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EFFECT OF DIFFERENT FARMYARD MANURE DOSES AND PHOSPHORUS RATES ON GROWTH AND YIELD OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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A B S T R A C T

The study comprises the effects of various ratios of phosphorus (P) and farmyard manure (FYM) on a variety of sunflower agronomic traits. Plant population, plant height, spike length, head diameter, number of seeds per head, weight of seeds per head, seed index, and seed yield were among these features. Five integrated applications of FYM and phosphorus were tested, namely T_1 (00-ton FYM + 00 kg P ha^{-1}), T_2 (1-ton FYM + 30 kg P ha^{-1}), T_3 (3-ton FYM + 60 kg P ha^{-1}), T_4 (4-ton FYM + 90 kg P ha^{-1}), and T_5 (5-ton FYM + 120 kg P ha^{-1}). Out of all the treatments given to the sunflower crops, the T5 treatment, which included applying 5 tons of FYM and 120 kg of P per hectare, produced the best results. This treatment yielded the highest number of seeds per head (2696.9), the heaviest seed weight per head (60.7 g), the largest seed index (32.7 g), the tallest plant height (273.7 cm), the widest stem girth (10.9 cm), the largest head diameter (53.8 cm), and the highest seed yield (2698.7 kg per hectare). On the other hand, the T1 treatment, which did not get either FYM or P, showed the least favorable results. This treatment exhibited the smallest plant height (217.7 cm), narrowest stem girth, and lowest plant density (6.6 plants per square meter). These findings recommend applying 5 tons of FYM and 120 kg of P to enhance the growth and seed yield of sunflower crops. The results clearly demonstrated that applying FYM and phosphorus significantly influenced sunflower growth and yield compared to the control plot (without FYM and phosphorus). The grain yield of sunflower showed a linear increase with increasing levels of FYM and phosphorus. Notably, the plot treated with 5 tons of FYM and 120 kg of P had the highest sunflower grain yield.

Keywords: Growth, Yield, Phosphorus, Farmyard manure, Sunflower.

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INTRODUCTION

Sunflower (*Helianthus annuus* L.) is cultivated widely as a globe of vital oilseed crops and belongs to the Compositae family (Vangelisti et al., 2022). According to reports, edible oil is one of the most significant everyday goods. The import bill for edible oil in 2018-19 was Rs 192.203 billion (GoP, 2019). Pakistan ranks as the third-largest exporter of edible oil. According to the Economic Survey of Pakistan, in the fiscal year 2015-16, the country's oil consumption reached 2.905 million tons. The remaining amount was exported, resulting in expenses of 44 billion rupees, with local producers meeting only 27 percent of this total (GoP, 2019). With the highest amount of edible oil imports, Pakistan comes in third place around the globe Soomro et al. (2015). A crop with great phenotypic plasticity that can be grown on every continent is the sunflower (Arif et al., 2017). Magsi et al. (2023) reported that sunflower is one of the most important oil crops in the world, valued for both its edible oil and its usage in animal feed. It is ranked second only to soybeans. Sunflower seeds normally have an oil content of 30 to 42 percent and a protein level of 20 to 21 percent, according to Awais et al. (2018). Farmyard manure (FYM) is recognized as an important source of nutrients, offering micronutrients that are critical for plant growth in addition to macronutrients like nitrogen, phosphorous, potassium, calcium, magnesium, and sulfur. It provides plants with an instant supply of nitrogen and releases more nutrients gradually as it breaks down. Moreover, FYM improves soil structure, water retention, nutrient accessibility, and fosters an environment that is favorable for soil microbes (Nouraein et al., 2019). Sunflowers may grow in a variety of soil types and climates (Nasim et al., 2018; Soomro et al., 2023). Packed full of vital nutrients for plants, FYM guarantees a consistent supply all through the crop cycle, improving traits linked to growth and output. Higher yields of straw and seeds are a result of this improved vigor in plant development and yield qualities. When it comes to soil fertility and productivity, FYM has a greater favourable influence than other fertilizer sources. In addition, FYM supplies nutrients that promote plant development, good bacteria that help produce humus, and microorganisms that improve soil nitrogen fixation. These elements are necessary to preserve the health of the soil and increase crop yield. According to Dambale et al. (2018), FYM normally comprises 0.5% nitrogen (N), 0.2% phosphorus (P), and 0.5% potassium (K). These elements are essential for maintaining soil health and attaining self-sufficiency in sunflower agriculture. By raising the levels of soil organic carbon, organic manures like FYM help make primary and secondary nutrients more accessible and guarantee a sufficient supply of vital micronutrients. Composted phosphorus and chemical fertilizers, when mixed with FYM, work synergistically to increase crop yields. Moreover, FYM and effective microorganisms (EM) work together to speed up the breakdown process and promote phosphorus's enhanced solubility from rock phosphate (RP) (Mallick and Majumder, 2023) and (Manzoor et al., 2024a). A crucial macronutrient, phosphorus, is often lacking in agricultural systems across the world. Sustaining ideal phosphorus levels in the cropping system has a significant impact on a number of crop growth factors. A sufficient amount of phosphorus increases grain yield while also enhancing the quality of the grains that are harvested. Furthermore, it promotes robust root growth and accelerates the maturity of crops. In the case of maize cultivation, the application of phosphorus fertilizers proves to be most advantageous when administered during the sowing phase rather than in later stages. To better understand the significance of phosphorus in crop production and its solubility enhancement through biological methods, studies were conducted to investigate the impact of phosphorus and farmyard manure (FYM) application, both with and without effective microorganisms, on wheat yields and plant phosphorus uptake. Additionally, the residual effects of these treatments on the subsequent sunflower crop were examined (Kaleri, 2023; Mukherjee et al., 2019).

