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Effect of Vermicompost and Organic and Inorganic Fertilizers on Growth, Yield Components and Sucking Insect Pest Populations of Cotton (*Gossypium Hirsutum* L.)

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ABSTRACT

A field experiment was conducted at the Cotton Research Institute (CRI), Multan, Punjab, Pakistan, during Kharif 2026 to assess the effects of vermicompost and other organic and inorganic fertilizers on cotton growth, yield, and sucking insect pest populations. Cotton cultivar MNH-1050 was evaluated in a randomized complete block design (RCBD) with three replications and six treatments: T1, unfertilized control; T2, recommended NPK (150-75-75 kg ha^{-1}); T3, farmyard manure (FYM) at 10 t ha^{-1}; T4, vermicompost at 5 t ha^{-1}; T5, vermicompost at 5 t ha^{-1} plus 50% recommended NPK; and T6, FYM at 10 t ha^{-1} plus 50% recommended NPK. Data were recorded for plant growth, yield components, and seed cotton yield. Populations of whitefly (Bemisia tabaci), jassid (Amrasca devastans), and thrips (Thrips tabaci) were monitored fortnightly. The integrated FYM-based treatment (T6) produced the highest seed cotton yield (2,512 kg ha^{-1}), 73.0% greater than the control (1,452 kg ha^{-1}). This advantage was associated with the highest average boll weight (3.58 g). In comparison, T5 recorded the maximum fresh leaf weight (214.5 g $plant^{-1}$), dry leaf weight (67.9 g $plant^{-1}$), dry fruit weight (118.2 g $plant^{-1}$), number of branches (18.4 $plant^{-1}$), and bolls per plant (34.7). The highest combined sucking-pest population occurred under sole chemical fertilization (T2), at 26.2 insects per three leaves, whereas T5 had the lowest population (15.8), a 39.7% reduction compared with T2. Whitefly and jassid populations responded more strongly to fertilizer treatments than thrips, and pest populations peaked at 75 days after sowing. Overall, integrating organic amendments with 50% of the recommended NPK rate improved cotton performance and reduced sucking-pest populations relative to sole chemical fertilization. FYM combined with reduced NPK was most effective for maximizing seed cotton yield, whereas vermicompost combined with reduced NPK promoted vegetative and reproductive growth and was associated with lower pest pressure. These findings demonstrate the potential of integrated nutrient management to support productive and sustainable cotton cultivation under the agro-climatic conditions of Multan.

Introduction

Cotton (*Gossypium hirsutum* L.) is the backbone of Pakistan's agrarian and industrial economy, providing raw material to the textile sector and a major source of livelihood for growers in the cotton belt of Punjab and Sindh (Hussain et al., 2022). Despite its economic importance, average cotton yields in Pakistan remain below the genetic potential of modern cultivars, largely due to imbalanced and excessive reliance on chemical fertilizers, progressive deterioration of soil organic matter, and inadequate integration of organic nutrient sources into fertilization programs (Khan et al., 2021).

Continuous and exclusive use of inorganic fertilizers, while effective in the short term, has been associated with declining soil physical health, reduced microbial activity and diminishing marginal returns on cotton yield (Meena et al., 2020; Rasool et al., 2021). Organic amendments such as farm yard manure (FYM) and vermicompost improve soil structure, water-holding capacity, cation exchange capacity and microbial biomass, while gradually releasing macro- and micro-nutrients that support sustained crop growth (Bhat et al., 2021; Manivannan et al., 2021). Vermicompost, in particular, is rich in readily available nutrients, plant growth-promoting substances and beneficial microflora, and several studies report its superiority over conventional FYM in improving crop growth and yield (Sharma & Garg, 2021; Shah et al., 2022).

Integrated nutrient management (INM), combining organic amendments with a reduced rate of chemical fertilizer, has emerged as a sustainable strategy that combines the immediate nutrient supply of inorganic fertilizers with the long-term soil-health benefits of organic sources (Iqbal et al., 2021; Naveed et al., 2022).

Fertilizer management also shapes the pest complex of the crop. Whitefly (Bemisia tabaci), jassid (Amrasca devastans) and thrips (Thrips tabaci) are the principal sucking pests of cotton in Punjab, and the nutrient status of the host plant influences their build-up: excessive nitrogen is generally reported to reduce host-plant resistance to hemipteran pests, whereas balanced fertilization can strengthen it (Singh & Sood, 2017). Studies in Pakistan have linked higher nitrogen doses with higher whitefly and jassid populations on cotton (Ahmed et al., 2007), and organic amendments, which usually give lower concentrations of soluble nitrogen in plant tissue, are frequently associated with fewer pests (Nisar, 2002). Whether vermicompost and FYM, alone or integrated with reduced chemical fertilizer, also modify sucking pest pressure under the conditions of southern Punjab has received little attention.

