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# Response of Sunflower (*Helianthus annuus* L.) to Nitrogen Levels in Irrigated Areas in Somalia

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author HNI laid down the experimental lay out, data collection procedure, data analysis and interpretation. Author MHM wrote the manuscript. Author YH took part the data collection and proofreading. Author HAM did filed management data control, data collection and proofreading. Authors HMHOM and OHHA were the ones who were handling the field from the land preparation to harvesting and data collection. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** SARTEC conducted an experimental study with the objective of determining the effects of various nitrogen rates on sunflower growth and yield in the Afgoi district, Lower Shabelle region.

**Materials and Methods:** The study was carried out at the SARTEC experimental farm in Afgoi during the Der season of 2020. The experiment used a Russian kind of sunflower and was laid out in a Randomized Complete Block Design (RCBD) with four replications and four plots for each. The crop was fertilized with different rates of N at 50, 100, and 150 kg $ha^{-1}$, with a control/unfertilized plot included in each of the replications. Plant height, head diameter, hundred-seed weight, seed, straw, and biological yield, as well as harvest index, were all measured on five plants from each plot for data collection.

**Results:** The different fertilizer rates applied to the sunflower crop resulted in highly significant variations in yield and yield components. Seed-related parameters like seed weight and seed yield were influenced substantially more than other variables, including plant height; stem diameter, head diameter, and straw yield. Despite having the highest seed yield, plots with 150 kg of N $ha^{-1}$ were not more cost-effective than plots with 100 kg $ha^{-1}$.

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**Conclusion:** In Somalia, 100 kg of N per hectare is the ideal rate for maximizing sunflower revenue and production while adhering to best management practices.

*Keywords: Different nitrogen rates; sunflower production; head diameter; seedy yield.*

## 1. INTRODUCTION

Sunflower (*Helianthus annuus)* is one of the important oilseed crops grown throughout the world as a source of culinary oil (SANFOIL) and fiber that considerably contributes to human health [1]. Sunflower is the fourth most significant oilseed crop in the world after soybeans, rapeseed, and safflower.

The sunflower crop was first introduced to Somalia by Italians in 1920, who planted it as an experimental crop in Giohor, but it was not commercially grown until 1960 in Baidoa, South-West State, by an Italian entrepreneur named Mr. Keim. Due to a lack of crop expertise and post-harvest equipment to extract the oil from the seeds, the crop was not widely cultivated in the region until 1975, when the Somali government reintroduced it as a pilot project in the Lower Shabelle region. However, the severe drought in Somalia in 1975 resulted in the influx of a huge population of birds into the irrigation areas, causing the crop to be heavily damaged during maturation. Although the fact that there is sufficient evidence suggesting that birds can be considered minor pests during normal growing seasons, sunflower has never been considered as the main crop in Somalia. Observations at CARS in 1977 showed that, although bird scarers were used, *Quelea* were attacking sorghum trials but ignored adjacent unguarded sunflower plots. Unless it is a dry season, only a few birds, primarily larger-seed-eating species such as widow birds (*Coliuspasser sp*.), are seen on the sunflower.

On the other hand, sunflower is gaining popularity and has a good potential of becoming a significant industrial crop in Somalia. Regarding its cultivation, sunflower requires agronomical management that is similar to that of maize, and also, given the problems of water shortages, weed control, and heavy soils, it's a more suitable oil crop than groundnuts cultivated in Somalia [2,3]. Common sunflower cultivars vary based on ecological conditions, precipitation, and irrigation regimes. Limited nutrients, among others, can cause a reduction in the yield of sunflower products such as seeds, oil content, and other products, while excessive nitrogen treatments may result in environmental pollution, imbalanced plant nutrition, decreased quality and increased production costs. Hence, choosing the proper doses of fertilizer nutrients will not only promote improvement in yield and quality but also prevent negative impacts on human and soil health. For this, SARTEC implemented an experimental study in 2020 with the objective of investigating the effects of different nitrogen rates on the growth and yield of sunflower in Afgoi district, Lower Shabelle region.

