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Enhancing Sesame Yield in Arid Conditions through NPK Fertilizer Optimization

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Sesame, an important oilseed crop and valuable source of protein, plays a central role in global agriculture. This study, conducted during the 2021-2022 Kharif season at Karor Adaptive Research Farm (ARF), Layyah, Pakistan, aimed to optimize the use of NPK (nitrogen, phosphorus and

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potassium) fertilizers to increase sesame yield under dry conditions. Our research aimed to determine the most effective application rates of NPK fertilizer (34:24:12) kg/acre for sesame variety TH-6 in the region, consistent with the objectives of maximizing sesame yield and biomass accumulation. The experimental design RCBD included multiple treatments, with meticulous attention to plot sizes, replicates, and robust data collection and analysis methods. These measures ensure the reliability of our results and their potential applicability to similar agroclimatic conditions. The use of NPK fertilizer at the rate of (113:113:60) kg ha-1 in ARF gave promising results. A maximum grain yield of 765.3 kg ha-1 was observed in 2021, exceeding the yield of 738.6 kg ha-1 in 2022. Similarly, the use of NPK (113:113:60) kg ha-1 in a farmer's field resulted in a maximum grain yield of 828.6 kg ha-1 in 2021, as opposed to 702.6 kg ha-1 in 2022. These results highlight the potential of NPK fertilizer application combined with optimal field practices to increase sesame yield and its components under the challenging agro-climatic conditions of Karor, Layyah. The discussion interprets the results and emphasizes the importance of NPK fertilizers for sesame cultivation. Although our primary focus is not on climate discussions, the consistent methodology in both years, from sowing to harvesting, revealed significant differences in yield and growth parameters, leading to climate change being considered as a potential contributing factor. This study shows that the application of NPK fertilizer at the rate of (113:113:60) kg ha-1 can significantly increase sesame yield under adverse conditions.

Keywords: Adaptive research farm karor; NPK; nutrient management; sesame; TH-6 variety; agronomy.

1. INTRODUCTION

Sesame cultivation has been established in the ancient past by botanical and textual evidence [1]. Sesame (*Sesamum indicum*) is a plant in the Sesamum genus, sometimes known as benne. Sesame (*Sesamum indicum* L.) is a significant oilseed crop. It is known as the "Queen of Oilseeds" due to its excellent oil quality and protein level (22.0%). The oil concentration ranges between 50 and 58% [2]. Because of its oil and protein-rich seeds, sesame is an oilseed crop that grows in hot, dry conditions. Sesame is utilized in a variety of products, including confectionery and baking items, as well as soaps, spices, vegetable and carbon paper. Sesame is an ancient and traditional oilseed crop that people in Pakistan are familiar with and use. Sesame seeds totaling 29,000 tons were produced in 2018 on a 176 ha farm. Pakistan has thousands of acres. Sesame seed production reached 366 million tonnes in 2018–2019, valued at Rs 9 billion, according to the Federal Bureau of Statistics. Gujrat, Sialkot, Gujranwala, Attock, Bhakkar, Faisalabad, and Tharparkar in Punjab, Dadu and Hyderabad in Sindh, Kohat and D.I. Khan in Khyber Pakhtunkhwa, and Nasirabad and Lesbela in Balochistan are potential sesame growing regions in Pakistan. Commonly, sesame seeds are grown for their essential oil. The high value of sesame products is due to the sesame seeds' high amount of unsaturated fatty acids, proteins, minerals, and antioxidants. Sesame is well known for its medicinal and nutritional properties in both the food and pharmaceutical industries [3]. According to a number of reports, the current market's high demand for sesame and the compatibility of environmental variables are the major reason that sesame output is rising annually [4].

Sesame varieties are excellent for many types of soil. Crops that produce high yields do best on soil that is pH-neutral, well-drained, and rich. They cannot survive water logging or soils with a high salt concentration, though. Commercial sesame crops need 90 to 120 days without any frost. Growth and yield are favored by warm temperatures above 23 °C (73 °F). Although sesame crops can grow in unfavorable soil, farms with proper fertilization produce the highest yields. Sesame grain yield in the Thal zone is lower than the potential yield. The majority of the time, it is cultivated on marginal ground with insufficient irrigation and fertilization, which fails to fulfill crop needs. According to [5], Pakistan's soil is deficient in phosphorus (80–90%), potassium (30–40%), and nitrogen (N).

