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Research Article

Comparing the influence of natural farming on cotton (*Gossypium hirsutum*) yield and economics with integrated and organic farming

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Abstract
Cotton, a vital global cash crop, influences the economy and sustainability. Natural farming is a cost-effective, eco-friendly method. This study examines Natural Farming's effects on cotton yield and the economics of cotton compared to Integrated and organic farming. Field experiments were conducted during 2021-22 and 2022-23 at Tamil Nadu Agricultural College, Coimbatore. The experiment consisted of eight treatments, laid out in Randomized Block Design and replicated thrice. The treatments consist of control (T_1), various Indian Natural farming practices including *Beejamirit* as a seed treatment, *Ghanajeevamirit* as basal, *Jeevamirit* with irrigation water, crop residue mulch, intercroping with pulses (T_2 to T_5), Organic farming practices (T_6), Integrated crop management (ICM) practices with organic pest control (T_7) and ICM with chemical pest (T_8). The results indicated a significant increase in yield components: sympodial branches plant^{-1} (12.85 and 13.40), number of squares (29.28 and 31.28), bolls plant^{-1} (10.74 and 11.32), and boll weight (4.30 and 4.38 g) under Integrated Crop Management practices in 2021-22 and 2022-23, respectively. However, organic farming practices, followed by natural farming practices, were at par with integrated crop management. Integrated crop management practices resulted in significantly higher seed cotton yields (2178 and 2232 kg/ha in 2021-22 and 2022-23, respectively) than organic and natural farming practices with a higher cost of cultivation and a gross return. Complete natural farming outperformed organic and integrated farming in cotton, yielding higher net returns and B: C ratios. This approach holds promise for enhancing yield, economic viability and environmental sustainability in cotton cultivation.

Keywords: *Beejamirit*, Economics, *Ghanajeevamit*, *Jeevamirit*, Organic Cotton, Natural Farming and Yield

INTRODUCTION

Cotton is a global cash crop, contributing significantly to the agricultural and industrial economy. It is the backbone of the textile industry in India, accounting for 75% of fiber consumption and 38% of exports, generating ₹ 50,000 crores annually (Muthukrishnan *et al.*, 2017). India cultivates the largest cotton area globally, covering 10.15 million hectares, equivalent to 25% of the world's cotton area and approximately 2.4% of arable land (Barotova *et al.*, 2023). In 2022-23, India produced 337 lakh bales (170 kg each) from 130.49 lakh hectares, with a productivity of 439 kg ha^{-1} (Indiastat, 2023). Green revolution technologies in the 1960s improved crop production, but the excessive use of agrochemicals led to soil fertility depletion, nutrient deficiencies, reduced crop productivity and diminished farmer returns (Ramesh *et al.*, 2005).

Agrarian distress arises from low returns, high input costs and natural disasters. Low-input practices offer reduced costs, higher yields, chemical-free food and improved soil fertility (Tripathi *et al.*, 2018). Input costs have outpaced the increase in output per hectare for most crops, resulting in reduced farm income (Naik et al., 2020).

Natural farming, influenced by Fukuoka's philosophy (Fukuoka, 1987) and championed by Palekar, gained popularity in India (Khadse *et al.*, 2018). Farmers avoid chemical inputs in natural farming and instead opt for homemade alternatives. These alternatives include Indian natural farming inputs crafted from cow dung and urine, such as *Jeevamirit, Beejamirit* and *Neemastra*. Additionally, they embrace practices like intercropping and mulching to promote ecological balance and sustainability. (Palekar, 2005). However, amid these practices, critics inquire about the scientific basis and underlying beliefs supporting these alternative approaches (Kumar *et al.*, 2019; Shottenkirk, 2018). Many studies lack field-level evidence. The present study was taken up to analyze cotton farming's impact on costs, yield and income, providing insights into organic, natural and integrated approaches.

MATERIALS AND METHODS

A field experiment was conducted in the Eastern block farm of Tamil Nadu Agricultural University, Coimbatore, which is located at 11°N latitude and 77°E longitude at an altitude of 426.7 m above mean sea level. The soil of the experimental field was sandy clay loam in texture with low available nitrogen (213 kg ha^{-1}), medium available phosphorus (16 kg ha^{-l}) and high available potassium (886 kg ha^{-1}). The experiment was laid out in a randomized complete block design with 8 treatments and replicated thrice. The treatments were as follows.

T_1 – Control (No input additions, only labor for weeding operations.)

