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Agronomic Performance of Sesame (Sesamum Indicum L.) Under Different Levels of Nitrogen and Phosphorus Fertilizers Management

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ABSTRACT:

The field experiment was conducted during Rabi 2024 to study effect of nitrogen and phosphorus application on growth and yield of sesame at The Experimental Farm for Students within the Department of Agronomy at Sindh Agriculture University, Tandojam, is organized according to a randomized complete block design (RCBD) with three replications. The treatments included T_1 = Control (No fertilizer), T_2 = 30-40 NP kg ha^{-1}, T_3 = 40-50 NP kg ha^{-1}, T_4 = 50-60 NP kg ha^{-1}, T_5 = 60-70 NP kg ha^{-1} and T_6 = 70-80 NP kg ha^{-1}. The results of the study indicated that the sesame treated with 70-80 NP kg ha^{-1} resulted maximum 179.5 cm plant height, 12.2 branches plant^{-1}, 170.8 capsules plant^{-1}, 43.7 seeds capsule^{-1}, 51.8 g seed weight plant^{-1}, 4.3 g seed index, 5213.4 kg ha^{-1} biological yield and 670.6 kg ha^{-1} seed yield. The nitrogen and phosphorus @ 60-70 kg ha^{-1} resulted 161.7 cm plant height, 10.7 branches plant^{-1}, 150.9 capsules plant^{-1}, 39.7 seeds capsule^{-1}, 45.9 g seed weight plant^{-1}, 3.8 g seed index, 4812.3 kg ha^{-1} biological yield and 625.9 kg ha^{-1} seed yield. Similarly, the sesame treated with 50-60 NP kg ha^{-1} resulted 140.1 cm plant height, 9.2 branches plant^{-1}, 133.8 capsules plant^{-1}, 35.1 seeds capsule^{-1}, 39.6 g seed weight plant^{-1}, 3.6 g seed index, 4311.7 kg ha^{-1} biological yield and 573.6 kg ha^{-1} seed yield. Nitrogen and phosphours 40-50 kg ha^{-1} resulted 125.6 cm plant height, 7.6 branches plant^{-1}, 111.4 capsules plant^{-1}, 28.8 seeds capsule^{-1}, 34.5 g seed weight plant^{-1}, 3.2 g seed index, 3941.3 kg ha^{-1} biological yield and 521.9 kg ha^{-1} seed yield. 30-40 NP kg ha^{-1} resulted 115.9 cm plant height, 6.7 branches plant^{-1}, 91.7 capsules plant^{-1}, 24.7 seeds capsule^{-1}, 26.7 g seed weight plant^{-1}, 3.1 g seed index, 3551.6 kg ha^{-1} biological yield and 473.8 kg ha^{-1} seed yield. However, control (No fertilizer) resulted minimum 100.2 cm plant height, 5.3 branches plant^{-1}, 71.9 capsules plant^{-1}, 19.8 seeds capsule^{-1}, 21.5 g seed weight plant^{-1}, 2.8 g seed index, 3129.4 kg ha^{-1} biological yield and 421.6 kg ha^{-1} seed yield. After going through the findings of the present research, it was concluded that the growth and yield of sesame increased simultaneously with increasing nitrogen and phosphorus levels and the sesame fertilized with 70-80 NP kg ha^{-1} resulted in maximum seed yield (670.6 kg ha^{-1}), followed by 60-70 NP kg ha^{-1} (625.9 kg ha^{-1}) and 50-60 NP kg ha^{-1} (573.6 kg ha^{-1}).

Keywords: Sesame, Inorganic fertilizers, Performance; Combination.