MATERIALS AND METHODS

To investigate the effects of soil-applied fertilizers on the growth and yield of sunflowers the experiment was structured using a completely randomized block design, with each plot measuring 6 m x 5 m (30 m^2). Land preparation methods appropriate for sunflower cultivation were applied, with emphasis placed on the HO^{-1} local variety, replicated three times. The fertilizers employed in the study included phosphoric fertilizer and farmyard manure.

Culture Practices

The soil underwent meticulous preparation, undergoing two rounds of ploughing and leveling before the planting process commenced. At the time of sowing, each treatment received the appropriate quantity of farmyard manure. Throughout the study period, phosphatic fertilizer was administered at different stages of sunflower growth. To monitor the growth and progression of the plants, five specimens from each plot were selected every five days within the initial 10 days following crop emergence.

1. T_1 = control (no FYM or phosphate)
2. T2 is equal to FYM at 1 tone and phosphorus at 30 kg ha^{-1}.
3. T_3 = FYM @ 3 tones + phosphorus @ 60 kg ha^{-1}
4. T_4 = FYM @ 5 tones + phosphorus @ 90 kg ha^{-1}
5. T_5 = FYM @ 7 tones + phosphorus @ 120 kg ha^{-1}

At the maturity stage of the experiment, we randomly selected 15 plants from each group to assess their plant height, stem thickness, and head diameter. The seed heads were delicately detached from each plant, threshed, and subsequently examined to determine the number of seeds per head, seed weight per head, weight of 1000 seeds (seed index), and total seed yield. Every collected dataset was meticulously documented for subsequent analysis.

Statistical Analysis

Using Statistix-8.1 computer software, an ANOVA was used to perform statistical analysis on the gathered data (Statistix, 2006). The LSD test was used to examine the effectiveness of various therapies in situations where they were still considered necessary.

RESULTS

Plant Population (m^{-2})

The results indicated a significant difference ($p<0.05$) in sunflower growth under different levels of FYM (farmyard manure) and phosphorus. T5 (5 tons of FYM + 120 kg of P ha-1) showed the highest plant population (10.5 plants per square meter). T4 (4 tons of FYM + 90 kg of P ha-1) came next, boasting a plant population of 9.9 plants per m2. T_3 (3 tons of FYM + 60 kg of P ha^{-1}) had a plant population of 8.6 plants per m^2. On the other hand, the lowest plant population of 6.6 plants m2 was recorded in T_1 (no FYM + no P), and T_2 (1 tons of FYM + 30 kg of P ha^{-1}) had a plant population of 7.0 plants m^2.

Plant Height (cm)

In terms of plant height (cm), treatment T_5 (comprising 5 tons of FYM and 120 kg of P ha^{-1}) yielded the tallest plants, reaching a height of 273.7 cm. T_4 (4 tons of FYM + 90 kg of P ha^{-1}) exhibited a plant height of 261.0 cm, whereas T_3 (3 tons of FYM + 60 kg of P ha^{-1}) showed a plant height of 240.3 cm. Conversely, the shortest plants, with a height of 217.7 cm, were observed in T_1 (no FYM + no P), while T_2 (1 tons of FYM + 30 kg of P ha^{-1}) had a plant height of 229.0 cm.

Stem Girth (cm)

In terms of stem girth (cm), treatment T_5 (consisting of 5 tons of FYM and 120 kg of P ha^{-1}) produced the thickest stems, measuring 10.9 cm in girth. T_4 (4 tons of FYM + 90 kg of P ha^{-1}) displayed a stem girth of 10.7 cm, while T_3 (3 tons of FYM + 60 kg of P ha^{-1}) exhibited a stem girth of 10.4 cm. On the other hand, T1 (no FYM + no P) had the smallest stem girth at 9.3 cm, while T2 (1 tone of FYM + 30 kg of P ha-1) had a stem girth of 9.5 cm.