T_2 – Complete Indian Natural Farming (NF) practices (*Beejamirit* + *Ghanajeevamirit* + *Jeevamirit* + crop residue mulching + Intercropping)

T_3 – Natural Farming Practices 1 (without *Beejamirit* + *Ghanajeevamirit* + *Jeevamirit*)

T_4 – Natural Farming Practices 2 (without crop residue mulching)

T_5 – NF 3 (without intercropping)

T_6 – Organic Farming (OF) practices (5 t ha^{-1} FYM + 2.5 t ha^{-1} Vermicompost)

T_7 – Integrated Crop Management (ICM) (50% organic +50 % inorganic with bio-pesticide)

T_8 – ICM (50% organic + 50% inorganic with chemical pesticide)

The treatments T_7 and T_8 were maintained separately with a plot size of 12 m x 8.4 m adjacent to the organic & natural farming area.

Indian Natural farming inputs preparation

Beejamirit

500 g of fresh cow dung was taken in a cloth, bound by tape, and hanged it in 2 litres of water. One litre of water was taken and 5 g of lime was added in it. Kept these two separately for 12 hours. Then this cow dung bundle was squeezed thoroughly in water to extract material. A pinch of undisturbed soil from bunds or under tree and then 500 ml of cow urine was added. Finally, the lime water was added and stirred well. *Beejamirit* was ready to treat the seeds.

Ghanajeevamirit

To prepare the mixture, 100 kg of fresh cow dung was taken and 1 kg of jaggery along with 1 kg of pulse flour were added. The mixture was then kept in shade and 250 g of soil from an undisturbed bund or under a tree was added. After adding all the materials, the mixture was shaped into cakes and stored. After 10 days of its preparation, it could be and was applied in the experiment as per the treatment details.

Jeevamirit

In a plastic drum, 10 kg of fresh cow dung was added, 2 kg of jaggery and 2 kg of pulse flour, and 150 grams of soil from undisturbed bunds or under trees. The mixture was thoroughly mixed using a wooden stick. Subsequently, 10 litres of cow urine were added, followed by 200 litres of water. Finally, Jeevamrit was prepared for application starting from the 3rd day onwards. It could be used for irrigation water for 7 days following its preparation.

Crop cultivation practices

Natural farming: According to Palekar (2006), cow-based organic formulations *Beejamirit, Ghanajeevamirit* and *Jeevamirit*) were used in natural farming plots. *Ghanjeevamirit* was incorporated before sowing at a rate of 250 kg ha^{-1}. *Jeevamirit* was applied twice a month at a rate of 500 l ha^{-1} through irrigation water. *Beejamirit* (1 liter per kg of seed) was used for seed treatment. Green gram (DGGV 2) intercrop was between cotton rows. No weeding in natural farming plots. Crop residue mulch @ 5 t ha^{-1} with millet straw was spread immediately after sowing. Ecological engineering method used for plant protection, including cowpea as border/trap crop. Organic pesticide (3 G) was 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 (90 x 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 at 40 DAS. Two hand weeding on 20 and 40 DAS was performed for control, organic farming plot and integrated plot. Irrigation was given at intervals with a withholding period of 15 days. 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 and pheromone traps (12 Nos ha^{-1}) were kept to trap pests. Neem oil (3%) was sprayed to control pests. Panchagavya (3%) spray was used as a growth regulator in organic farming plots. These practices were followed for two years (2021-22 and2022-23).

Data collection and analysis

Five plants per plot were randomly chosen and tagged for biometric observations. The count of reproductive branches originating from extra-auxiliary buds represented branches per plant. Bolls retained per plant were counted at 120 DAS. The total number of squares produced per plant was recorded. Five matured bolls from marked plants in each plot were weighed for average boll weight (g). The boll setting percentage was calculated as the ratio of bolls to fruiting points using the formula below:

Boll setting percentage =Total no. of bolls on 120 DAS / Total no. of fruiting points on 120 DAS X 100 Eq. 1

Kapas from net plots were carefully collected, ensuring no bracts or trash adherence. The kapas were dried, cleaned and weighed, yielding seed cotton in kg ha^{-1}. Samples of 100 seed cotton from each plot were weighed. After ginning, the weight of lint and seed was recorded (kg ha^{-1}). The fresh weight of cotton plants at harvest was measured as stalk yield and expressed in kg ha^{-1}. Using local prices, standard procedure was followed to determine cultivation cost, gross returns, net returns, and B: C ratio. Expenses from sowing to harvest, including field preparation, were calculated at current TNAU input prices. Income from seed cotton was computed. Net returns were obtained by subtracting cultivation cost from gross return. Benefit Cost Ratio (BCR) was calculated as follows.