Information comparing sole and integrated application of vermicompost and FYM with chemical fertilizers under the specific agro-climatic conditions of the cotton belt of southern Punjab therefore remains limited. The present study was undertaken at the Cotton Research Institute, Multan, during Kharif 2026 to evaluate the comparative effect of vermicompost, FYM, chemical fertilizer and their integrated combinations on the growth, yield and yield-contributing traits of cotton and on the populations of whitefly, jassid and thrips, with the objective of identifying the most productive and resource-efficient fertilization strategy for the region.

Materials and Methods

Experimental site and design

The field experiment was conducted at the Cotton Research Institute (CRI), Multan, Punjab, Pakistan (30.20° N, 71.47° E), during the Kharif season of 2026. The experiment was laid out in a Randomized Complete Block Design (RCBD) with six treatments replicated three times, giving a total of 18 experimental units. Each plot measured 6 m × 4.5 m (net plot 5 m × 3.6 m), with a row-to-row spacing of 75 cm and plant-to-plant spacing of 30 cm. Cotton cultivar MNH-1050 was sown in the first week of May 2026 using the dibbling method, and standard agronomic practices were followed uniformly across all plots throughout the crop season. No insecticide was applied against sucking pests in the experimental plots, so that pest populations reflected the effect of the fertilizer treatments.

Treatment	Description	Nutrient source and rate
T1	Control	No fertilizer applied
T2	Chemical fertilizer	NPK @ 150-75-75 kg ha^{-1} (urea, DAP, SOP)
T3	Farm yard manure (FYM)	FYM @ 10 t ha^{-1} (sole)
T4	Vermicompost	Vermicompost @ 5 t ha^{-1} (sole)
T5	Vermicompost + chemical fertilizer	Vermicompost @ 5 t ha^{-1} + 50% recommended NPK (75-37.5-37.5 kg ha^{-1})
T6	FYM + chemical fertilizer	FYM @ 10 t ha^{-1} + 50% recommended NPK (75-37.5-37.5 kg ha^{-1})

Table 1. Treatments imposed for evaluating the effect of vermicompost and other fertilizers on cotton, Kharif 2026.

Full doses of FYM and vermicompost, together with phosphorus, potassium and one-third of the nitrogen dose (as applicable), were incorporated into the soil at the time of seedbed preparation (basal dose). The remaining two-thirds of the nitrogen dose was applied in two equal split doses — the first dose one month after sowing (squaring stage) and the second dose at flowering — as detailed in Table 2. FYM and vermicompost used in the study contained, on average, 0.55% and 1.45% N, 0.28% and 0.85% P_2O_5, and 0.52% and 1.10% K_2O, respectively, on a dry-weight basis.

Treatment	Basal dose (at sowing)	1st dose (After 1 month)	2nd dose (Flowering time)	Total amount of fertilizer received/ha
T1 (Control)	—	—	—	No fertilizer applied
T2 (Chemical fertilizer)	50 kg N + 75 kg P_2O_5 + 75 kg K_2O	50 kg N	50 kg N	150-75-75 kg NPK ha^{-1}
T3 (FYM)	FYM 10 t ha^{-1} (full dose)	—	—	FYM 10 t ha^{-1}
T4 (Vermicompost)	Vermicompost 5 t ha^{-1} (full dose)	—	—	Vermicompost 5 t ha^{-1}
T5 (Vermicompost+50% NPK)	Vermicompost 5 t ha^{-1} + 25 kg N + 37.5 kg P_2O_5 + 37.5 kg K_2O	25 kg N	25 kg N	Vermicompost 5 t ha^{-1} + 75-37.5-37.5 kg NPK ha^{-1}
T6 (FYM+50% NPK)	FYM 10 t ha^{-1} + 25 kg N + 37.5 kg P_2O_5 + 37.5 kg K_2O	25 kg N	25 kg N	FYM 10 t ha^{-1} + 75-37.5-37.5 kg NPK ha^{-1}

Table 2. Fertilizer application schedule and total amount of fertilizer received per treatment during the crop season.

Growth and yield data

Ten randomly selected and tagged plants per plot were used for recording plant height (cm) and number of sympodial branches per plant at 90 days after sowing (DAS), fresh and dry weight of leaves (g $plant^{-1}$) at peak flowering, and number of fruits (bolls) per plant, average boll weight (g) and dry weight of fruits (g $plant^{-1}$) at the time of first picking. Seed cotton yield was recorded plot-wise at each picking, summed over three pickings, and converted to kg ha^{-1}.

Sucking insect pest populations

Populations of whitefly (adults), jassid (nymphs) and thrips (adults and nymphs) were recorded at fortnightly intervals from 30 to 120 DAS (seven observations) on ten randomly selected plants per plot. On each plant, three leaves one each from the upper, middle and lower canopy were examined in the early morning (before 09:00 h) and the insects counted in situ with the help of a hand lens. Population is expressed as the number of insects per three leaves per plant, and the seasonal mean of the seven observations was used for comparison among treatments.