1. Introduction

Sesame, scientifically termed (*Sesamum indicum* L.) boasts a rich history dating back around 3,000 years, marking it as one of the oldest oilseed crops consumed by humans. Dubbed the

"Queen of oilseeds," sesame has largely been overlooked by researchers, earning it the classification of an orphan crop. Nonetheless, its popularity has soared in recent times owing to its sought-after qualities such as high-quality oil, protein content, antioxidant properties, and adaptability to diverse environmental conditions (Majdalawieh et al., 2017). Pakistan presently heavily depends on imported edible oil, sourcing over 70% of its supply from other nations (Ibrahim et al., 2021). With limited resources for oilseed production, Pakistan must look to international sources to meet its demand for edible oil (Abbas et al., 2020). According to the Economic Survey of Pakistan for 2020–21, the country's workforce, which is mostly concentrated in rural areas, works in agriculture, which generates 19.2% of the country's GDP (Ajmal et al., 2022). Sesame seeds have an important role in human nutrition, since they are used in many different types of food preparation, such as salad dressings, halva, tahini paste, and sesame brittle (Adisu et al., 2020). An ancient oil crop that is widely grown in Asia and Africa, sesame is a major source of edible oil that is utilised in a broad range of culinary items, most notably animal feed and baked foods. Sesame oil is often used in health and wellness products because of its well-known therapeutic and pharmacological qualities. Sesame seeds have a 50–60% oil content, a 25% protein content, and important antioxidants as sesamoid and sesame lignans. Their high mineral content—which includes calcium, tryptophan, and methionine has made them useful in antiseptics, disinfectants, and other medical treatments (Khan et al., 2021). When it comes to plants, especially crops like sesame, nitrogen is a vital component. It is an essential component of proteins, enzymes, amino acids, and chlorophyll, all of which are necessary for the metabolic processes of plants. A sufficient supply of nitrogen greatly increases sesame crop development and production (Safdar et al., 2021). It facilitates essential processes like cell division and expansion, fostering robust root systems that enhance nutrient uptake and water absorption. Moreover, sufficient nitrogen levels promote vigorous vegetative growth, resulting in taller and more resilient sesame plants (Hakeem et al., 2020). Nitrogen is an important component of proteins in plant metabolism, which helps with vital physiological functions. Its use in agriculture is essential for raising crop yields and enhancing food quality. Similar to how phosphorus, another essential macronutrient, plays a major role in energy transfer, nucleic acid synthesis, and root establishment, it is also essential for the growth and development of plants (Saboury, et al., 2021). It plays a critical role in energy transfer and storage within the plant, facilitating various metabolic processes. Adequate phosphorus supply promotes root growth, increases shoot biomass, and enhances overall plant growth in sesame (Thuc et al., 2023). Phosphorus promotes the development of a strong root system in sesame plants. Adequate phosphorus levels enhance root growth and branching, enabling plants to absorb water and nutrients efficiently. This improved root system allows sesame plants to access deeper soil layers, making them more resilient to drought conditions (Bhavana et al., 2022). Phosphorus availability affects oil biosynthesis and oil quality in sesame seeds. Phosphorus is involved in the synthesis and activation of enzymes responsible for lipid metabolism and oil accumulation. Adequate phosphorus levels contribute to increased oil content and improved oil quality in sesame crops (Jhansi et al., 2023).

2. Material and Methods

The research was carried out at the student-operated farm within the Agronomy Department at Sindh Agriculture University in Tando Jam. Its objective was to evaluate the impact of various fertilizers on the growth and yield of sesame crop. The trial employed a RCBD design, with each plot measuring 4x5 meters (20 m^2). The land preparation adhered to the recommended practices for sesame cultivation. The study focused on the S-9 local variety and was replicated three times to ensure precision. Fertilizers containing nitrogen and phosphorus were administered at the recommended NP doses.

Culture Practices

The soil underwent meticulous preparation involving two rounds of ploughing and leveling to establish an optimal seed bed. Throughout the planting phase, nitrogen and phosphorus were judiciously applied at different stages of sesame growth. The progress of plant growth and development was vigilantly tracked by choosing five plants every five days from each plot throughout the first ten days after crop emergence.