BCR = Gross return /Cost of Cultivation Eq. 2

Statistical analysis

The data were statistically analyzed using R Software (Gopinath *et al.*, 2021) with the grapesAgri1 package, Version 1.0.0.

RESULTS AND DISCUSSION

Yield parameters

Sympodial branches

Significant differences were observed in the number of sympodial branches and presented in Table 1 among the different farming practices, including natural, organic, and integrated farming. Significantly higher sympodia $plant^{-1}$ 12.85 and 13.40 in 2021-22 and 2022-23, respectively was recorded in ICM with organic pest management followed by ICM with chemical pest management (12.33 and 12.63) and organic farming practices (11.73 and 12.96) during both the years 2021-22 and 2022-23, respectively. The control plot produced lesser sympodia $plant^{-1}$ (9.38 and 9.71 in 2021-22 and 2022-23, respectively), which was at par with natural farming practices. The seed cotton yield is influenced

Table 1. Sympodia, Squares, Bolls and Boll setting percentage of cotton as influenced by Natural farming practices, Organic Farming practices and Integrated crop management method

Treatment	Total no. of Sympodia (Nos.)		Total no. of squares (Nos.)		Total no. of bolls (Nos.)		Boll setting%	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1- Control	9.38	9.71	18.43	20.43	5.72	6.12	31.04	29.96
T_2- Complete Natural Farming	11.00	10.99	26.17	28.17	7.18	8.25	27.44	29.29
T_3- NF (except GA, BA, JA)	9.93	10.23	23.07	25.07	6.15	7.26	26.66	28.96
T_4- NF (except mulching)	10.42	10.72	25.64	27.64	6.37	7.45	24.84	26.95
T_5- NF (except Intercropping)	10.78	10.91	26.37	28.37	6.81	7.93	25.82	27.95
T_6- Organic Farming	11.73	12.96	26.28	28.28	8.86	9.59	33.71	33.91
T_7- ICM (organic pest management)	12.85	13.40	29.28	31.28	10.74	11.32	36.68	36.19
T_8- ICM (Chemical pest management)	12.33	12.63	28.10	30.10	10.06	10.87	35.80	36.11
Sed	0.96	0.99	2.22	2.39	0.71	0.78	2.66	2.72
CD (p=0.05)	2.07	2.11	4.77	5.13	1.52	1.67	5.71	5.84