NPK are essential for sesame yield. Employing nutrients to their full potential increases yield and lowers production costs. According to [6], raising the NPK content up to 150% improved yield characteristics and yield. NPK enhance the crop growth and yield [7] carried out the experiment on canola and proved that NPK recommended doses increase yield. A field experiment was carried out in [8] during the summers of 2010 and 2011 to examine how sesame responded to fertilizer management and irrigation techniques.

The soil type was sandy loam. So, the purpose of this study was to determine the ideal nutritional value of kharif sesame. For a very long period, sesame nutrition was antagonistic [9].

A crucial stage that will assist in making decisions and enhancing sesame plant production management is the role of nutrients in terms of their intake, distribution, and translocation [10]. The goal of this experiment is to maximize sesame productivity and provide benefits to the farmers in the Thal region. An experiment was carried out in an arid environment at an adaptive research farm in Karor during the kharif season to determine the ideal combination of nutrients for sesame. Additionally, contribute to Pakistan's economic development. It is imperative to utilize fertilizers in moderation in order to maximize production. Soil is a naturally occurring substrate that gives plants the necessary nutrients for greater growth and development. Nitrogen and phosphorus are regarded as macronutrients among all other important nutrients. In order to improve crop and dry matter output, nitrogen is necessary for cell division, root growth, leaf area expansion, protein metabolism, and growth [11]. According to Jouyban and Moosavi [12], an increase in N level from 0 to 200 kg/ha was associated with a significant increase in seed yield, plant height, pod diameter, number of auxillary branches per plant, initial capsule distance from ground, and capsule length. Against a N application rate of 112.5 kg/ha, [13] recorded the largest number of branches, leaves, seed/pod, seed yield, and dry matter. The native cultivar provided the highest yield, 862- 869 kg/ha, between 150 and 200 kg N/ha. The best sesame yield was achieved in the majority of sesame-producing nations by using 46–100 kg N/ha [14]. According to Zenawi and Mizan [15], adequate nitrogen fertilizer also increases the uptake of other nutrients, particularly P and K and several micronutrients.

While phosphorus is essential for the conversion of energy, early root development, cellular storage, flowering, maturation, and seed development. [16]. According to Haruna [17], using 13.2 kg P/ha of phosphorus fertilizer increased the yield and economic return of sesame production. According to Shehu [18], the maximum seed production was achieved with an application of 45 kg P/ha. The ability of plants to withstand disease, insect attack, cold, and drought stress is increased by potassium, which also boosts the output and quality of agricultural products [19]. The activation of enzymes is greatly aided by potassium [20]. When photosynthetic products are transported to the pod and converted to oil, potassium plays a role [21]. The goal of the current study was to compare various doses of NPK applied to different varieties of sesame to see how they affected various growth indicators. NPK® is a viable fertilizer replacement for urea in sustainable sesame farming. NPK is crucial for crop growth and is required for sesame plant development and biomass accumulation [22]. The experiment was set up using a five-treatment, duplicate Randomized Competing Block Design (RCBD). There were 5 treatments: the control, 1st, 2nd, 3rd, and 4th. Each treatment consists of 3 repetitions. To promote growth and monitor changes in several growth parameters, SesameTH-6 was sown using the seeding method and applied with various NPK concentrations. The TH-6 sesame variety's germination properties, yield, and pod count were all examined in this study. The recommended planting rate of 2 kg per acre served as the basis for the seeding rate.

2. METHODOLOGY

2.1 Research Site

The sesame variety TH-6 was used in this experiment, which was carried out at the Adaptive Research Farm Karor Lal Eson, Layyah, Pakistan (31.200 N, 71.090 E), during the Kharif seasons of 2021 and 2022.

2.2 TH-6

TH-6 features a single-stemmed sesame variety known for its impressive pod production, enabling farmers to achieve exceptional yields. With its superior yield potential, the TH 6 sesame variety plays a critical role in the food security and livelihoods of countless communities around the world (Anwar et al., 2013).

2.3 Soil Type

The soil consists predominantly of sand (42.4%), followed by silt (35.1%) and clay (20.0%). Its pH is between 8.4 and 8.5, indicating slightly alkaline conditions. In addition, it has an electrical conductivity (EC) of 1.39 dSm-1 and contains 0.88% organic matter. The high sand content of this soil suggests good drainage, while the mud and clay components provide potential for nutrient storage.