1. T_1 = Control (No fertilizer)
2. T_2 = 30-40 NP kg ha^{-1}
3. T_3 = 40-50 NP kg ha^{-1}
4. T_4 = 50-60 NP kg ha^{-1}
5. T_5 = 60-70 NP kg ha^{-1}
6. T_6 = 70-80 NP kg ha^{-1}

During the maturity stage of the experiment, 15 plants were chosen from each sample group to measure various plant characteristics. These metrics cover Plant height (cm), Branches $plant^{-1}$, Capsules $plant^{-1}$, Seed $capsules^{-1}$, Seed weight $plant^{-1}$(g), Seed index (1000-seed wt., g), Biological yield (kg ha^{-1}), Seed yield (kg ha^{-1}) were meticulously recorded for subsequent analysis.

Statistical analysis

The gathered data underwent analysis utilizing ANOVA with the assistance of Statistix-8.1 Computer Software (Statistix, 2006). When necessary, the LSD test was employed to assess the efficacy of different treatments.

3. Results

The information presented in Table 1 suggests that there are no notable distinctions between the plant height at the beginning and end stages. This indicates that the treatments did not exert a significant influence on seed emergence or seedling survival rates. This observation aligns with the findings of Gudeta (2015), which demonstrated that different levels of nitrogen and phosphorus did not alter the number of plants per square meter in sesame crop.

Plant height (cm)

The results was recorded that the plant height (cm) of sesame as impacted by various phosphorus and nitrogen concentrations are displayed in Table 1. According to the analysis of variance, that there was significant ($P<0.05$) impact of various nitrogen and phosphorus levels in plant height (cm). The highest plant height (179.5 cm) was achieved with the treatment involving with 70-80 NP kg ha^{-1}. Following this, the treatments 60-70 NP kg ha^{-1} and 50-60 NP kg ha^{-1} resulted in average plant height 161.7 cm and 140.1 cm, respectively. Significant decreases in plant height were observed in treatments that included 40-50 NP kg ha^{-1} and 30-40 NP kg ha^{-1} (125.6 cm), (115.9 cm). The smallest plant height (100.2 cm) was observed in control (No fertilizer).

Branches $plant^{-1}$

The results presented in Table 1 illustrate how different nitrogen and phosphorus levels affect the growth of sesame plants in terms of branch $plant^{-1}$. Statistical analysis indicated a noteworthy effect ($P<0.05$) of varying nitrogen and phosphorus levels on branch $plant^{-1}$. Specifically, the most significant number of branches $plant^{-1}$ (12.2) was observed under certain conditions with the treatment involving with 70-80 NP kg ha^{-1}. Following this, the treatments

60-70 NP kg ha^{-1} and 50-60 NP kg ha^{-1} resulted in average branches plant^{-1} 10.7 and 9.2 respectively. Significant decreases in branches plant^{-1} were observed in treatments that included 40-50 NP kg ha^{-1} and 30-40 NP kg ha^{-1} (7.6), (6.7). The lowest branches plant^{-1} (5.3) was observed in control (No fertilizer).

Capsules plant^{-1}

The results was recorded that the capsules plant^{-1} of sesame as influenced by various nitrogen and phosphorus the variance analysis demonstrated that there was significant ($P<0.05$) impact of various nitrogen and phosphorus levels in capsules plant^{-1}. The maximum capsules plant^{-1} (170.8) was achieved with the treatment involving with 70-80 NP kg ha^{-1}. Following this, the treatments 60-70 NP kg ha^{-1} and 50-60 NP kg ha^{-1} resulted in average capsules plant^{-1} 150.9 and 133.8 respectively. Significant decreases in capsules plant^{-1} were observed in treatments that included 40-50 NP kg ha^{-1} and 30-40 NP kg ha^{-1} (111.4), (91.7). The lowest capsules plant^{-1} (71.9) was observed in control (No fertilizer).

Seed capsules^{-1}

The results was recorded that the seed capsules^{-1} of sesame as influenced by various nitrogen and phosphorus the variance analysis demonstrated that there was significant ($P<0.05$) impact of various nitrogen and phosphorus levels in seed capsules^{-1}. The maximum seed capsules^{-1} (43.7) was achieved with the treatment involving with 70-80 NP kg ha^{-1}. Following this, the treatments 60-70 NP kg ha^{-1} and 50-60 NP kg ha^{-1} resulted in average seed capsules^{-1} 39.7 and 35.1 respectively. Significant decreases in seed capsules^{-1} were observed in treatments that included 40-50 NP kg ha^{-1} and 30-40 NP kg ha^{-1} (28.8), (24.7). The lowest seed capsules^{-1} (19.8) was observed in control (No fertilizer).