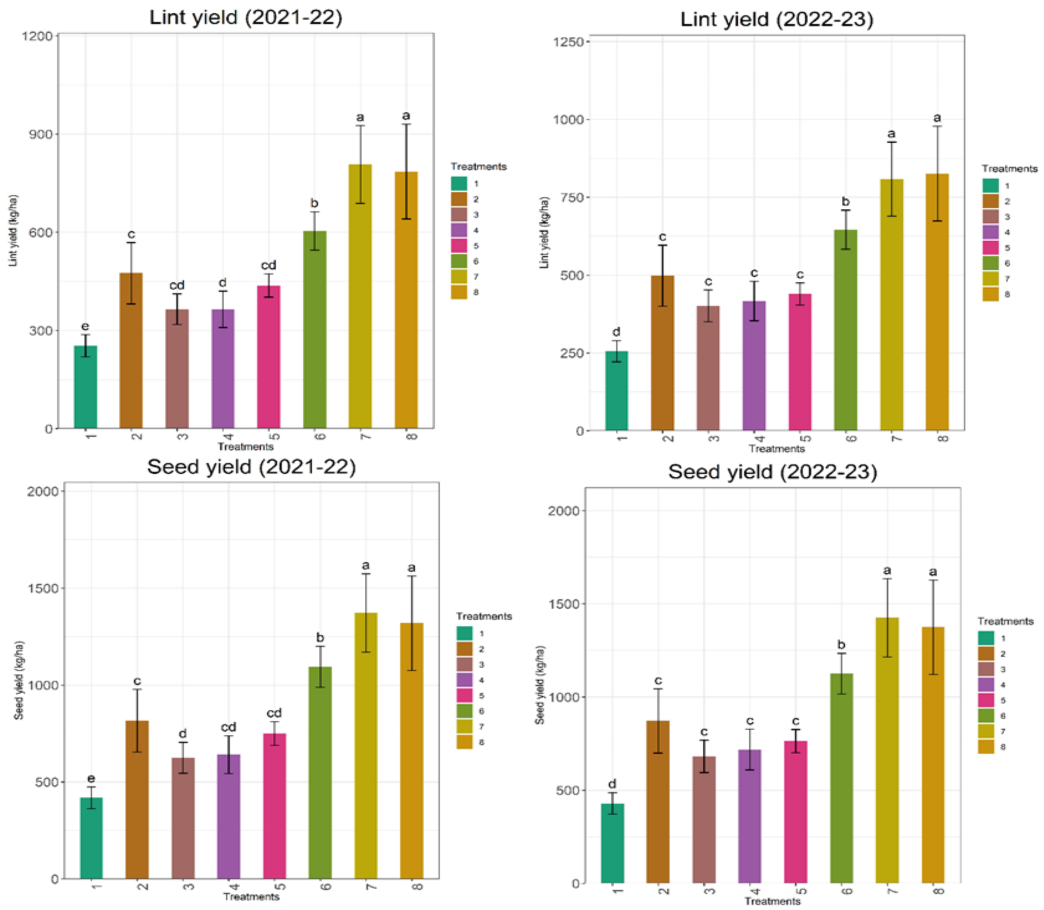

Fig. 1. *Lint yield (kg ha^{-1}), Seed yield (kg ha^{-1}) of cotton as influenced by Natural Farming practices, Organic Farming practices and Integrated Crop Management method*

by yield-attributing characteristics, which contribute to variations in the yield. Muthukrishnan *et al.* (2017) also reported that integrated farming produced more sympodial branches. The basic structure responsible for bearing various reproductive organs of the crop is the sympodial branches. Different farming practices, such as the utilization of *Beejamirit*, *Jeevamirit* and *Ghanajeevamirit* in natural farming, farm yard manure, vermicompost in organic farming and ICM practices, might have altered the development of these branches.

The higher number of sympodial branches observed can be attributed to the enhanced concentration of accessible nutrients achieved through the combined utilization of chemical fertilizers and organic manures. This synergistic approach positively influenced the development of sympodial branches, leading to increased vertical growth of the plant and more nodes that serve as the points of origin for these branches (Vani *et al.*, 2021). This variation could be attributed to factors such as better establishment and improved growth in cotton. This finding aligns with the research of Adeli *et al.* (2022). The combined application of organic manures and inorganic fertilizers, supplying nutrients consistently during the crop growth period, might have facilitated accelerated cell division and elongation, consequently leading to enhanced growth characteristics and increased sympodial branches in cotton. Similar results, with increased branches due to nutrient levels, were reported in cotton by Kalaichelvi (2009). The presence of additional nutrients in the organic natural farming treatments resulted in higher sympodial branches when compared to the control, which did not receive any manures or fertilizers.

Number of bolls and squares

The number of bolls per plant is a crucial factor that greatly affects seed cotton yield. Various farming practices significantly influenced the number of bolls per plant (Table 1). Among these practices, ICM with organic pest management (10.74 and 11.32), ICM with chemical pest management (10.06 and 10.87) demonstrated their superiority over other methods of organic farming practices (8.86 and 9.59) and complete natural farming (7.18 and 8.25) by achieving a higher count of bolls per plant in 2021-22 and 2022-23, respectively. Muthukrishnan *et al.* (2017) also proved that integrated farming practices attained more bolls from *suraj* variety than others. The number of squares plant^{-1} exhibited a similar trend to that observed in the number of bolls plant^{-1}. The most widely adopted practice in natural

Table 2. Boll weight, Seed cotton yield, Stalk yield), Harvest Index of cotton as influenced by Natural farming practices, Organic farming practices and Integrated crop management method

Treatment	Boll weight (g)		Seed cotton yield (kg ha^{-1})		Stalk Yield (kg ha^{-1})		Harvest Index	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1- Control	3.86	3.95	672	685	3195	3211	0.17	0.17
T_2- Complete Natural Farming	4.13	4.21	1287	1364	3647	3602	0.26	0.26
T_3- NF (except GA, BA, JA)	4.03	4.12	987	1083	3478	3449	0.22	0.22
T_4- NF (except mulching)	4.04	4.16	1005	1135	3538	3436	0.22	0.22
T_5- NF (except Intercropping)	4.11	4.18	1186	1199	3599	3686	0.25	0.25
T_6- Organic Farming	4.20	4.29	1695	1768	4798	4886	0.26	0.26
T_7- ICM (organic pest management)	4.30	4.38	2178	2278	5970	5972	0.27	0.27
T_8- ICM (Chemical pest management)	4.28	4.37	2104	2187	5969	5980	0.26	0.26
Sed	0.35	0.36	138	144	397	396	0.02	0.02
CD (p=0.05)	NS	NS	296	309	852	850	0.05	0.05

