yield and Quality of Panchagavya and Trichoderma viride Applied Cotton. International Journal of Agricultural Sciences. 17(1): 14-21. doi: DOI: 10.3923/ijar.2022.14.21.

Voora, V., Bermudez, S., Larrea, C., Farrell, J.J. and Luna, E. (2020). Global Market Report: Cotton prices and sustainability: Winnipeg: International Institute for Sustainable Development.

Xu, W., Yang, W., Chen, P., Zhan, Y., Zhang, L. and Lan, Y. (2023). Cotton fiber quality estimation based on machine learning using time series UAV remote sensing data. Remote Sensing. 15(3): 586. doi: https://doi.org/10.3390/rs15030586.

Yaqoob, M., Fiaz, S. and Ijaz, B. (2016). Correlation analysis for yield and fiber quality traits in upland cotton. Communications in Plant Sciences. 6(34): 55-60.