Treatments	Plant height (cm)	Branches plant^{-1}	Capsules plant^{-1}	Seed capsules^{-1}
T_1 = Control (No fertilizer)	100.2 F	5.3 F	71.9 F	19.8 F
T_2 = 30-40 NP kg ha^{-1}	115.9 E	6.7 E	91.7 E	24.7 E
T_3 = 40-50 NP kg ha^{-1}	125.6 D	7.6 D	111.4 D	28.8 D
T_4 = 50-60 NP kg ha^{-1}	140.1 C	9.2 C	133.8 C	35.1 C
T_5 = 60-70 NP kg ha^{-1}	161.7 B	10.7 B	150.9 B	39.7 B
T_6 = 70-80 NP kg ha^{-1}	179.5 A	12.2 A	170.8 A	43.7 A
S.E.±	2.4463	0.0606	0.3456	0.3542
LSD 0.05	1.0979	0.0272	0.1551	0.1590
P-value	0.0000	0.0000	0.0000	0.0000

Seed Weight Plant^{-1} (G)

The results was recorded that the seed weight plant^{-1} (g) of sesame as impacted by various phosphorus and nitrogen concentrations are displayed in Table 1. According to the analysis of variance, that there was significant ($P<0.05$) impact of various nitrogen and phosphorus levels in seed weight plant^{-1} (g). The maximum seed weight plant^{-1} (51.8 g) was achieved with the treatment involving with 70-80 NP kg ha^{-1}. Following this, the treatments 60-70 NP kg ha^{-1} and 50-60 NP kg ha^{-1} resulted in average seed weight plant^{-1} 45.9 g and 39.6 g respectively.

Significant decreases in seed weight plant^{-1} (g) were observed in treatments that included 40-50 NP kg ha^{-1} and 30-40 NP kg ha^{-1} (34.5 g), (26.7 g). The lowest seed weight plant^{-1} (21.5 g) was observed in control (No fertilizer).

Seed index (1000-seed wt., g)

The results was recorded that the seed index (1000-seed wt., g) of sesame as impacted by various phosphorus and nitrogen concentrations are displayed in Table 1. According to the analysis of variance that there was significant ($P<0.05$) impact of various nitrogen and phosphorus levels in seed index (1000-seed wt., g) . The maximum seed index (4.3 g) was achieved with the treatment involving with 70-80 NP kg ha^{-1}. Following this, the treatments 60-70 NP kg ha^{-1} and 50-60 NP kg ha^{-1} resulted in average seed index 3.8 g and 3.6 g respectively. Significant decreases in seed index (1000-seed wt., g) were observed in treatments that included 40-50 NP kg ha^{-1} and 30-40 NP kg ha^{-1} (3.2 g), (3.1 g). The minimum seed index (2.8 g) was observed in control (No fertilizer).

Biological yield (kg ha^{-1})

The results was recorded that the biological yield (kg ha^{-1}) of sesame as impacted by various phosphorus and nitrogen concentrations are displayed in Table 1. According to the analysis of variance that there was significant ($P<0.05$) impact of various nitrogen and phosphorus levels in biological yield (kg ha^{-1}). The high biological yield (5213.4 kg ha^{-1}) was achieved with the treatment involving with 70-80 NP kg ha^{-1}. Following this, the treatments 60-70 NP kg ha^{-1} and 50-60 NP kg ha^{-1} resulted in average biological yield 4812.3 kg ha^{-1} and 4311.7 kg ha^{-1} respectively. Significant decreases in biological yield (kg ha^{-1}) were observed in treatments that included 40-50 NP kg ha^{-1} and 30-40 NP kg ha^{-1} (3941.3 kg ha^{-1}), (3551.6 kg ha^{-1}). The low biological yield (3129.4 kg ha^{-1}) was observed in control (No fertilizer).

