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Comparative evaluation of organic, inorganic, and integrated nutrient management practices on growth and yield attributes of sunflower in alluvial soil

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ABSTRACT

A field experiment was conducted in 2021-2022 and 2022-2023 to investigate the comparative effect of organic, inorganic, and integrated nutrient management practices on the growth and yield of sunflowers in alluvial soils of eastern Uttar Pradesh. The experiment was conducted in twelve treatment combinations with a three-replication under a randomised block design. The application of green leaf @ 20 t ha $^{-1}$ + 50% RDF (T_8) resulted in significantly higher plant height (178.03 cm), stem girth (6.43 cm), number of leaves per plant (28.14), leaf area (546.17 cm^2), head diameter (20.08 cm), head weight (413.72 g), number of seeds per head (704.00), seed yield per head (37.57 g), test weight (5.35 g), and biological yield (64.94 q ha $^{-1}$)The maximum root volume (70.94 cm^3) was observed with the application of green leaf @ 40 t ha $^{-1}$ (T_9). Other treatment combination as well as integrated nutrient management.

Keywords: Growth attributes inorganic fertilizer, organic manure, sunflower, yield attributes

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops and contributes significantly to the global edible oil supply. It is the fourth most cultivated oilseed crop in terms of area worldwide (Yi *et al.,* 2025). Yield and quality of sunflower is regulated by many factors, components and approaches. Among the several factors for lower productivity, imbalanced and insufficient nutrient supply through inorganic fertilizers is the major factor (Savci, 2012), which deteriorates soil health and decreases productivity in subsequent seasons (GTZ, 2009). Excessive fertilization of sunflowers poses environmental risks, negatively impacting grain quality by decreasing soil content and reducing yield owing to increased plant lodging (Kulkarni *et al.,* 2002). In contrast, organic manures are found that significant improvement in soil fertility by enhancing water retention capacity, reducing soil erosion, increasing oxygen levels, and promoting beneficial organisms and overall productivity (Hamza and Abd-Elhady, 2010). Organic materials, such as green manure, poultry manure, vermicompost, and farmyard manure, can be valuable sources of essential nutrients when applied at optimized rates. They also influence the temporal dynamics of nutrient availability by affecting the physical and chemical properties of soil (Akbari *et al.,* 2011). Therefore, the present investigation aimed to understand the relationship between nutrient levels and sunflower yield, which is essential for implementing judicious management practices, especially for resource-poor farmers in the region.

MATERIALS AND METHODS

The experiment was conducted during two consecutive rabi seasons of 2021-2022 and 2022-2023 on agricultural farm of Shri Murli Manohar Town P. G. College Ballia (25^0.76” N latitude, 84^0.12” E longitude, and altitude 59 m), Uttar Pradesh, India. The variety used in this experiment was ‘‘KBSH-1.” The treatments consisted of manure, fertilizer, and their combined use with twelve treatments: T_1 Control (RDF @ 100 N 60 P_2O_5 40 K_2O kg ha^{-1}), T_2 Poultry manure @ 8 t ha^{-1} + 50 % RDF, T_3 Poultry manure @ 10 t ha^{-1}, T_4 FYM @ 20 t ha^{-1}+ 50 % RDF, T_5 FYM @ 40 t ha^{-1}, T_6 Compost @ 20 t ha^{-1}+50 % RDF, T_7 Compost @ 40 t ha^{-1}, T_8 Green leaf @ 20 t ha^{-1}+50 % RDF, T_9 Green leaf @ 40 t ha^{-1}, T_{10} Paddy straw @ 20 t ha^{-1}+50 % RDF, T_{11} 100 % RDF + 40 kg S + 12 kg Zn+ 3 kg B, T_{12} Biochar @ 5t ha^{-1} were laid out in a randomized block design (RBD) with three replications. Organic manure sources, including