Statistical analysis

Data recorded for each parameter were subjected to analysis of variance (ANOVA) appropriate for RCBD using Statistix 8.1. Pest counts were square-root transformed [$\sqrt{(x + 0.5)}$] before analysis, and back-transformed means are presented. Treatment means were compared using the Least Significant Difference (LSD) test at a 5% probability level, and means sharing the same letter within a column are not significantly different ($p > 0.05$). Simple correlation coefficients were computed among yield and yield-contributing traits (plot data, $n = 18$) and between pest populations and growth and yield traits (treatment means, $n = 6$).

Results

Plant height and number of branches

Data on plant height and number of branches per plant as influenced by different fertilizer treatments are presented in Table 3. The maximum plant height (124.7 cm) and number of branches (18.4 $plant^{-1}$) were recorded in T5 (Vermicompost + 50% NPK), statistically at par with T6 (121.5 cm; 17.2 branches $plant^{-1}$), and significantly higher than all sole fertilizer treatments and the control. The minimum values for both parameters were recorded in the control (T1).

Treatment	Plant height (cm)	No. of branches/plant
T1 (Control)	98.4 ± 1.8 e	11.6 ± 0.5 e
T2 (Chemical fertilizer)	112.6 ± 2.1 c	14.8 ± 0.6 c
T3 (FYM)	108.3 ± 1.9 d	13.5 ± 0.5 d
T4 (Vermicompost)	116.9 ± 2.0 bc	15.9 ± 0.6 bc
T5 (Vermicompost+50% NPK)	124.7 ± 2.3 a	18.4 ± 0.7 a
T6 (FYM+50% NPK)	121.5 ± 2.2 ab	17.2 ± 0.6 ab
LSD (0.05)	4.62	1.14
CV (%)	3.81	3.95

Table 3. Effect of fertilizer treatments on plant height and number of branches per plant of cotton (values are mean ± SE of three replications; means sharing the same letter within a column do not differ significantly at $p \leq 0.05$).

Fresh and dry weight of leaves

Fresh and dry weights of leaves per plant were significantly influenced by the fertilizer treatments (Table 4, Fig. 1). The highest fresh weight (214.5 g plant^{-1}) and dry weight of leaves (67.9 g plant^{-1}) were recorded in T5, followed closely by T6 (205.3 and 63.4 g plant^{-1}, respectively). Among the sole fertilizer sources, vermicompost (T4) produced greater leaf biomass than FYM (T3) or chemical fertilizer (T2) alone, while the control recorded the lowest values for both parameters.

Treatment	Fresh weight of leaves (g/plant)	Dry weight of leaves (g/plant)
T1 (Control)	145.2 ± 3.6 e	42.8 ± 1.3 e
T2 (Chemical fertilizer)	178.4 ± 4.1 c	54.6 ± 1.6 c
T3 (FYM)	168.9 ± 3.9 d	50.3 ± 1.5 d
T4 (Vermicompost)	186.7 ± 4.3 bc	58.1 ± 1.7 bc
T5 (Vermicompost+50% NPK)	214.5 ± 4.8 a	67.9 ± 1.9 a
T6 (FYM+50% NPK)	205.3 ± 4.6 ab	63.4 ± 1.8 ab
LSD (0.05)	8.95	3.24
CV (%)	3.53	3.98

Table 4. Effect of fertilizer treatments on fresh and dry weight of leaves of cotton (mean ± SE; means sharing the same letter within a column do not differ significantly at $p \leq 0.05$).