Table 1. Soil parameter quantity

Sand	42.4%
Silt	35.1%
Clay	20.0%
PH	8.4-8.5
EC	1.39dSm^{-1}
Organic matter	0.88%

2.4 Experiment Design

The experiment was run in triplicate with five treatments and was based on a randomized compete block design (RCBD). There were five different treatments, including the control treatment T5, treatments 1, 2, 3, and 4. There are three replications for each treatment. SesameTH-6 was sown through broadcast method and applied different doses of NPK to enhance growth and check the variation occurs in different growth parameters. This study investigated the germination, growth and yield characteristics of sesame TH-6 variety. Seed rate on the bases of recommended seed rate 2kg/acre. The crop that was grown at Adaptive farm on the base of broadcast seed sowing method but in farmer field seed was sown with help of drill.

2.5 Treatment-related Nutrient Variations

Treatments range from T1 to T5 and represent different agricultural nutrient applications. T1 includes 28 kg/ha nitrogen (N), 28 kg/ha phosphorus (P) and 16 kg/ha potassium (K). T2has higher doses with 57 kg/ha N, 57 kg/ha P and 32 kg/ha K. The doses increase further with T3 (85 kg/ha N, 85 kg/ha P, 48 kg/ha). ha K) and T4 (113 kg/ha N, 113 kg/ha P, 60 kg/ha K). T5, referred to as the control group, does not receive NPK nutrients. Different dosages in agricultural treatments are crucial to determining the optimal nutrient levels required for plant growth. This allows farmers to optimize their yields while minimizing excessive nutrient consumption and potential environmental impact. Nitrogen is supplied in the form of urea, while DAP serves as a source of both phosphorus and potassium. Potassium is provided in the form of MOP (Muriate of Potash). These fertilizers are purchased from a local shop in Layyah district. The brand name used for DAP and urea is "Fatima Fertilizer."

2.6 Data Collection

Soil analysis was performing in the lab of soil science of karor by using self-collected soil samples and weather data record on daily base; Base temperature maximum and minimum temperature, humidity and precipitation. As climatic data is outside the scope of our goals, we did not collect it. Due to the interconnectedness of the plot or field boundaries, we gathered data from nearby field researchers at the same station.

2.7 Data Analysis

Data collection and recording using Excel 16 were followed by analysis of variance utilizing

Table 2. Experimental treatments overview

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	28	28	16
T_2	57	57	32
T_3	85	85	48
T_4	113	113	60
T_5	No NPK (control)		

Table 3. Monthly temperature and precipitation data for May-August 2021-2022

Months	Year	Max Temp °C	Min Temp °C	Avg Temp °C	Precipitation inches
May	2021	45°C	23°C	34°C	3.2 in
June	2021	44°C	23°C	35°C	1.8 in
July	2021	43°C	27°C	35°C	0.7 in
August	2021	39°C	24°C	34°C	0.3 in
May	2022	47°C	26°C	36°C	2.7 in
June	2022	45°C	21°C	35°C	0.6 in
July	2022	40°C	24°C	32°C	0.2 in
August	2022	39°C	26°C	32°C	0.5 in

statistic 8.1 for the examination of various parameters. use several formulas for the study of various parameters. Based on the work of Steele and Torrie (1980), parameter means were separated using the least significant difference (LSD), at the 5% probability level.

2.8 Formulas and Calculations

Plant Population: To determine the plant population per unit area (m), follow these steps:

- First, convert the distances between plants and rows from centimeters (cm) to meters (m). Example: 30 cm = 0.3 m and 90 cm = 0.9 m.
- Multiply the distance between plants (in meters) by the distance between rows (in meters). For example, if the distances between plants are 0.3 m and between rows are 0.9 m, the area occupied by one plant is 0.3 m * 0.9 m = 0.27 square meters.
- Calculate the number of plants per hectare (ha) by dividing the total area 1 ha (10,000 square meters) equals the area occupied by one plant (0.27 square meters).
- Therefore, 10,000 m / 0.27 m = 37,037 plants per hectare.
- Example: If you have a field of 0.5 hectares, you can estimate the total crop cover by multiplying the number of plants per hectare (37,037) by the field size in hectares (0.5 Ha). The result would be 18,518 plants throughout the field.