Note : NS – Non Significant

farming is *Ghanajeevamirit*, *Jeevamirit* and *Beejamirit*, allowing for innovation in natural farming practices (Pujeri *et al.*, 2022). Malewar *et al.* (2000) and Sreenivasan (2004) found that higher levels of nitrogen and phosphorus influenced the number of bolls in cotton. Developing several squares and bolls in cotton is a multifaceted process influenced by a combination of factors, including nutrition, hormonal balance, field environment and weather conditions (Rathiya *et al.*, 2010). Furthermore, the cotton crop that did not receive any nutrients, *i.e., the* control plot, exhibited the lowest count of bolls per plant (5.72 and 6.12) and a lesser number of squares (18.43 and 20.43) during 2021-22 and 2022-23, respectively, indicating the negative impact of nutrient deficiency.

Boll setting percentage

There were notable differences in the boll setting percentage observed across various farming practices (Table 1). The implementation of ICM with organic pest management showed a higher boll setting percentage (36.68% and 36.19%). The practice of ICM with chemical pest management (35.80% and 36.11%) and organic farming practices (33.71% and 33.91%) were comparable with ICM with organic pest management throughout both years. These results indicated that ICM practised treatments outperformed all other treatments regarding boll setting percentage. Cotton is an indeterminate crop, meaning that its vegetative and reproductive structures compete for available photosynthates throughout the growth period. The availability of sufficient nutrients during critical stages, particularly under ICM practices, significantly enhances the boll setting percentage and the overall number of bolls produced. Muthukrishnan *et al.* (2017) have recorded that integrated farming practices achieved a higher boll-setting percentage than organic farming practices and control. According to Forster *et al.* (2013), nitrogen had the most significant impact on the retention of bolls in cotton plants. The combined application of fertilizers and manures improves boll retention by enhancing the fertility coefficient. Using *Jeevamirit, Ghanajeevamirit* and *Beejamirit* in natural farming plots might be the reason behind their significance.

Boll weight (g)

Different farming practices did not significantly impact boll weight, as depicted in Table 2. However, among the treatments, the crop that received ICM practice with organic pest management exhibited higher boll weight (4.30 and 4.38 g) compared to ICM with chemical pest management (4.89 and 4.68 g) and organic farming practices (4.20 and 4.29 g) during the years 2021-22 and 2022-23, respectively. The crop without any nutrient application recorded the lowest boll weight (3.86 and 3.95 g) in both study years. The same trend was demonstrated by Muthukrishnan *et al.* (2017). The size and weight of cotton bolls were influenced by the presence of timely and sufficient nutrients provided to the cotton crop through both organic and inorganic sources.

Yield

Different farming practices significantly influenced seed cotton yield (Table 2). In both 2021-22 and 2022-23, ICM with organic pest management achieved the highest seed cotton yield of 2178 and 2232 kg ha^{-1}, respectively. The practice of ICM with chemical pest management (2104 and 2187 kg ha^{-1}) followed by organic farming practices (1695 and 1768 kg ha^{-1}) was comparable with ICM with organic pest management during both years (Table 2). Similar trends were observed for seed

Table 3. Economics of cotton as influenced by Natural farming practices, Organic farming practices and Integrated crop management method

Treatment	Cost of Cultivation (₹ ha^{-1}) For both years	Gross Return (₹ ha^{-1})		Net return (₹ ha^{-1})		B: C ratio	
		2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1- Control	49650	40858	41648	-8792	-8002	0.82	0.84
T_2- Complete Natural Farming	37296	120751	124037	83454	86741	3.24 (3.66)	3.33 (3.77)
T_3- NF (except GA, BA, JA)	35800	89398	101000	53598	65200	2.50 (2.83)	2.82 (3.19)
T_4- NF (except mulching)	35046	87702	97931	52656	62885	2.50 (2.85)	2.79 (3.19)
T_5- NF (except Intercropping)	36296	72109	72899	35813	36603	1.99 (2.39)	2.01 (2.41)
T_6- Organic Farming	89925	103056	107494	13131	17569	1.15 (1.38)	1.20 (1.44)
T_7- ICM (organic pest management)	94450	132422	135706	37972	41256	1.40	1.44
T_8- ICM (Chemical pest management)	90262	127923	132970	37661	42708	1.42	1.47

yield, lint yield (Fig. 1), and stalk yield, with ICM practices outperforming organic and natural farming practices. The results of this research are consistent with the investigations carried out by Babalad *et al.* (2021) and Duddigan *et al.* (2022), where practicing Integrated crop management practices on cotton resulted in a higher seed cotton yield. Yield increase resulted from rapid nutrient release by inorganic fertilizer and nutrient supplementation with organic manures. Organic and natural farming with organic manure yielded less due to slow nutrient release. Organic manures contain nutrients but are less accessible to crops, causing nutrient deficiencies in early growth (Nagavani, 2010; Varsha *et al.*, 2022).