Head Diameter (cm)

The treatment T_5, consisting of 5 tons of FYM (farmyard manure) and 120 kg of phosphorus ha^{-1}, exhibited the largest head diameter among the crops, measuring 53.8 cm. Following closely, treatment T_4, which involved 4 tons of FYM and 90.00 kg of phosphorus ha^{-1}, displayed the second-highest head diameter of 46.4 cm. Treatment T_3, with 3 tons of FYM and 60 kg of phosphorus ha^{-1}, yielded a head diameter of 42.4 cm. On the other hand, the smallest head diameter of 30.3 cm was recorded in treatment T_1, with no FYM and no phosphorus applied, followed by a head diameter of 36.0 cm in treatment T_2, which involved 1 tone of FYM and 30 kg of phosphorus ha^{-1}.

Table 1 Different farmyard manure doses and phosphorus rates on growth and yield of sunflower.

Treatments	Plant population (m^{-2})	Plant height (cm)	Stem girth (cm)	Head diameter (cm)
T_1 = 00 ton FYM + 00 P kg ha^{-1}	6.6 d	217.7 d	9.3 d	30.3 d
T_2 = 1 tons FYM + 30 P kg ha^{-1}	7.0 c	229.3c	9.5 c	36.0 c
T_3 = 3 tons FYM + 60 P kg ha^{-1}	8.6 b	240.3b	10.4 b	42.4 b
T_4 = 4 tons FYM + 90 P kg ha^{-1}	9.9 a	261.0 a	10.7a	46.4 a
T_5 = 5 tons FYM + 120 P kg ha^{-1}	10.5 a	273.7a	10.9a	53.8 a
S.E. ±	0.4673	4.7823	3.7845	2.8972
P value	0.0000	0.0000	0.0000	0.0000
LSD 0.05%	0.3188	1.0871	0.2595	3.0639

Number of seeds per head

Treatment T5 obtained the highest count of 2696.7 seeds per head, followed by treatment T4 with 2443.7 seeds per head. Treatment T3 yielded 2142.7 seeds per head, while treatment T1 yielded the lowest count of 1510.7 seeds per head. Treatment T_2 yielded 1815.0 seeds per head.

Seed weight head^{-1} (g)

The weight of seed head^{-1} was found to be the greatest in treatment T_5, with a weight of 60.7 grams. Treatment T_4 recorded a weight of 53.1 grams while treatment T_3 resulted in a weight of 42.2 grams. Treatment T1 achieved the minimum weight of seeds head-1 at 26.6 grams, while treatment T2 yielded 33.6 grams.

Seed index (g)

Treatment T5 had the highest seed index at 32.7 grams, followed by treatment T4 at 31.7 grams. Treatment T3 recorded a seed index of 27.0 grams, while treatment T1 recorded the lowest index of 23.0 grams. Treatment T_2 had a seed index of 25.7 grams.

Seed yield kg ha^{-1}

Finally, treatment T5 yielded the highest seed kg ha^{-1}, with a yield of 2698.7 kg ha^{-1}. Treatment T_4 recorded a yield of 2617.3 kg ha^{-1}, while treatment T_3 resulted in a yield of 2499.7 kg ha^{-1}. Treatment T1 yielded the lowest seed yield of 2100.0 kg ha^{-1}, while treatment T2 yielded 2348.7 kg ha^{-1}.

Table 2. Different farmyard manure doses and phosphorus rates on growth and yield of sunflower.

Treatments	Number of seeds head^{-1}	Seeds weight head^{-1} (g)	Seed index (1000-seeds wt., g)	Seed yield kg ha^{-1}
T_1 = 00 ton FYM + 00 P kg ha^{-1}	1510.7 d	26.6 d	23.0 d	2100.0 d
T_2 = 1 tons FYM + 30 P kg ha^{-1}	1815.0 c	33.6 c	25.7 c	2348.7 c
T_3 = 3 tons FYM + 60 P kg ha^{-1}	2142.7 b	42.2 b	27.0 b	2499.7 b
T_4 = 4 tons FYM + 90 P kg ha^{-1}	2443.7 a	53.1 a	31.7 a	2617.3 a
T_5 = 5 tons FYM + 120 P kg ha^{-1}	2696.7 a	60.7 a	32.7 a	2698.7 a
S.E. ±	5.9852	0.4426	0.4672	3.4572
P value	0.0000	0.0000	0.0000	0.0000
LSD 0.05%	147.55	1.8911	1.6124	58.163

DISCUSSION

The findings indicated that the treatment containing 5 tons of farmyard manure (FYM) combined with 120 kg ha1 of phosphorus (P) resulted in the best outcomes. This treatment exhibited the highest plant population m^2 (10.5), tallest plant height (273.7 cm), widest stem girth (10.9 cm), largest head diameter (53.8 cm), highest number of seeds head^{-1} (2696.9), heaviest seed weight head-1 (60.7 g), largest seed index (32.7 g), and highest seed yield (2698.7 kg ha-1). On the other hand, the treatment with no FYM and no phosphorus (T_1) yielded the lowest results, with a plant population per square meter of 6.6, plant height of 217.7 cm, stem girth of 9.3 cm, head diameter of 30.3 cm, number of seeds head^{-1} of 1510.7, seed weight head^{-1} of 26.6 g, seed index of 23.0 g, and seed yield of 2100.0 kgha-1.