Number of Pods per Plant: To estimate the number of pods per plant, do the following:

- Randomly select 10 plants from field.
- Count the total number of pods (each containing one or more seeds) of these 10 plants.
- Calculate the average number of pods per plant by dividing the total number of pods by 10 (the number of plants you sampled).
- Example: If you count a total of 80 pods on 10 randomly selected plants, the average number of pods per plant is 80 pods / 10 plants = 8 pods per plant.

Plant Height: To measure the height of a plant, follow these steps:

- Use a ruler, scale, or tape measure with metric units (e.g., centimeters).
- Measure the height of the tallest stem of the plant, excluding leaves. Place the measuring tool on the soil surface closest to the base of the plant.
- Example: If the tallest stem of a plant measures 90 centimeters, the plant height is 90 cm.

1000 Grain Weight: To calculate the weight of 1,000 seeds, use the following formula:

1000 grain weight (g) = (total seed weight, g) / (total number of seeds) * 1000
Example: If you have a total seed weight of 3 grams and a total of 1000 Seeds, the 1000 grain weight would be (3g / 1000) * 1000 = 3g.

Yield: To calculate the yield in tonnes per hectare (t/ha), use the formula:

Yield (t/ha) = (A B C) / 10,000
Where:

- A represents the average number of ears/pods per square meter (m).
- B represents the average number of grains per head/pod. C equals 100 (to convert kilograms to tons).
- Example: If A = 20 pods per square meter m, B = 10 grains/pod and C = 100, the yield would be (20 * 10 * 100) / 10,000 = 2 t/ha.

To evaluate the true impact of fertilizers, measurements of plant population were modified to generally manage weeds, insects, and pests. All other parameters, excluding treatments, were maintained at the same level across all experimental units. Following established protocols, information on emergence dynamics, plant population (m2), pods per plant, plant height (cm), 1000 grain weight (g), and grain yield (kg ha-1) was gathered. The statistical analysis of variance technique was used to differentiate differences in treatment means using the honest significance difference test with a 5% probability.

3. RESULTS AND DISCUSSION

3.1 Plant Population

The ARF data in the tables (Tables 4 and 5) showed that the influence of plant population was insignificant and comparable to other factors. Tables 4 and 5 show the average plant population of the sesame crop for the two years (2021 and 2022). The data on seed germination from the bulk sample also did not reach statistical significance. Compared to 2022, when the maximum plant population was 35.3, the average maximum plant cover in 2021 was 39.3. The data from agricultural fields presented in the tables (Tables 6 and 7) showed that the effect of plant population is not statistically different from zero. Tables 5 and 6 show the average plant population of the sesame harvest for the two years (2021 and 2022). The average maximum plant population number was not significant in the farmer's field in both years (2021 and 2022). [6] examined the response of sesame genotypes to plant density and NPK levels, observed that higher plant density (1,66,000/ha) gave a yield of 768 kg/ha. Increasing NPK to 150% of the recommended dose improved yield characteristics and resulted in a seed yield of 734 kg/ha. Optimum plant density and increased NPK levels showed potential to increase sesame productivity.

3.2 Plant Height (cm)

The height of the plant is determined by the interaction of genetic makeup, environment and management techniques. In 2022, at ARF, treatment T4 (144.0 cm) had the tallest plants, followed by T3 (138.3 cm) and T2 (130 cm). In T5, the minimum plant height was recorded in both 2021 and 2022. Plant height under T4 (147 cm) was highest in 2021 and was statistically different from all other treatments. The plant height at T1, T2 and T5 was highly significant, but the plant height at T3 and T4 was not significant in 2022 according to the ARF data presented in the tables (Tables 4 and 5). Compared to T3 and T4, plant height at T1 and T2 in 2021 was significant. At ARF, the average maximum plant height was notable in both years (2021 and 2022). Plant growth was significantly affected by the presence of nitrogen and phosphorus in the soil. The tallest plants were found in plots with higher nitrogen and phosphorus contents, while the shortest plants were found in control plots. Similarly, the highest number of capsules per plant was observed in plots with the largest combination of nitrogen and phosphorus, supporting the results of Moradzadeh [23]. NPK fertilizer application significantly increases grain weight in crops, according to research conducted Omer and Mahmood [24,25]. Increased biomass output, the growth of more secondary branches, and enhanced plant height number of pods are all linked to the rise in grain weight, which is principally caused by the soil's higher nitrogen content. The research conducted Daniya [26] phosphorus fertilizers are essential for increasing soil fertility and encouraging both plant height and overall plant growth.