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poultry manure, FYM, compost, water hyacinth, Parthenium hysterophorus, paddy straw, and biochar were used in this study. One-year old poultry manure was sourced from a local poultry farm, whereas well-decomposed FYM was obtained from a farmer, and compost purchased from the local market was evenly spread over the plot 20 days before sowing of seeds. Freshwater hyacinth and Parthenium hysterophorus were collected from the college farm pond and nearby fields, respectively, chopped, and incorporated into the soil four weeks before sowing for decomposition. Fresh paddy straw was chapped into 1-2 cm pieces and mixed into the soil one month before cultivation. Biochar was procured from Arista Eco Pvt. Ltd., Karnataka. The inorganic fertilizers viz, urea, single super phosphate (SSP), and muriate of potash (MOP) were purchased from the local market and used as sources of RDF. A half dose of N with the full dose of P and K was applied as basal, and the remaining 50% of nitrogen was top-dressed 30 days after sowing (DAS). Sunflower seeds were sown at a spacing of 45 × 30 cm and a plot size was 3x5 meters. All other recommended agronomic plant protection was adopted to raise the crop, and intercultural practices were taken as per needed. At observation and harvesting, border-row plants were left intact, and five representative plants were randomly selected from each plot to record various growths and yield attributes. Growth attributes included plant height (cm), stem girth (cm), number of leaves per plant, and leaf area (cm^2), as described by Saxena and Singh (1965). Additionally, yield attributes were measured, including the diameter of the head (cm), weight of the head (g), seed yield per head (g), number of seeds per head, test weight of 100 seeds (g), and harvest index (%), which is the ratio of economic to biological yield, as outlined by Donal (1962). The following analysis of variance (ANOVA) technique and mean differences were adjusted using a multiple comparison test (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Growth attributes

The application of organic and inorganic sources of nutrients in different combinations marked variations in the growth attributes of sunflowers (Table 1). The tallest plants height (178.03 cm) was observed under the treatment combination of green leaf @ 20 t ha^{-1}+50 % RDF (T_8), followed by green leaf @ 40 t ha^{-1} (T_9) 166.10 cm, might be due to using of organic manure significantly increased plant height (Reyhan and Amiaslani 2006). Poultry manure @ 8 t ha^{-1} + 50 % RDF (T_2) increased plant height of 160.01 cm, which aligns with the findings reported by Nanjundappa *et al.* (2001). In contrast, the lowest plant height (115.55 cm) was recorded in the Biochar at 5t ha^{-1} (T_{12}) treatment, indicated that biochar was less effective in promoting vertical growth than other treatments. Stem girth remained relatively consistent across most treatments, with a minimum value of 4.90 cm recorded in the

Table 1: Effect of manure, fertilizer and their combined use on crop growth attributes (Pool data of 2021-2022 and 2022-2023 seasons)

Treatment	Plant Height (cm)	Stem girth (cm)	No. of leaves per plant	Leaf area (cm^2)	Root Volume cm^3
T_1	137.61	5.25	23.00	313.81	58.40
T_2	160.01	5.53	25.84	404.07	56.54
T_3	157.76	5.61	25.70	361.76	55.60
T_4	149.19	5.60	24.83	337.83	66.20
T_5	147.26	5.65	24.90	335.46	67.54
T_6	143.57	5.54	24.73	335.62	56.00
T_7	139.61	5.64	24.20	337.33	59.67
T_8	178.03	6.43	28.14	546.17	69.80
T_9	166.10	6.16	27.64	460.65	70.94
T_{10}	145.57	5.50	23.35	325.93	62.67
T_{11}	142.41	5.26	22.97	332.80	59.00
T_{12}	115.55	4.90	17.24	313.42	48.80
S.Em. (±)	3.3345	0.14	1.280	4.21	0.58
C.D.@ 5 %	9.7805	0.40	3.760	12.34	1.67

biochar @ 5 t ha^{-1} (T_{12}) treatment and a maximum of 6.43 cm observed in the green Leaf @ 20 t ha^{-1}+50% RDF (T_8) treatment. The use of organic manures, along with their combinations with inorganic materials, showed the role of organic amendments in enhancing the structural strength of the stem girth. Similar results have been reported by Reddy *et al.* (2009). The highest number of leaves per plant (28.14) was recorded under green leaves @ 20 t ha^{-1}+50% RDF (T_8), followed closely (27.64) by green leaves @ 40 t ha^{-1} (T_9). The lowest number of leaves per plant, recorded at 17.24, was observed in the biochar @ 5 t/ha (T_{12}) treatment. The finding emphasizes the effectiveness of combining organic and inorganic nutrients to enhance vegetative growth and increase the number of leaves (Maheshbabu *et al.* (2007). The maximum leaf area (546.17 cm^2) was observed in green leaf @ 20 t ha^{-1}+50 % RDF (T_8), followed by 460.65 cm^2 in the green leaf @ 40 t ha^{-1} (T_9) and 404.04 cm^2 in the poultry manure @ 8 t ha^{-1} + 50 % RDF (T_2) (Rasool *et al.,* 2013). In comparison, the lowest leaf area (313.42 cm^2) was recorded in the biochar @ 5 t ha^{-1} (T_{12}) treatment, indicating a limited impact of biochar on leaf expansion. green Leaf @ 40 t ha^{-1} (T_9) resulted in the highest root volume, measuring 70.94 cm^3, indicating enhanced root growth and improved soil structure (Angadi, and Entz, 2002). The green leaf @ 20 t ha^{-1}+50 % RDF (T_8) treatment (69.80 cm^3) and FYM @ 40 t ha^{-1} (T_5) treatment (67.54 cm^3) also effectively promoted root development. In contrast, biochar @ 5 t ha^{-1} (T_{12}) exhibited the lowest root volume at 48.80 cm^3, likely due to its slow nutrient mineralization rate. The superior performance of the green leaf @ 20 t ha^{-1}+50 % RDF (T_8) indicated the need for adding organic manure to the soil in conjunction with inorganic fertilizers. Organic manure improves the soil structure, water retention, and microbial activity, thereby enhancing nutrient availability. When combined with inorganic nutrients, they ensure a steady and balanced nutrient supply, thereby promoting better plant growth (Abdel Gader, 2010). The application of organic and inorganic compounds resulted in increased growth parameters of sunflowers, as shown. The inferior performance of biochar @ 5 t ha^{-1} (T_{12}) might be attributed to slow nutrient release and limited nutrient availability (Ali *et al.,* 2024).