## 2. MATERIALS AND METHODS

The study was carried out during the Der season of 2020 at the Somali Agriculture Research and Technology Centre (SARTEC) experimental farm in Afgoi, near the former Central Agricultural Research Station (CARS). The area is well-known for its suitability for farming, having alluvial soils with an optimum water holding capacity of the irrigation water accessed from the Shebelle River, which runs close by. The Russian type of sunflower seeds collected from the Juba Agro Company farm in Afgoi was used for the experiment, which was laid out in a Randomized Complete Block Design (RCBD) with four replications. Each replica had 4 plots, with an area of 19.2 $m^2$ for each, making a total of 16 plots for the whole experiment.

The experimental farm was prepared well by removing the previous crops from the field, followed by ploughing and harrowing using the conventional implements common in the study area. The seeds were manually planted with 0.80 m between rows and 0.30 m between plants within the same row, using a hoe to dig the holes and place the seeds in them. Different rates of nitrogen fertilizer of 50, 100, and 150 kg/ha have been applied to the crop, but with one plot of zero fertilizer included as a control plot in each replica. Following crop establishment, the field has provided all the necessary management practices using the traditional methods well-known in the area. For example, thinning was done uniformly across the whole field as soon as the seedlings accomplished their germination and emergence. Irrigation was applied four times using the typical furrowing method, with water being pumped from the river and then supplied through the pre-constructed canals in the field. To reduce the effects of weeds on crop production and yield, manual weeding was done four times, and the necessary crop protection measures were carried out proactively to limit the damage caused by pests and diseases. Except for white grubs and birds, there were no other pests or diseases in the sunflower field. To control the white grubs, foliar spraying of a pesticide with the name "Agenda" has been applied before flowering. Spraying after flowering would restrict insect pollination in the sunflower field. Although the birds' infestation was not severe due to sorghum cultivation near farms, scaring devices and shouting were used to minimize their damage. At its maturity on the 90th day, the sunflower crop has been harvested manually, but before all the required agronomic yield data, such as plant height and diameter measurements, has been collected. Post-harvest operations, primarily threshing, drying, and cleaning, have been done manually in the field.

In terms of data collection, five plants were selected from each plot and all the required data for the evaluation of the effects of the various applied fertilizer rates, according to the general goal of the study, were measured and recorded. Plant height (taken from the base of the plant or the top of the soil to the tip of the plant) and head diameter were measured for each plant sample using the conventional tape measure and recorded in centimeters (cm). Seed-related variables of each plot, namely the hundred-seed weight (in grams) and seed yield or grain yield (in kg $ha^{-1}$), were measured using a reliable digital scale and documented. This was done after the seeds had been thoroughly dried and cleaned to provide precise and trustworthy statistical data. Following that, physical balances were used to measure the straw (in kg $ha^{-1}$) and the biological yield of the sunflower crops per plot. The latter was computed by adding the grain and straw yields together. Furthermore, the Harvest Index (HI) was determined using the formula:

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100\%$$

Finally, the data was processed using the computer-installed MSTAT-C program to separate the total variance [4], and the treatment means were compared using Duncan's Multiple Range Test (DMRT) [5].

## 3. RESULTS AND DISCUSSION

### 3.1 Plant Height and Stem Diameter

The crop's total vegetative development in response to various management approaches is revealed by plant height and stem diameter. According to Table 1, plant heights ranged from 145.60 to 159.70 cm, with the highest being those that received 50 kg of N $ha^{-1}$ and the lowest being those that received the most fertilizers, at 150 kg $ha^{-1}$. Those plants that received 50 and 100 kg $ha^{-1}$ had almost similar heights with a 1.3 cm difference, but with 159.70 and 158.40 cm, respectively. In terms of the stem girth, or diameter, the sunflower plants had various measurements ranging from 9.05 to 12.10 cm, with the highest being those given 50 kg of N $ha^{-1}$ as the plant height parameter. The lowest height was recorded from the zero fertilizer plots, where no fertilizer was applied, although it was fairly similar to those who applied 100 kg of N $ha^{-1}$, with a length of 9.35 cm.

This suggests that applying N fertilizers improved plant height and stem diameter, which is most likely due to increased nitrogen availability, which increased the photosynthetic vegetative parts (as it's obvious in the straw yield), resulting in greater photo-assimilation and hence more dry matter accumulation. These results are in line with those of Mostafa and Abo-Baker [6], who reported increased sunflower growth due to a higher rate of nitrogen application. Similar experimental results were attained by Shah and Khanday [7].