3.3 No of Pods Plant-^{1}

The number of pods per plant plays an important role in the overall yield. The amount of capsules planted in the trial year 2022 varied significantly between treatments, as shown in the ARF data presented in tables (Tables 4 and 5). The average maximum number of sesame pods recorded in T41 (27) and the minimum number of sesame pods1 recorded in T5 (13.6) in 2022 at ARF are shown in Table 2 below. In contrast, in 2021, a comparable response of the number of pods per plant 1, T2, T3 and 4 to each other was not significant, while T1 was significant to others. The maximum average number of pods of sesame plant 1 found in T4 was 20. The average number of pods per plant was higher in 2022 than in 2021 during the experimental year. According to [27], the application of optimal doses of NPK has a significant impact on both the yield and yield components of sesame, especially the number of pods or capsules per plant. Their research found that treatments with higher NPK application resulted in higher yield and number of pods per plant, while the opposite was observed at lower NPK doses. This finding is consistent with the work of (Kashani et al., 2015). Omer and Mahmood [24,25] and Suleiman and Mahmood (2021) both proved in their respective research that the application of NPK fertilizer has a favorable impact on crop yield and related data like grain weight and the number of pods. The formation of secondary branches and improved biomass output are attributable to this enhancement, which was primarily made possible by the soil's higher nitrogen content. Additionally, the increased nitrogen levels help the leaves survive better, which ultimately results in a rise in the number of capsules produced per plant.

3.4 1000 Grain Weight (g):

The grain yield of the sesame crop is estimated based on the thousand grain weight. The 1000 grain weight treatments differed significantly in both years (2021 and 2022) according to the ARF data presented in the tables (Tables 4 and 5). In 2022, T4 had the average maximum grain weight (2.79 g), while T5 had the average minimum grain weight (1.92 g) (Table 2). While T4 (3.57 g) recorded the highest average weight for 2021, T1 (2.72 g) recorded the minimum average weight (Table 4). The average 1000 grain weight in 2021 was higher in the two test years (Tables 3 and 4) than in 2022. In a study by [28] on sesame cultivation, they examined the influence of NPK fertilizers. The results of their research are largely consistent with our findings and support the significant impact of NPK fertilizers on critical sesame yield components, such as pod number and 1000 seed weight. Notably, the highest recorded weight of 1000 grains occurred under conditions of optimal NPK application.

3.5 Grain Yield (kg ha^{-1})

Each country's economy benefits from the yield of its crops. ARF data from Tables 4 and 5 showed that the relationship between fertilizer use and grain yield was not significant in T1, T2 or between T3 and T4. Although significant, there is no difference between T1, T2, T3, T4 or T5. The highest grain yield (738.6 kg ha-1) was obtained in T4, while the lowest yield (371 kg ha-1) was obtained in T5, where no NPK was treated in 2022 (Table 4). The maximum grain yield in T4 for 2021 was 765.3 kg ha-1, while the lowest yield in T1 was 520.6 kg ha-1 (Table 5). According to farmers' field data from the tables (Tables 5 and 6), fertilizer had a noticeable impact on grain yield in both years (2021 and 2022). In T4, the highest grain yield was observed (702.6 kg ha-1), while in T5, where NPK was not administered in 2022, the lowest yield (405.3 kg ha-1) was recorded (Table 4). The maximum grain yield in T3 was 828.6 kg ha-1 in 2021, while the minimum yield in T1 was 645.3 kg ha-1 (Table 6). The average grain yield was higher throughout the entire trial year in 2021 than in 2022 (tables 6 and 7). Research in tropical areas such as India, Pakistan and Tanzania shows how NPK fertilizers increase sesame yields [29]. To increase yield, nitrogen application should be optimized (46100 kg/ha) in fertile areas and reduced (below 46 kg/ha) in less productive zones [15,27]. Our work supports these conclusions by highlighting the positive effects of NPK on plant growth, increasing sesame yield and sesame components. Sesame farming is a common activity in the Iraqi Kurdistan Region, and farmers frequently use nitrogen and phosphorus fertilizers. In this area, a study by Ali [30] observed that the proper fertilizer application considerably obtained sesame production and enhanced crop growth. This result highlights the necessity of fertilizer application in sesame production, which is a principle that applies to many crops in the savannah region [31,32,33,34,35].