Table 2: Effect of manure, fertilizer and their combined use on crop yield attributes (Pool data of 2021-2022 and 2022-2023 seasons)

Treatment	Diameter of head cm	Weight of head (g)	Number of seed per head	Seed yield per head (g)	Test weight (g)
T_1	16.60	341.74	629.50	31.14	5.02
T_2	18.62	384.74	662.50	34.92	5.29
T_3	18.02	379.37	655.50	34.53	5.29
T_4	17.97	369.10	642.50	33.64	5.26
T_5	17.80	362.39	636.00	33.17	5.22
T_6	17.62	368.90	646.00	33.47	5.20
T_7	17.42	356.12	636.50	32.75	5.19
T_8	20.08	413.72	704.00	37.57	5.35
T_9	19.22	402.65	689.00	36.57	5.32
T_{10}	17.47	357.34	622.50	32.55	5.24
T_{11}	16.69	352.68	608.50	32.13	5.30
T_{12}	12.45	283.72	500.00	24.77	4.97
S.Em. (±)	0.39	3.56	12.69	0.66	0.01
C.D.@ 5 %	1.15	10.45	37.23	1.93	0.03

Yield attributes

The pool data of sunflower yield attributes are presented in Table 2. The largest head diameter, measuring 20.08 cm, was significantly recorded with the treatment of green leaves @ 20 t ha^{-1}+50 % RDF (T_8), followed closely by a diameter of 19.22 cm observed in green leaves @ 40 t ha^{-1} (T_9) might be due to green manure increased the average yield compared to treatments without green manure (Bhal and Pasricha 2000). In contrast, the smallest head diameter, measuring 12.45 cm, was observed with the application of biochar @ 5t ha^{-1} (T_{12}) (Alburquerque *et al.,* 2014). The highest weight of the sunflower head was

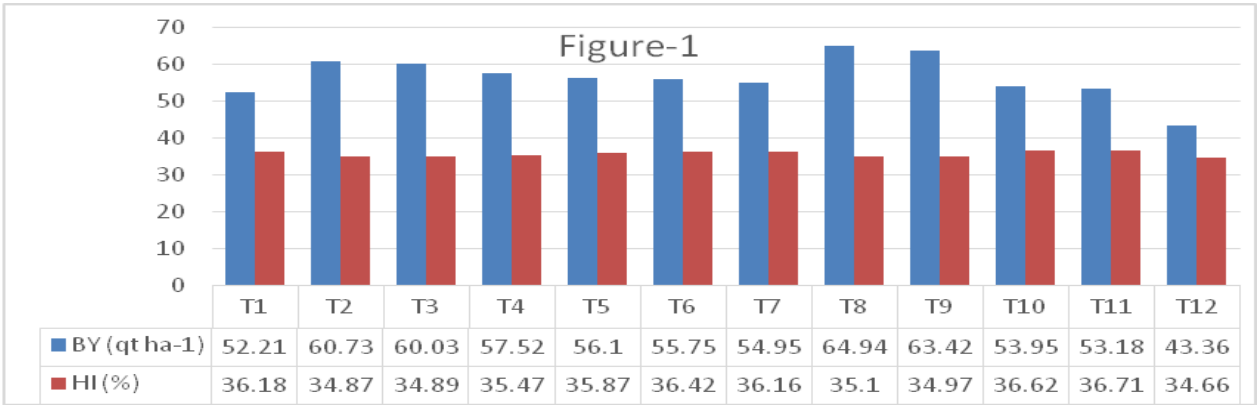

Figure 1: Effect of manure, fertilizer, and their combined use on biological yield and harvest index parameter (Pool data of 2021-2022 and 2022-2023 seasons)