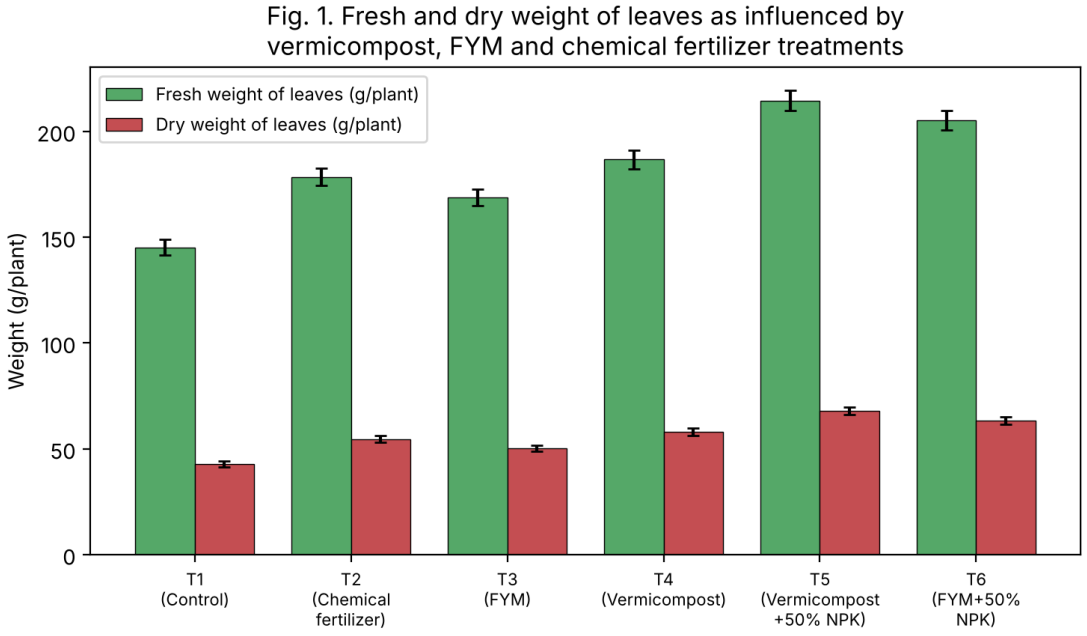


Fig. 1. Fresh and dry weight of leaves as influenced by vermicompost, FYM and chemical fertilizer treatments.

Number of fruits per plant, boll weight and dry weight of fruits

The number of fruits (bolls) per plant, average boll weight and dry weight of fruits are presented in Table 5 and Fig. 2. The maximum number of bolls per plant (34.7) and dry weight of fruits (118.2 g plant^{-1}) were recorded in T5, statistically comparable with T6 (32.9 bolls plant^{-1}; 117.5 g plant^{-1} dry weight of fruits). However, T6 produced the significantly heaviest individual bolls (3.58 g), exceeding all other treatments including T5 (3.34 g).

Treatment	No. of fruits (bolls)/plant	Boll weight (g)	Dry weight of fruits (g/plant)
T1 (Control)	21.8 ± 0.8 e	2.68 ± 0.06 d	58.4 ± 1.9 e
T2 (Chemical fertilizer)	27.4 ± 0.9 c	3.02 ± 0.07 c	82.8 ± 2.3 c
T3 (FYM)	25.6 ± 0.9 d	2.91 ± 0.06 c	74.5 ± 2.1 d
T4 (Vermicompost)	29.1 ± 1.0 bc	3.11 ± 0.07 bc	90.5 ± 2.4 bc
T5 (Vermicompost+50% NPK)	34.7 ± 1.1 a	3.34 ± 0.08 b	118.2 ± 3.0 a
T6 (FYM+50% NPK)	32.9 ± 1.0 ab	3.58 ± 0.08 a	117.5 ± 2.9 a
LSD (0.05)	2.36	0.19	6.14
CV (%)	4.51	3.44	3.75

Table 5. Effect of fertilizer treatments on fruiting parameters of cotton (mean ± SE; means sharing the same letter within a column do not differ significantly at p ≤ 0.05).

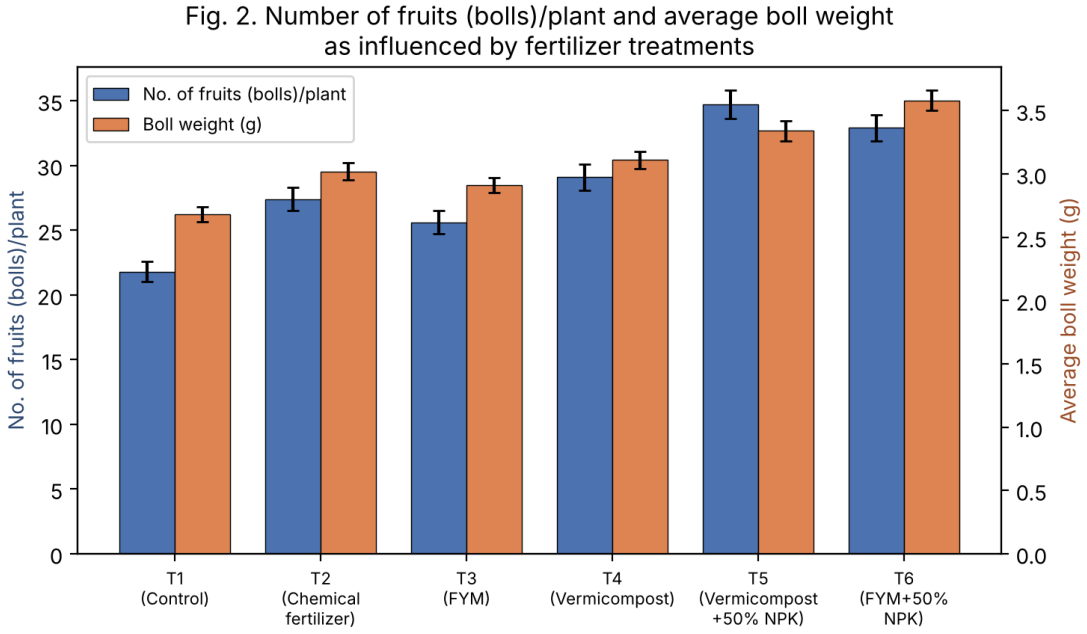


Fig. 2. Number of fruits (bolls) per plant and average boll weight as influenced by fertilizer treatments.