Seed yield (kg ha^{-1})

The results was recorded that the seed yield (kg ha^{-1}) of sesame as impacted by various phosphorus and nitrogen concentrations are displayed in Table 1. According to the analysis of variance that there was significant ($P<0.05$) impact of various nitrogen and phosphorus levels in seed yield (kg ha^{-1}). The maximum seed yield (670.6 kg ha^{-1}) was achieved with the treatment involving with 70-80 NP kg ha^{-1}. Following this, the treatments 60-70 NP kg ha^{-1} and 50-60 NP kg ha^{-1} resulted in average seed yield 625.9 kg ha^{-1} and 573.6 kg ha^{-1} respectively. Significant decreases in seed yield (kg ha^{-1}) were observed in treatments that included 40-50 NP kg ha^{-1} and 30-40 NP kg ha^{-1} (521.1 kg ha^{-1}), (473.8 kg ha^{-1}). The lowest seed yield (421.6ss kg ha^{-1}) was observed in control (No fertilizer).

Treatments	Seed weight plant^{-1} (g)	Seed index (1000-seed wt., g)	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})
T_1 = Control (No fertilizer)	21.5 F	2.8 F	3129.4 F	421.6 F
T_2 = 30-40 NP kg ha^{-1}	26.7 E	3.1 E	3551.6 E	473.8 E
T_3 = 40-50 NP kg ha^{-1}	34.5 D	3.2 D	3941.3 D	521.1 D
T_4 = 50-60 NP kg ha^{-1}	39.6 C	3.6 C	4311.7 C	573.6 C
T_5 = 60-70 NP kg ha^{-1}	45.9 B	3.8 B	4812.3 B	625.9 B
T_6 = 70-80 NP kg ha^{-1}	51.8 A	4.3 A	5213.4 A	670.6 A
S.E.±	0.3137	0.0610	0.5668	0.2995
LSD 0.05	0.1408	0.0274	0.2544	0.1344
P-value	0.0000	0.0000	0.0000	0.0000