Organic inputs enhance crop yields through gradual nutrient release, aiding absorption and supplementing gibberellin, cytokinin, auxins, Indole Acetic Acid, and macro and micronutrients (Devakumar *et al.*, 2014; Lalitha *et al.*, 2000). Integrated nutrient management with 12.5 t ha^{-1} FYM yielded the highest seed cotton yield of 2252 and 1752 kg ha^{-1} during rabi 2012-13 and 2013-14, respectively, as evaluated by Muthukrishnan *et al.* (2017).

Natural farming practices achieved yield the same as organic farming practices due to using cow-based formulations like *Beejamirit, Ghanajeevamirit*, and *Jeevamirit*. Regularly applying liquid manures stimulate plant systems, enhancing the production of growth regulators and hormones. This sustains nutrient availability and uptake, improving crop growth and yield. The yield increase may be attributed to improved nutrient availability during crop growth, possibly resulting from enhanced soil microbial activity. These findings align with the studies conducted by Kaur *et al.* (2021) in wheat crop and Kasbe *et al.* (2009) in aerobic rice.

Kumar *et al.* (2020) and Kumar *et al.* (2023) reported that several crops that received natural farming practices at different trials showed superior yield. According to Chandrakala *et al.* (2011), combining *Beejamirit, Jeevamirit* and *Panchagavya* resulted in increased yield and dry matter production in chili crops. Similarly, Gore & Sreenivasa (2011) found that a mix of *Beejamirit, Jeevamirit,* and *Panchagavya* in a 1:1:2 ratio boosted tomato yield. This could be due to jeevamirit's role, potentially aided by increased microbial activity. Improved soil moisture and nutrient accumulation might have also boosted yield. Kaur and Saini (2021) reported that using 20% *jeevamirit* resulted in significant increases in grain yield (3117 kg ha^{-1}) and straw yield (6193 kg ha^{-1}) in wheat crops.

Harvest index

The Harvest index was influenced significantly by the farming practices and a significantly higher harvest index (0.27) was recorded from ICM with organic pest management. A lower harvest index (0.17) was obtained from the control during both years (Table 2). The ICM had a higher harvest index due to more seed cotton yield than other treatments. It was similar to the results found in cotton crop by Nagender *et al.* (2017).

Economics

From an economic perspective, the Integrated Crop Management (ICM) practices registered the highest cost of cultivation at ₹94450, involving a blend of 50% organic manures and 50% inorganic nutrients with organic pest management (T_7). This can be attributed to the incorporation of urea, single super phosphate and muriate of potash, driving up production costs, followed by organic farming approaches. Generally, organic manure-applied plots tend to have higher production costs due to relatively elevated unit costs of organic inputs.

Yet, within the ICM framework, amalgamating organic manure and inorganic fertilizer escalates cultivation expenses due to their combined application. Furthermore, ICM practices yielded elevated crop output, culminating in the highest gross returns (₹132422 and ₹135706 in 2021-22 and 2022-23, respectively) compared to alternative farming methods across both cotton cultivation years. This augmentation stems from superior yields achieved through ICM practices relative to other treatment combinations. Muthukrishnan *et al.* (2017) reported that combining RDF and 12.5 t ha-1 of FYM led to increased gross returns, net returns, and B:C ratio, showing analogous results.

In the midst of this, cotton cultivation under natural farming practices yielded greater net returns (₹83454 and ₹86741 in 2021-22 and 2022-23, respectively) and a more favorable B:C ratio (3.24 and 3.33 in 2021-22 and 2022-23) compared to alternative approaches. While cotton growth under ICM practices generated higher gross returns due to augmented yields, the utmost net returns and B:C ratio were achieved through natural farming practices. Consistently positive net returns characterized both years within the natural farming system, consistent with the findings of Singh *et al.* (2023). These studies underscored that natural farming treatments yield higher net returns than conventional practices.