Seed cotton yield

Seed cotton yield differed significantly among treatments (Table 6, Fig. 3). The highest seed cotton yield (2512 kg ha^{-1}) was recorded in T6 (FYM + 50% NPK), representing a 73.0% increase over the control, and was significantly superior to all other treatments, including T5 (2213 kg ha^{-1}; 52.4% increase). Among the sole treatments, vermicompost (T4) produced a higher yield (1921 kg ha^{-1}) than chemical fertilizer (T2, 1854 kg ha^{-1}) or FYM (T3, 1782 kg ha^{-1}) alone. The lowest yield (1452 kg ha^{-1}) was recorded in the unfertilized control.

Treatment	Seed cotton yield (kg/ha)	% increase over control
T1 (Control)	1452 ± 38 f	—
T2 (Chemical fertilizer)	1854 ± 42 d	27.7
T3 (FYM)	1782 ± 40 e	22.7
T4 (Vermicompost)	1921 ± 44 cd	32.3
T5 (Vermicompost+50% NPK)	2213 ± 48 b	52.4
T6 (FYM+50% NPK)	2512 ± 52 a	73.0
LSD (0.05)	78.4	—
CV (%)	3.16	—

Table 6. Effect of fertilizer treatments on seed cotton yield and percent increase over control (mean ± SE; means sharing the same letter within a column do not differ significantly at $p \leq 0.05$).

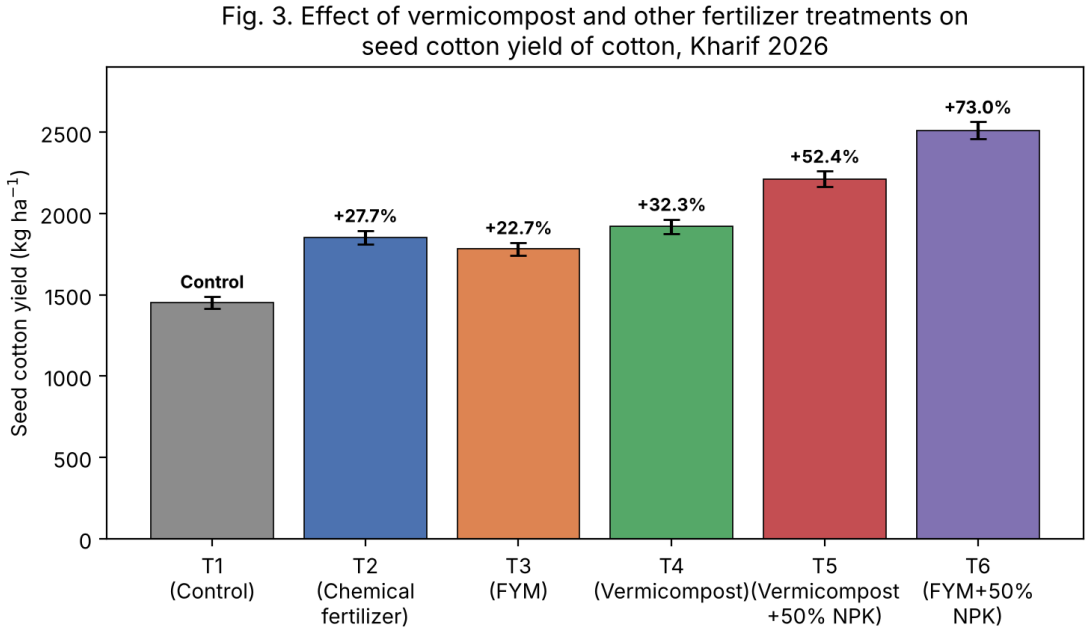


Fig. 3. Effect of vermicompost and other fertilizer treatments on seed cotton yield of cotton, Kharif 2026.

Sucking insect pest populations

Populations of whitefly, jassid and thrips differed significantly among fertilizer treatments (Table 7, Fig. 4). Whitefly adults were most abundant on plants receiving sole chemical fertilizer (T2, 12.6 per three leaves), significantly more than under any other treatment. The lowest whitefly population (6.9) occurred under T5 (vermicompost + 50% NPK), statistically at par with T4 (7.6), a 45.2% reduction relative to T2. The unfertilized control (9.8) and FYM alone (T3, 9.4) supported intermediate populations that did not differ from each other, while T6 (8.3) was significantly lower than both. Jassid nymphs followed the same pattern, ranging from 5.9 per three leaves under T2 to 3.3 under T5 (44.1% lower than T2).

Thrips showed the weakest response to fertilizer source. T2 again recorded the highest population (7.7), but even the lowest populations, under T5 (5.6) and T4 (5.9), were only 27.3% and 23.4% below T2, respectively, and thrips on T3 and T6 did not differ significantly from those on the control or on T4 and T5 (Table 7).