The data shown in Fig. 1 provide insightful information about the state of the climate. Climate change may have affected other parameters, such as the yield of sesame. It appears that temperature and precipitation changes in both 2021 and 2022 may have had an impact on the sesame harvest. Significantly higher temperatures were seen throughout the growth season of 2021, particularly in May and June, with potential maximum of 45°C and 44°C, respectively. The sesame plants may have been stressed by these high temperatures, which might have contributed to a decline in yield indicators like grain yield and pod count per plant. It's conceivable that the extreme heat played a role in this result. Additionally, it's possible that the yields were impacted by the comparatively low amounts of rainfall that fell during these months (3.2 inches for May and 1.8 inches for June). On the other hand, it seemed like the weather in 2022 might be better for growing sesame. The average temperatures in May and June were somewhat milder, hovering around 36°C and 35°C, respectively. A moderate quantity of rain fell during these months, measuring 2.7 inches and 0.6 inches, which would have provided some relief to the plants. So, compared to the previous year, sesame yield parameters including grain yield and pod count per plant showed evidence of improvement. While these observations hint at a potential link between climate conditions and sesame yield, it's important to recognize that various other factors like NPK doses, or Nutrient management and farming techniques might have also contributed to the observed variations.

The investigation of weather or climate change and its effects on sesame agriculture is not the main subject of this study. A secondary goal of including this information is to acknowledge the conceivable impact of climate factors on sesame growth. In both years, we adhered to the same methodology, including sowing time, fertilizer rate, seed rate, and the number of irrigations; every aspect remained consistent. However, there was a noticeable variation in yield and other growth parameters between the two years. This leads us to consider that climate change could be a potential factor contributing to these differences. It is crucial to stress that the results of our research do not represent certitude or provide definitive proof in this regard; rather, we propose a speculative hypothesis indicating the potential influence of climatic factors on crop outcomes. The main focus of this work is the evaluation of sesame yield in dry environmental circumstances. In order to undertake this assessment, different NPK fertilizer application levels are used. For the purpose to conduct this assessment, different NPK fertilizer application levels are used. The main objective of this study is to identify and verify the ideal NPK fertilizer dosage that increases sesame productivity in mentioned arid conditions.

The temperature and precipitation information for May through August in the years 2021 and 2022 are shown in the Fig. 1. Along with the average temperature, the highest (Max) and minimum (Min) temperatures are recorded in degrees Celsius (°C). The amount of precipitation is also expressed in inches (in).

Table 4. NPK fertilizer impact on sesame yield parameters in 2022 at ARF

Treatment	Plant population (m^2)	Plant height(cm)	No of pods / plant	1000 grain weight(g	Grain Yield (Kg/ha)
T_1=NPK 28:28:16	36 ^{NS}	113.3 b	16.3 b	2.72 d	520.6 c
T_2=NPK 57:57:32	36 ^{NS}	119.6 b	19.0 a	3.16 c	617.0 b
T_3=NPK 85:85:48	39.3 ^{NS}	134.3 a	19.3 a	3.40 b	717.0 a
T_4=NPK113:113:60	38.3 ^{NS}	147.0 a	20.0 a	3.57 a	765.3 a
T_5 =NPK=0	34.8 ^{NS}	104.2c	17.1 c	2.11 e	377.6 d

Table 5. NPK fertilizer impact on sesame yield parameters in 2021 at ARF

Treatment	Plant population (m^2)	Plant height(cm)	No of pods / plant	1000 grain weight(g)	Grain Yield (Kg/ha)
T_1 =NPK 28:28:16	33.6 ^{NS}	121.3 c	18c	2.42 b	503.2 b
T_2=NPK 57:57:32	35.3 ^{NS}	130.b	21.6b	2.61 ab	557.3b
T_3=NPK 85:85:48	33.3 ^{NS}	138.3a	25.6a	2.74 a	693.6 a
T_4=NPK 113:113:60	35.4 ^{NS}	144.a	27a	2.79 a	738.6a
T_5 =NPK=0	33.6 ^{NS}	98.3d	13.6 d	1.92 c	371.3c