Conclusion

Two years of field experiments on various farming practices demonstrated that combining inorganic fertilizers and organic manures enhanced yield parameters and seed cotton yield, surpassing organic and natural farming alone. Complete Natural farming (*Beejamirit* (1 l/kg of seeds as seed treatment) + *Ghanajeevemirit* (250 kg ha^{-1} as basal) + *Jeevamirit* (500 l ha^{-1} along with irrigation water) + Crop residue mulch (5 t ha^{-1}) + intercropping) showed the highest monetary gains, with greater net returns and B:C ratio than ICM (50% organic manure and 50% inorganic fertilizer) and organic practices (50% nutrient through FYM and 50% nutrient through vermicompost). This underscores the viability of adopting natural farming for sustainable cotton production in Tamil Nadu.

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Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Adeli, A., Brooks, J.P., Miles, D., Misna, T., Feng, G. & Jenkins, J.N. (2022). Combined effects of organic amendments and fertilization on cotton growth and yield. *Agronomy Journal, 114*(6), 3445-3456.
2. Babalad, H., Gunabhagya, Saraswathi & Navali, G.V. (2021). Comparative Economics of Zero Budget Natural Farming with Conventional Farming Systems in Northern Dry Zone (Zone-3) of Karnataka. *Economic Affairs, 66*(2), 355-361. doi: DOI: 10.46852/0424-2513.2.2021.23
3. Barotova, A., Xurramov, A., Raxmatullayev, S. & Ismoilova, A. (2023). Evaluation of Fiber Quality Indexes in different varieties of Cotton plants. *Journal of Agriculture & Horticulture, 3*(2), 41-46. doi: https://doi.org/10.5281/zenodo.5584563
4. Chandrakala, M., Hebsur, N. & Nalina, C. (2011). Effect of FYM and fermented liquid manures on yield and economics of Chilli (*Capsicum annum* L.). *Research Journal of Agricultural Sciences, 2*(3), 722-724.
5. Devakumar, N., Shubha, S., Gowder, S. & Rao, G. (2014). Microbial analytical studies of traditional organic preparations beejamrutha and jeevamrutha. *Building organic bridges, 2*, 639-642.
6. Duddigan, S., Collins, C.D., Hussain, Z., Osbahr, H., Shaw, L.J., Sinclair, F., Sizmur, T., Thallam, V. & Ann Winowiecki, L. (2022). Impact of zero budget natural farming on crop yields in Andhra Pradesh, SE India. *Sustainability, 14*(3), 1689. doi: https://doi.org/10.3390/su14031689
7. Forster, D., Andres, C., Verma, R., Zundel, C., Messmer, M.M. & Mäder, P. (2013). Yield and economic performance of organic and conventional cotton-based farming systems--results from a field trial in India. *PLoS One, 8* (12), 81039. doi: 10.1371/journal.pone.0081039
8. Fukuoka, M. (1987). The Natural Way of Farming: The Theory and Practice of Green Philosophy, Revised Edition: Japan Publications, Kodansha International-USA through Harper and Row.
9. Gopinath, P.P., Parsad, R., Joseph, B. & Adarsh, V. (2021). grapesAgri1: 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
10. Gore, N.S. & Sreenivasa, M. (2011). Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicon esculentum* Mill.) in the sterilized soil. *Karnataka Journal of Agricultural Sciences, 24*(2), 153-157.
11. 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
12. Kalaichelvi, K. (2009). Bt cotton response to plant geometry and fertilizer levels. *Journal of Cotton Research and Development, 23*(1), 96-99.
13. Kasbe, S.S., Mukund, J. & Bhaskar, S. (2009). Characterization of farmers' Jeevamruta formulations with respect to aerobic rice. *Mysore Journal of Agricultural Sciences, 43* (3), 570-573.