Treatment	Whitefly (adults/3 leaves)	Jassid (nymphs/3 leaves)	Thrips (/3 leaves)	Total sucking pests (/3 leaves)	Reduction over T2 (%)
T1 (Control)	9.8 ± 0.31 b	4.4 ± 0.15 b	6.8 ± 0.24 b	21.0 ± 0.42 b	19.8
T2 (Chemical fertilizer)	12.6 ± 0.38 a	5.9 ± 0.19 a	7.7 ± 0.27 a	26.2 ± 0.50 a	—
T3 (FYM)	9.4 ± 0.30 b	4.5 ± 0.15 b	6.4 ± 0.23 bc	20.3 ± 0.41 b	22.5
T4 (Vermicompost)	7.6 ± 0.26 cd	3.4 ± 0.13 cd	5.9 ± 0.21 c	16.9 ± 0.36 cd	35.5
T5 (Vermicompost+50% NPK)	6.9 ± 0.25 d	3.3 ± 0.12 d	5.6 ± 0.20 c	15.8 ± 0.34 d	39.7
T6 (FYM+50% NPK)	8.3 ± 0.28 c	3.8 ± 0.14 c	6.1 ± 0.22 bc	18.2 ± 0.38 c	30.5
LSD (0.05)	1.02	0.47	0.86	1.41	—
CV (%)	7.8	8.6	8.4	7.1	—

Table 7. Effect of fertilizer treatments on seasonal mean populations of whitefly, jassid and thrips on cotton (mean ± SE of seven fortnightly observations; means sharing the same letter within a column do not differ significantly at $p \leq 0.05$; last column shows the reduction in total sucking pests relative to sole chemical fertilizer).

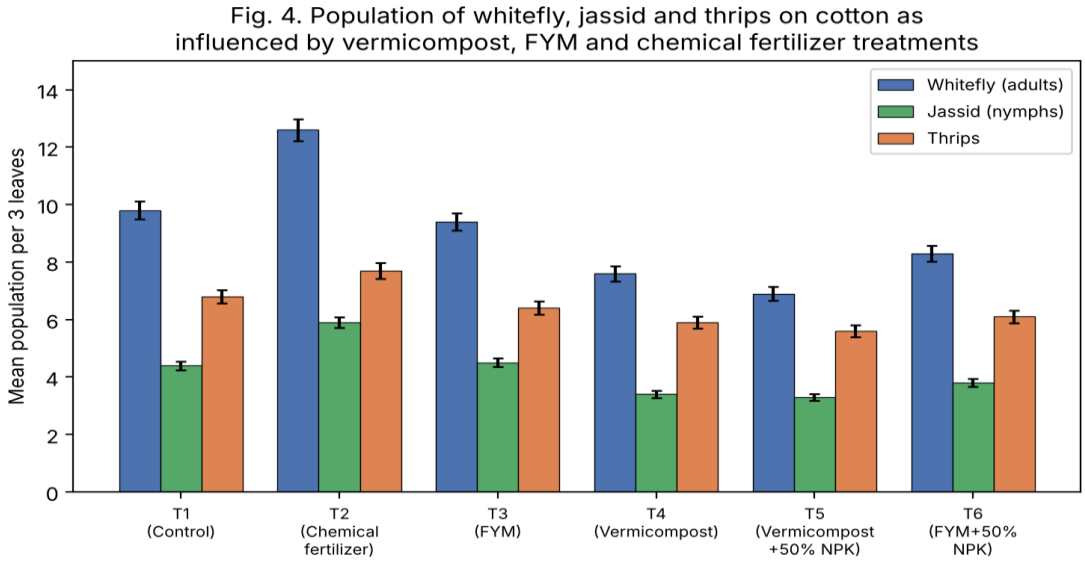


Fig. 4. Population of whitefly, jassid and thrips on cotton as influenced by vermicompost, FYM and chemical fertilizer treatments.

The total sucking pest population (whitefly + jassid + thrips) was highest under T2 (26.2 per three leaves), which was 24.8% above the unfertilized control (21.0), and lowest under T5 (15.8), a 39.7% reduction relative to T2. Vermicompost alone (T4, 16.9) and FYM + 50% NPK (T6, 18.2) reduced the total pest load by 35.5% and 30.5%, respectively, whereas FYM alone (T3, 20.3) did not differ significantly from the control. Pest populations in all treatments rose from 30 DAS, peaked at 75 DAS and declined thereafter (Fig. 5); thrips peaked earliest (around 45 DAS) and whitefly latest (around 90 DAS). At the combined peak, the total population reached 38.5 per three leaves in T2 against 22.9 in T5 (40.6% lower), and treatment differences were widest at this stage.