**Table 1. Analysis of variance for the variables plant height, stem diameter and head diameter**

| Fertilizer rates (kg $ha^{-1}$) | Plant height (cm) | Stem diameter (cm) | Head diameter (cm) |
|---|---|---|---|
| Control | 146.20 | 9.05 | 18.80 |
| 50 | 159.70 | 12.10 | 21.75 |
| 100 | 158.40 | 9.35 | 20.45 |
| 150 | 145.60 | 10.05 | 20.95 |
| Level of significance | Ns | Ns | Ns |
| CV (%) | 10.43 | 10.52 | 6.72 |

*CV= Coefficient variation; Ns = Not significant*

**Table 2. Analysis of variance for the variables seed weight/head, 100 seed weight, seed yield, straw yield, biological yield and harvest index**

| Fertilizer rates (kg/ha) | Seed weight / head (g) | 100 Seed weight (g) | Seed yield (Kg $ha^{-1}$) | Straw yield (kg $ha^{-1}$) | Biological yield (kg $ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|---|
| Control | 68.00 | 4.10 | 559.00 | 1178.50 | 1737.50 | 32.18 |
| 50 | 76.75 | 5.31 | 591.00 | 2231.00 | 2822.00 | 20.96 |
| 100 | 88.25 | 6.59 | 615.80 | 3010.00 | 3625.75 | 16.99 |
| 150 | 88.25 | 6.59 | 617.00 | 9764.75 | 10381.75 | 13.28 |
| Level of significance | ** | ** | ** | * | * | * |
| CV (%) | 2.61 | 3.85 | 1.16 | 16.74 | 14.50 | 8.24 |

*CV = Coefficient variation; ** = Highly significant at 1% level*

### 3.2 Head Diameter

Regarding the head where the sunflower seeds are located, its diameter length varied among the plants in the different fertilizer treatments, but with a smaller difference noticed across the plots received 100 and 150 kg of N fertilizer $ha^{-1}$. As in the above table, the lowest head diameter length was 18.80 cm in zero fertilizer plots, while the maximum length was 21.75 cm in plots treated with 50 kg of N $ha^{-1}$. This demonstrates that the nitrogen fertilizer applications caused the rise in head diameter. As it's mentioned earlier, nitrogen boosts photosynthesis, and the carbohydrates are deposited in the vegetative regions, increasing their growth. Many authors found similar results and generally, larger heads of sunflower are harvested with higher nitrogen applications and associated with a greater quantity of grains, resulting in better yields [8,9].

### 3.3 Seed Weight

Unlike the above-described elements, the seed-related variables among the four fertilizer treatments showed a high significant variance. Seed weight (whether it is the total or the hundred) is an important yield contributing factor showing the yield potential of the crops (Anwar-Ul-Haq et al., 2006), which is related to the increased intake and availability of additional nitrogen, as well as increased reproductive and productive components. According to Table 2, increased nitrogen fertilizer application had a major impact on the seed weight. The total seed weight per head, for example, ranged from 68 to 88.25 grams, with the lowest figure in the zero fertilizer plots and the greatest in the 100 and 150 kg N plots. Also, the values of the 100 seed weight show that each of the 50 and 100 kg per hectare N treatments resulted in a seed weight gain of more than 1 kg, despite the fact that the highest feasible quantity of 150 kg per hectare produced the same weight as 100 kg per hectare. All of these show that sunflower seed weight increased as fertilizer levels increased, but any extra quantity beyond 100 kg had no effect on the seeds' marginal weight and, in fact, had damaged on the economy and the environment.

Apparently, the head diameter of the sunflower plant is directly proportional to the weight of the seeds, as indicated in Table 2; that is, as the head diameter of the individual plant expands so does the overall weight of the seeds per head. Though the study did not clarify, the rise in seed weight may be due to either an increase in the weight of individual seeds or an increase in the number of seeds per head. The increase of the seeds in size and number comes due to the transportation of dry matter from the floral parts to the seeds on the head, and as an author [10] explained that this is a result of both the sink-source relationship and the persistence of leaf area after flowering. Furthermore, the stem serves as a modest storage site for non-building carbohydrates that are also transported to the seeds following flowering and physiological maturity.