These results indicate that 5 tons of FYM and 120 kg of phosphorus per hectare should be applied in sunflower farming to achieve higher growth and seed output. In comparison to the group that did not apply farmyard manure (FYM) or phosphorus, the study showed a substantial influence on the growth and production of sunflower plants when FYM and phosphorus were applied. The crop yield of sunflower showed a steady increase with higher FYM and phosphorus treatment levels. However, the treatment with 5 tons of FYM and 120 kg ha1 of phosphorus produced the maximum grain yield for sunflower. The current study's findings demonstrate that both farmyard waste and inorganic fertilizers significantly enhanced the vegetative growth characteristics. The findings of this study align with those of Piracha et al. (2023), attributing the significant contribution of farmyard manure to the supply of essential plant nutrients to a specific researcher or research group.

In semi-arid regions, crop yield is predominantly influenced by the interaction between water and nutrient availability, affecting the source-sink relationship. At the plant level, one of the crucial factors governing growth and development is the equilibrium between the demands for organic assimilates and their availability (Kaleri et al., 2024b; White et al., 2016). In this recent investigation, nutrient management demonstrated a noticeable impact on both sink and source organs. Consequently, both organic and inorganic fertilizers had discernible effects on leaf number and surface area. The main organ responsible for photosynthetic processes, leaves are essential for light absorption, Evapotranspiration, and high fertilizer and irrigation responses (Kaleri et al., 2024a; Mahapatra et al., 2021).

Expanding leaf coverage not only serves as a protective barrier, reducing soil surface evaporation, but also directly influences the rate of food production through photosynthesis. Reducing water vapor evaporation from the soil surface can improve water conservation at critical development phases in dry agricultural contexts when water supply is restricted, improving overall water usage efficiency (Singh et al., 2017). This idea is supported by the results of our earlier study, which showed that efficient fertilizer management greatly enhanced the source size of safflower plants (Janmohammadi et al., 2016). Moreover, the concentration of chlorophyll demonstrated a significant reaction to nutrient management, reaching its maximum when zinc and farmyard manure were administered at the same time. The amount of chlorophyll and the plant's ability to absorb carbon dioxide during photosynthesis are tightly correlated. Hence, an increase in chlorophyll content can be seen as a reinforcement of the source's vigor.

Consequently, a comprehensive definition of source strength should encompass the rate of export of photosynthesis from the source tissue (Kousar et al., 2020; Manzoor et al., 2024b). Plant growth, resource allocation, and sink size can all be impacted by nutrient management. Applying as much phosphorus as possible to sunflower recorded the highest plant height at harvest (273.7 cm) and seed yield (2698.7 kg ha^{-1}). This might be because AM fungus formed an outer layer of mycelium surrounding the roots, which may have improved the availability of nutrients at the root surface, leading to an increase in the plant's intake and growth. A related discovery was previously published by (Hammad et al., 2021; Laghari et al., 2023). Among the various phosphorus levels, application of 5 tons FYM + 120 P kg ha^{-1} significantly recorded the highest plant population (10.5 cm), stem girth (10.9 cm), and head diameter (53.8 cm). In the therapy, the growth attribute values were the lowest 00-ton FYM + 00 P kg ha^{-1}. This might be explained by the fact that FYM and P accelerate crop growth by having a stimulating influence on root development and expansion. Similar results were previously published by Alzamel et al. (2022).

CONCLUSIONS

The research findings indicated that the growth of sunflowers and the quantity of seeds produced were significantly impacted by the levels of farmyard manure (FYM) and potassium, in contrast to plots managed without any fertilizer. As the levels of FYM and phosphorus rose, there was a proportional increase in seed yield. Notably, the plot treated with 5 tons of FYM + 120 kg ha-1 of phosphorus exhibited the highest sunflower seed yield at 2698.7 kg ha-1, closely followed by the plot treated with 4 tons of FYM + 90 kg ha-1 of phosphorus at 2617.3 kg ha-1. Overall, the differences in seed yield among the various treatments were marginal.

CONFLICT OF INTEREST

The authors declare that there is no conflict in the publication of this article.

AUTHOR’S CONTRIBUTION

All the authors contributed equally in research, data analysis, manuscript writing and editing.

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