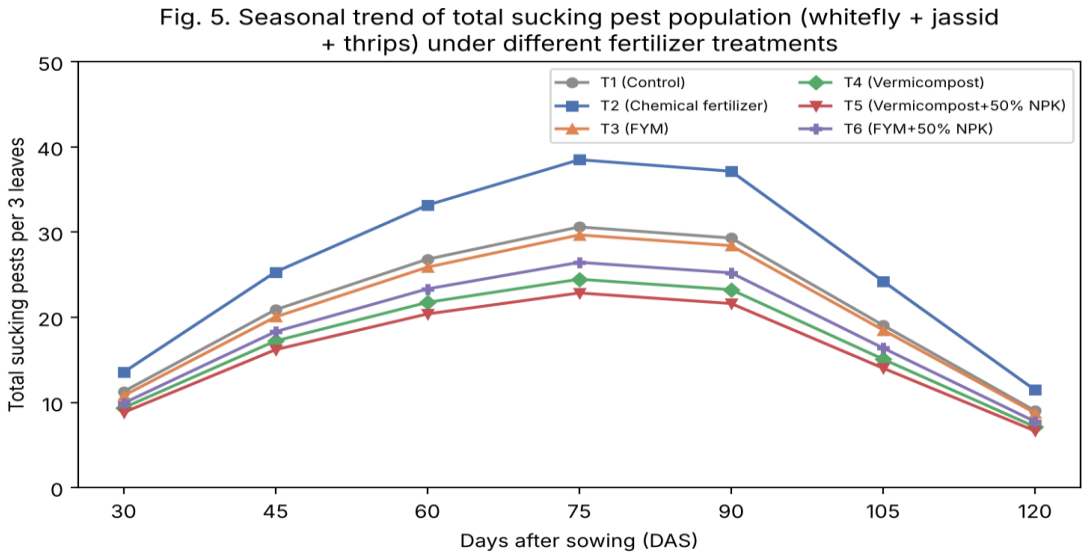


Fig. 5. Seasonal trend of total sucking pest population (whitefly + jassid + thrips) under different fertilizer treatments.

Correlation among yield, growth and pest traits

Simple correlation analysis (Table 8) revealed that seed cotton yield was positively and significantly correlated with boll weight (r = 0.91**) and dry weight of fruits (r = 0.86**), and moderately correlated with number of bolls per plant (r = 0.74*), indicating that boll weight was the trait most closely associated with the superior yield performance of the FYM-based integrated treatment (T6).

Trait pair	Correlation coefficient (r)
Seed cotton yield × No. of bolls/plant	0.74*
Seed cotton yield × Boll weight	0.91**
Seed cotton yield × Dry weight of fruits	0.86**
No. of bolls/plant × Dry weight of fruits	0.88**

Table 8. Simple correlation coefficients among yield and yield-contributing traits of cotton (significant at p ≤ 0.05; ** significant at p ≤ 0.01, n = 18).*

Correlations between pest populations and growth and yield traits (Table 9) were negative but weak to moderate and none reached significance, which is not surprising given that only six treatment means were available (critical r = 0.81 at p ≤ 0.05).

Pest	Seed cotton yield	Fresh weight of leaves	No. of bolls/plant
Whitefly	−0.46 ns	−0.55 ns	−0.57 ns
Jassid	−0.43 ns	−0.50 ns	−0.52 ns
Thrips	−0.50 ns	−0.58 ns	−0.60 ns
Total sucking pests	−0.46 ns	−0.54 ns	−0.57 ns

Table 9. Correlation coefficients between sucking pest populations and growth and yield traits of cotton (treatment means, n = 6; ns = not significant at p ≤ 0.05).

Discussion

Growth and vegetative response

The superior plant height, branching, and leaf biomass observed under vermicompost combined with chemical fertilizer (T5) can be attributed to the synergistic effect of readily available nutrients from inorganic fertilizer and the humic substances, plant growth-promoting microorganisms and hormone like compounds supplied by vermicompost, which enhance root proliferation, nutrient uptake and vegetative vigor (Chaudhry et al., 2020; Nawaz et al., 2021). Similar improvements in vegetative growth with integrated vermicompost and NPK application have been reported in cotton by Saleem et al. (2022) and in other field crops by Choudhary et al. (2021).

Yield and yield components

Although T5 produced more bolls per plant and greater fruit biomass, the significantly higher boll weight recorded under T6 (FYM + 50% NPK) translated into the highest final seed cotton yield, a 73% increase over the control. This finding runs somewhat counter to the general literature trend favoring vermicompost over FYM (Aslam et al., 2022; Gul et al., 2023), but can plausibly be explained by the greater bulk organic matter and superior soil water-holding capacity conferred by FYM relative to vermicompost, which likely sustained soil moisture and photosynthetic supply during the critical boll-filling period under the hot, moisture-limited conditions of Multan, reducing boll abortion and improving individual boll weight even though fewer bolls were set per plant (Rasool et al., 2021; Ali et al., 2021). Chaudhry et al. (2020) similarly reported heavier, better-filled cotton bolls under FYM-amended integrated treatments than under sole application of more readily available nutrient sources. The strong positive correlation between yield and boll weight ($r = 0.91$) observed in this study further supports boll weight, rather than boll number alone, as the principal driver of the yield advantage recorded under T6.