14. Kaur, P., Saini, J., Meenakshi & Avnee. (2021). Optimization of Jeevamrit doses and application time for enhancing productivity of wheat under natural farming system. *Journal of Pharmacognosy and Phytochemistry, 10*(1), 405-408.
15. Khadse, A., Rosset, P.M., Morales, H. & Ferguson, B.G. (2018). Taking agroecology to scale: The zero budget natural farming peasant movement in Karnataka, India. *The Journal of Peasant Studies, 45*(1), 192-219. doi: https://doi.org/10.1080/03066150.2016.1276450
16. Kumar, R., Kumar, S., Yashavanth, B. & Meena, P. (2019). Natural Farming practices in India: Its adoption and impact on crop yield and farmers income. *Indian Journal of Agricultural Economics, 74*(3), 420-432.
17. Kumar, R., Kumar, S., Yashavanth, B., Meena, P., Ramesh, P., Indoria, A., Kundu, S. & Manjunath, M. (2020). Adoption of Natural Farming and its Effect on Crop Yield and Farmers' Livelihood in India: ICAR: National Academy of Agricultural Research Management and Telangana.
18. Kumar, R., Kumar, S., Yashavanth, B., Venu, N., Meena, P., Dhandapani, A. & Kumar, A. (2023). Natural Farming Practices for Chemical-Free Agriculture: Implications for Crop Yield and Profitability. *Agriculture, 13*(3), 647. doi: https://doi.org/10.3390/agriculture13030647
19. Lalitha, R., Fathima, K. & Ismail, S. (2000). Impact of biopesticides and microbial fertilizers on productivity and growth of Abelmoschus esculentus. *Vasundhara The Earth, 1*(2), 4-9.
20. Malewar, G., Badole, S., Mali, C., Siddiqui, M. & Syed, I. (2000). Influence of flyash with and without FYM and fertilizer on physico-chemical properties of sunflower and cotton growing soils. *Annals of Agricultural Research, 21* (2), 187-191.
21. Muthukrishnan, P., Thavaprakaash, N. & 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.
22. Nagavani, A. (2010). *Effect of integrated nutrient management practices on soil fertility and productivity of maize.* (Ph.D), Tamil Nadu Agricultural University, Coimbatore.
23. Nagender, T., Reddy, D.R., Rani, P.L., Sreenivas, G., Surekha, K., Gupta, A. & Sreekanth, P. (2017). Response of nitrogen fertilization and plant densities on Bt and Non-Bt Cotton (*Gossypium hirsutum* L.) hybrids. *International journal of current microbiology and applied sciences, 6*(9), 3199-3207. doi: https://doi.org/10.20546/ijcmas.2017.609.394
24. Naik, A., Brunda, S. & Chaithra, G. (2020). Comparative economic analysis of zero budget natural farming for Kharif groundnut under central dry zone of Karnataka, India. *Journal of Economics, Management and Trade, 26*(6), 27-34. doi: https://doi.org/10.9734/jemt/2020/v26i630263
25. Palekar, S. (2005). The Philosophy of Spiritual Farming II . Amravati, Maharashtra, India: Amravati: Zero Budget Natural Farming Research. *Development and Extension Movement*.
26. Palekar, S. (2006). *Text book on shoonya bandovalada naisargika krushi, published by swamy anand* (Vol. 67).
27. Pujeri, M.S., Gaddanakeri, S. & Chandrashekara, C. (2022). Evaluation of natural farming practices on productivity and economics of rabi sorghum in Northern transition zone of Karnataka. *The Pharma Innovation Journal, 11* (12), 3551-3553.
28. Ramesh, P., Singh, M. & Rao, A.S. (2005). Organic farming: Its relevance to the Indian context. *Current science, 88*(4), 561-568.
29. Rathiya, P., Lakpale, R., Shrivastava, G. & Bargali, S. (2010). Effect of nutrient blending with FYM on biomass production and economics under hybrid cottonsoybean intercropping system. *Journal of Plant Development Sciences, 2*(1&2), 9-18.
30. Shottenkirk, D. (2018). Against purity: living ethically in compromised times. *Ethics and Social Welfare, 12*(1), 84-89. doi: https://doi.org/10.1080/17496535.2018.1433466
31. Singh, G., Sharma, V.K., Kaur, N., Pathania, P. & Sharma, S.K. (2023). Productivity and land use of different cropping systems under conventional and natural farming in mid hills of Himachal Pradesh. *Himachal Journal of Agricultural Research, 49*(1), 78-83.
32. Sreenivasan, S. (2004). *Quality scenario of Indian cotton and fibre requirements*. Paper presented at the Nation. Symp. On Changing World Order–Cotton Res. and Dev. and Policy in Context.
33. Tripathi, S., Shahidi, T., Nagbhushan, S. & Gupta, N. (2018). Zero Budget Natural Farming for the Sustainable Development Goals (Council on Energy, Environment and Water,). *Council on Energy, Environment and Water*.
34. Vani, K., Rekha, B. & Nalini, N. (2021). Yield and nutrient uptake of Bt cotton as influenced by composted waste, organic and inorganic fertilizers. *Chemical Science Review and Letters, 9*(34), 432-441.
35. Varsha, P., Prasad, V.M., Topno, S.E. & Bahadur, V. (2022). Effect of Organic Manures and Inorganic Fertilizers on Growth, Yield and Quality of Broccoli (*Brassica oleraceae* var. italica L.) cv. Green Magic. *International Journal of Plant & Soil Science, 34*(21), 665-671. doi: https://doi.org/10.9734/ijpss/2022/v34i2131316