4. Discussion

Sesame (*Sesamum Indicum* L.) is an important oilseed crop that holds significant economic value globally. As agricultural practices continue to evolve, optimizing crop yield and quality becomes a central focus for researchers and farmers alike. Nitrogen and phosphorus are essential nutrients that play crucial roles in plant growth and development. The intricate interplay between these elements and sesame plants has garnered attention in agricultural research, aiming to unravel the specific impacts of nitrogen and phosphorus application on the growth and yield of sesame. Understanding how these nutrients influence key physiological processes and biochemical pathways in sesame plants is pivotal for developing sustainable and efficient agricultural practices that enhance sesame productivity. This review explores the current body of knowledge surrounding the effects of nitrogen and phosphorus application on sesame, shedding light on the intricate dynamics that govern the plant's response to these essential nutrients and their implications for overall crop performance. The results demonstrated that the plant height (179.5 cm), branches plant^{-1} (12.2), capsules plant^{-1} (170.8), seed capsules^{-1} (43.7), seed weight plant^{-1} (51.8 g), seed index (4.3 g), biological yield (5213.4 kg ha^{-1}) and seed yield (670.6 kg ha^{-1}) were recorded on T_6 = 70-80 NP kg ha^{-1}, Similarly, T_5 = 60-70 NP kg ha^{-1} with high plant height (161.7 cm), branches plant^{-1} (10.7), capsules plant^{-1} (150.9), seed capsules^{-1} (39.7), seed weight plant^{-1} (45.9 g), seed index (3.8 g), biological yield (4812.3 kg ha^{-1}) and seed yield (625.9 kg ha^{-1}). However minimum results were observed in T_1 = Control (No fertilizer) the minimum plant height (100.2 cm), branches plant^{-1} (5.3), capsules plant^{-1} (71.9), seed capsules^{-1} (19.8), seed weight plant^{-1} (21.5 g), seed index (2.8 g), biological yield (3129.4 kg ha^{-1}) and seed yield (421.6ss kg ha^{-1}). After going through the findings of the present research, it was concluded that the growth and yield of sesame increased simultaneously with increasing nitrogen and phosphorus levels and the sesame fertilized with T_6 = 70-80 NP kg ha^{-1} resulted in highest seed yield (670.6 kg ha^{-1}), followed by T_5 = 60-70 NP kg ha^{-1} (625.9 kg ha^{-1}). The results are further compared with the study of Ozer et al., (2016) indicated that leaf area index was increased with an increasing level of N rates up to 80 kg ha^{-1} and decreased with further increase in the N rate. Increasing level of N up to 150 kg ha^{-1} increased the leaf area. Ansa (2018) compared the effects of poultry manure [PM] with N.P.K. (15, 15, 15) rates on sesame in rivers state, southern rainforest of Nigeria. The PM and NPK rates per seedling per pot were 0, 5, 10, and 20g. Results indicate that NPK initially developed taller plants, but with time over NPK, PM increased growth rate. Taller sesame plants at 10 WAP over NPK rates were provided by PM at 5, 10 and 20 g. The number of leaves between plants that obtained PM and NPK did not differ significantly, while NPK affected greater LA. With doses of both fertilizers, diameter of head, head weight and seed weight increased, 20 g PM produced the widest diameter sesame plants and the weightiest seeds. This was still lower than the highest number of seeds fertilized with 20 g PM produced by sesame plants. For sesame development in the southern rainforest, Nigeria, twenty (20 g) PM application rates per seedling are recommended. Similarly the study of Nasim et al. (2017) reported that the nitrogen is an imperative macronutrient that is demanded in large amounts for sesame production. But nitrogen deficiency and low nitrogen use efficiency negatively effects the sesame growth and yield (Ahmad et al., 2018). In the current study the LAI, CGR and time series TDM were highest with neem-coated urea fertilization at N increment N100 (148 kg ha^{-1}) in comparison to all other SRNF at N increment N100 (148 kg ha^{-1}). These results were correlated with higher availability of nitrogen and imperious role of N in improving up all the plant functions by the production of protein, enzymes, hormones, chlorophyll, and vitamins which resulted in higher LAI, CGR, and time series TDM. Furthermore, higher values of LAI, CGR, and time series TDM were because of the more availability of (N) by reducing the losses of (N) in the form of runoff, nitrate leaching, and ammonia volatilization; hence, continuous availability of (N) due to the slow release of (N) from neem-coated urea. The increase in LAI was attributed due to the more expansion of leaves as the plants were using their whole (N) requirement that is why the growth of these plants treated with coated fertilizers was more effective. With this factor, all the other growth parameters were also enhanced as these are correlated with each other (Hassan et al., 2021). Nitrogen use efficiency was observed maximum with the use of slow release fertilizer as compared to simple urea (Geng et al., 2016). Adequate phosphorus levels contribute to larger seed size, which is desirable in the sesame market (Jat et al., 2021). Moreover, phosphorus enhances oil synthesis within the seeds, leading to higher oil content, which is a critical factor for commercial value. The impact of phosphorus on sesame yield may vary depending on various factors such as soil conditions, climate, and management practices. Conducting soil tests and following recommended phosphorus application rates based on the specific requirements of sesame cultivation will help optimize yield and maximize the benefits of phosphorus fertilization (Patwardhan et al., 2022).

5. Conclusions

It was concluded that sesame biological yield and seed yield at the same time increasing nitrogen and phosphorus applications levels and the sesame fertilized with T_6 = 70-80 NP kg ha^{-1} resulted in maximum biological yield (5213.4 kg ha^{-1}) and 670.6 kg ha^{-1} highest seed yield.

Recommendations

From the present study it was recommended that sesame variety S-9 recommended for general cultivation due to its better yield performance T_6 = 70-80 NP kg ha^{-1} recommended on the basis of higher biological yield and seed yield.

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