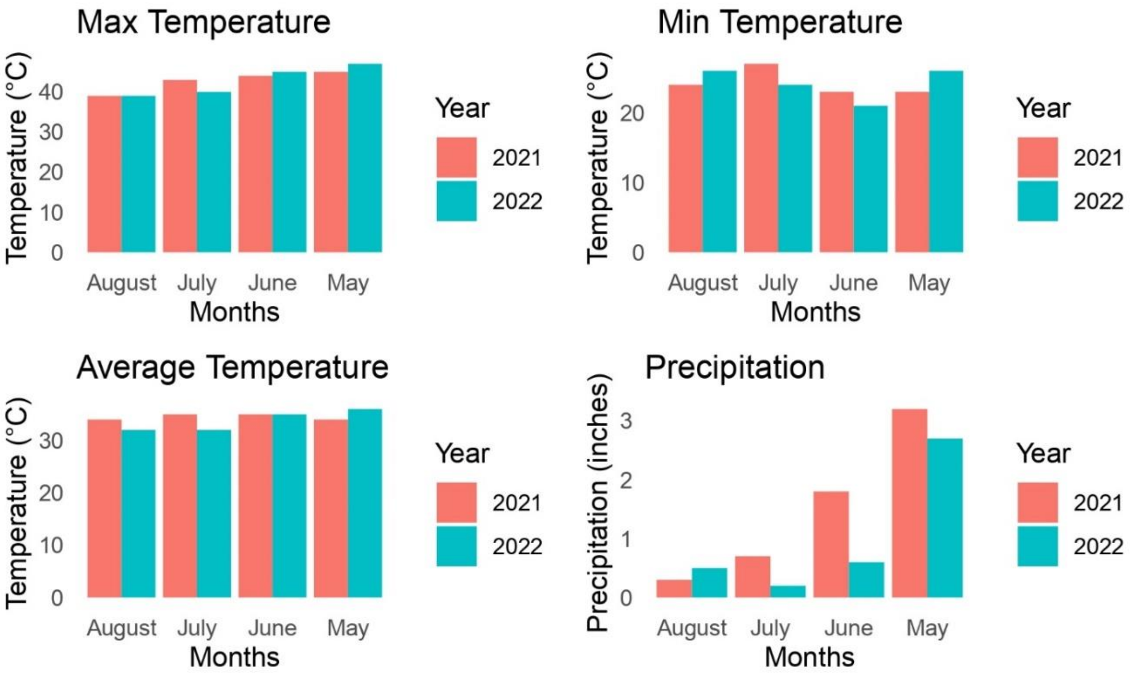

Fig 1. Seasonal climate trends (2021-2022) in karor layyah

Table 6. NPK fertilizer impact on sesame yield parameters in 2022 at farmer field

Treatment	Plant population (m^2)	No of pods / plant	Grain Yield (Kg/ha)
T_1 =NPK 28:28:16	33. ^{NS}	18c	524.3 d
$T_{2=}$NPK 57:57:32	33.3 ^{NS}	22.3 b	588.6 c
$T_{3=}$NPK 85:85:48	34.3 ^{NS}	25.6 ab	655.b
$T_{4=}$NPK 113:113:60	34.3 ^{NS}	26.6 a	702.6 a
$T_{5\,=}$NPK=0	32.6 ^{NS}	13.3 d	405.3 e

Table 7. NPK fertilizer impact on sesame yield parameters in 2021 at farmer field

Treatment	Plant population (m^2)	No of pods / plant	Grain Yield (Kg/ha)
T_1=NPK 28:28:16	34.3 ^{NS}	16c	645.3 c
$T_{2=}$NPK 57:57:32	34. ^{NS}	20 b	734.3 b
$T_{3=}$NPK 85:85:48	32.6 ^{NS}	23.3 ab	828.6 a
$T_{4=}$NPK 113:113:60	32.6 ^{NS}	28 a	816.6 a
T5= NPK=0	29.2^{NS}	10 d	398 d

4. CONCLUSION

The application of NPK had a significant impact on the growth and yield parameters of the sesame crop in Karor la eason, Punjab, Pakistan. The grain yield was at its highest (738.6 kg ha-1) in 2022 and 765.3 kg ha-1 in 2021, respectively, where NPK was applied at the rate of (113:113:60) kg ha-1. And on the farmer's field, the highest grain output of 828.6 kg ha-1 was produced in 2021. The general agreement is that the TH-6 variety of sesame, grown with recommended NPK levels, is ideal for arid regions. Therefore, this NPK (113:113:60) kg ha-1 fertilizer dose is advised for farmers in arid zones to achieve the maximum output.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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