recorded at 413.72 g in the treatment combination of green leaf @ 20 t ha^{-1}+50 % RDF (T_8). This was followed by a head weight of 402.65 g in green leaves @ 40 t ha-1 (T_9) and 384.74 g in poultry manure @ 8 t ha^{-1} + 50 % RDF (T_2). In contrast, the lowest head weight (283.72 g was observed in the biochar @ 5t ha^{-1} (T_{12}). These results are consistent with those obtained for sunflowers (Ram *et al.,* 1992 and Mallikarjuna *et al.,* 2000). The combination of green leaf @ 20 t ha^{-1}+50 % RDF (T_8) led to the highest no of seeds per head 704. This finding aligns with the reports of Manivannan *et al.* (2009) and Rajaram *et al.* (2024) which indicated that using a combination of fertilizers and manure resulted in the maximum number of seeds. Green leaves @ 40 t ha^{-1} (T_9) produced 689 seeds, and poultry manure @ 8 t ha^{-1} + 50 % RDF (T_2) yielded 662 seeds, both of which were also effective. In contrast, the lowest seed count of 500 seeds was recorded with biochar @ 5 t ha^{-1} (T_{12}). The treatment using green leaf @ 20 t ha^{-1}+50 % RDF (T_8), produced the highest seed yield per head of 37.57 g. Singh (2020) reported that application of organic and inorganic sources of nutrients increased the grain. This was followed by green leaf 40 t ha^{-1} (T_9), which yielded 36.57 g, and poultry manure @ 8 t ha^{-1} + 50 % RDF (T_2), which yielded 34.92 g, indicating that organic manure can have a synergistic effect when used in combination with inorganic fertilizers (Das *et al.,* 2006). The lowest seed yield per head (24.77 was recorded with biochar @ 5 t ha^{-1} (T_{12}) (Jeffery *et al.,* (2011), suggesting that applying biochar doses below 5 t ha^{-1} does not generate consistent yield increases. The highest test weight was observed in the green leaf in the 20t ha^{-1}+50 % RDF (T_8) treatment, measuring 5.35 g, followed by the green leaf 40 t ha^{-1} (T_9) treatment at 5.32 g and the 100 % RDF + 40 kg S + 12 kg Zn+ 3 kg B (T_{11}) treatment at 5.30 g, indicated that positive interaction between B and S could synergistically enhance seed yields. (Tahir *et al.* (2014). The lowest test weight (4.97 g was recorded with 5 t ha^{-1} biochar (T_{12}). Might be due to organic manure improved the physical quality of seeds by enhancing nutrient availability and soil moisture retention.

Biological yield and Harvest index

The data pertaining to biological yield and harvest index (Figure 1) revealed that the maximum biological yield 64.94 q ha^{-1} was calculated in the application of green leaf @ 20 t ha^{-1}+50 % RDF (T_8), whereas slightly higher biological yield calculated in the green leaf @ 40 t ha^{-1} (T_9) 63.42 q ha^{-1} and the minimum biological yield 43.36 q ha^{-1} was calculated in the biochar @ 5t ha^{-1} (T_{12}). The response to applied fertilizers could be attributed to availability of nutrients in the soil during the physiological growth and development stages of the plants, (Shehata & El-Khawas, 2003) and Yasin *et al.,* 2013). The maximum harvest index (36.71 %) was calculated with the application of the 100 % RDF + 40 kg S + 12 kg Zn+ 3 kg B (T_{11}), whereas a slightly higher harvest index was calculated in 36.62% of the Paddy straw @ 20 t ha^{-1} +50 % RDF (T10), and the minimum harvest index (34.66 %) was calculated in the biochar @ 5t ha^{-1} (T12). Sunflower yield parameter is significantly increased by combining organic manures and inorganic fertilizers, leading to superior yield components compared to sole organic manure application (Bheemaiah and Subrahmanyam, 2004).

CONCLUSION

The application of different organic and inorganic nutrient sources, including biochar, has appeared to increase yield and growth attributes, but the application of green leaf @ 20 t ha-1+50 % RDF has significantly increased the growth and yield of the sunflower crop. Among the organic and inorganic sources of nutrients, the finding highlighted that sole reliance is less effective than the balanced interrogation of organic and inorganic nutrients.

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