Comparative performance of organic sources

Between the two sole organic amendments, vermicompost (T4) outperformed FYM (T3) across nearly all parameters, corroborating earlier findings that vermicompost, despite being applied at a lower rate (5 t ha^{-1} versus 10 t ha^{-1} FYM), supplies a greater proportion of readily plant-available nutrients due to its advanced state of decomposition and microbial enrichment during the vermicomposting process (Sharma & Garg, 2021; Manivannan et al., 2021). This supports the practical advantage of vermicompost as a more nutrient-dense and logistically efficient organic amendment for cotton production systems where organic matter availability or transport is a constraint (Bhat et al., 2021).

Implications for integrated nutrient management

The consistently superior performance of both integrated treatments (T5 and T6) over their respective sole organic or sole inorganic counterparts reinforces the principle that integrated nutrient management, rather than exclusive reliance on either organic or inorganic sources, offers the most effective strategy for maximizing cotton productivity while reducing the chemical fertilizer requirement by half (Iqbal et al., 2021; Naveed et al., 2022; Zafar-ul-Hye et al., 2021). Given the substantially higher yield advantage of FYM-based integration (T6, +73%) over vermicompost-based integration (T5, +52.4%), FYM supplemented with 50% recommended NPK emerges as the more agronomically and economically promising option for cotton growers in the Multan region, warranting further multi-location and multi-season validation.

Sucking pest populations under different fertilizer sources

Sucking pest populations tracked the nutrient-supply pattern of the treatments more closely than they tracked plant growth. Sole chemical fertilizer (T2) supported the highest populations of whitefly, jassid and thrips, in line with reports that higher nitrogen supply increases whitefly and jassid densities on cotton in Punjab (Ahmed et al., 2007) and that jassid and thrips populations were highest in cotton plots receiving chemical fertilizer alone (Nagendra, 2015). More generally, excess readily available nitrogen is held to lower host-plant resistance to hemipteran pests (Singh & Sood, 2017), probably by improving the nutritional quality of phloem sap for piercing-sucking insects. Organic amendments release nitrogen more slowly and typically result in lower concentrations of soluble nitrogen in plant tissue, which has been put forward as one reason for lower pest numbers in organically fertilized crops.

The lower whitefly and jassid populations under vermicompost (T4) and vermicompost + 50% NPK (T5) than in the unfertilized control indicate that the response was not simply a matter of nitrogen deprivation; balanced fertilization has been reported to strengthen the biochemical, physical and mechanical defences of the plant against hemipteran pests (Singh & Sood, 2017). The pattern for FYM was more modest: FYM alone (T3) did not differ from the control, whereas FYM + 50% NPK (T6) reduced the total pest load by 30.5% relative to T2. This agrees with Channagouda et al. (2017), who recorded significantly lower thrips and aphid populations at 90 DAS in cotton under recommended fertilizer plus FYM than under other nutrient practices, and with Nisar (2002), who found fewer insect pests on organically fertilized cotton at Faisalabad while concluding that organic fertilizer alone would not suffice to control them.

Thrips responded least to fertilizer source, consistent with the lack of a clear trend between nitrogen level and thrips numbers reported by Ahmed et al. (2007); their population also peaked earlier in the season than that of whitefly. Herbivore responses to organic and synthetic fertilizers are not uniform across species (Staley et al., 2009), and natural enemies were not recorded in the present study, so the mechanisms suggested above should be regarded as hypotheses for further testing.

The pest counts were negatively, but not significantly, related to yield and growth traits across treatment means (Table 9). T6 gave the highest yield despite carrying more pests than T5, indicating that yield in this trial was governed mainly by nutrient supply and boll weight rather than by pest load alone. Nevertheless, the integrated treatments combined high yield with lower

sucking pest pressure than sole chemical fertilizer, which may reduce the dependence on insecticide sprays; fertilizer choice should therefore be treated as one component of an integrated pest management programme rather than a substitute for monitoring.

Conclusion

Integrated application of organic amendments with a reduced rate of chemical fertilizer significantly improved the growth, yield-contributing traits and seed cotton yield of cotton over sole fertilizer sources and the unfertilized control. Vermicompost combined with 50% recommended NPK (T5) was most effective in enhancing vegetative growth, branching and fruit-bearing capacity, whereas FYM combined with 50% recommended NPK (T6) produced the highest seed cotton yield (2512 kg ha^{-1}), a 73% increase over the control, mainly through a marked improvement in boll weight. Sole chemical fertilizer (T2) supported the highest populations of whitefly, jassid and thrips, while vermicompost-based treatments (T4 and T5) carried the lowest, with whitefly and jassid more responsive to fertilizer source than thrips.

Recommendation

FYM-based integrated nutrient management can serve as a sustainable and highly productive fertilization strategy for cotton cultivation.

Also offering yield and input-efficiency advantages together with lower sucking pest pressure than conventional chemical fertilization alone.

Author's Contribution

All the authors contributed equal to this research.

Competing Of Interest

There is no conflict of interest.

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