### 3.4 Seed Yield

Returning to the second table, the grain or seed yield per hectare is boosted by the amount of fertilizer per hectare. For example, the seed yield at the zero fertilizer plots was 559 kg $ha^{-1}$, in contrast to the 50 kg $ha^{-1}$ applied plots, where the seed output improved by roughly 7% (to 591 kg/ha). It was raised from 591 to 615.8 kg $ha^{-1}$ at 100 kg of N $ha^{-1}$, and from 615.8 to 617 kg $ha^{-1}$ at 100 kg of N $ha^{-1}$, reflecting a marginal increase of nearly 4% and 0.2%, respectively. This clearly implies that every extra N applied over the rate of

100 kg ha$^{-1}$ reduces the marginal yield of the sunflower production industry. The study also demonstrates that the treatment that results in the highest parameters does not always imply the highest overall yield. In light of this, plots treated with 150 kg ha$^{-1}$ of N were more successful than those treated with other rates of the fertilizer. This might be because the greater nitrogen rate could provide necessary and effective nutrients throughout sunflower growth. These results are in agreement with the findings of many authors [11,12,13] who highlighted higher grain yields with increased nitrogen rates.

## 3.5 Straw Yield

About to the straw yield, it's highly noticeable from the table that there was a significant variation across the plots that were fertilized with different rates of nitrogen. In the data, the lowest straw yield (1178.50 kg ha$^{-1}$) was obtained in the zero fertilizer or control plots, while the maximum (9764.75 kg ha$^{-1}$) was found from the plots that received the maximum fertilizer rate applied in the experiment. This indicates that every increase in nitrogen fertilization rates was linked to an increase in the straw yield of the sunflower measured in kg ha$^{-1}$. Despite the fact that the research did not show it, this might be attributable to an increase in the number of leaves and their size per plant.

## 3.6 Biological Yield

Considering the biological yield, which is comprised of seed and straw yields, follows the same rationale as their previous argument. As Table 2 shows, the lowest biological yield (1737.50 kg ha$^{-1}$) was found in the control plots where the fertilizer was not applied, while the highest (3625.75 kg ha$^{-1}$) was found in the plots that received 100 kg of N ha$^{-1}$. This clearly points out that the yields of straw and seed are proportional to the biological yield, meaning that the biological yield grows in tandem with one or both of these elements. The sunflower plants' biological yield was severely hampered in the control plots due to a lack of nitrogen. Gray literatures cite that the restricted availability of nitrogen by plants reduces leaf size, which causes a reduction in light absorption and light utilization efficiency for plant photosynthesis, resulting in a reduction in total dry matter or biological yield, and vice versa. Similar findings were made by Dreccer [14]. Nevertheless, the study points out that any quantity of N fertilizer beyond 100 kg ha$^{-1}$ may result in a decrease in production since the biological yield at plots receiving 150 kg/ha (10, 381.75 kg ha$^{-1}$) is lower than the preceding nitrogen amount of 100 kg ha$^{-1}$.

## 3.7 Harvest Index

In case of the crop's harvest index which is determined by its physiological efficiency and capacity to convert photosynthetic material into economic yield, the control plots, as shown in the last table, had a maximum harvest index of 32.18 percent. Limited biomass production in the plants might be related to a low number of leaves per plant (albeit the study has not demonstrated this), thin stalks (stem diameter), and short plant heights, all of which could lead to a higher harvest index. The study shows that the Harvest Index (HI) is inversely proportional to the rate of N applied to the crops. As the N fertilizer increased across the plots in the experiment, the harvest index decreased until it was found to have the lowest index (13.28%) at the plots that got the most fertilizer. This might be because when plants have ample growth resources, they produce more leaves and chlorophyll, which help to trap more sunlight and perform more photosynthesis, resulting in more carbohydrates going to the reproductive parts. These results are in agreement with those produced by Wajid et al. [15].

# 4. CONCLUSION

According to the findings, the different N fertilizer rates applied to the sunflower crop resulted in highly significant variations in yield and yield components. Seed-related parameters like seed weight and seed yield were influenced substantially more than other variables, including plant height; stem diameter, head diameter, and straw yield. Despite having the highest grain yield, plots with 150 kg of N ha$^{-1}$ were not more cost-effective than plots with 100 kg ha$^{-1}$. As a result, using 100 kg of N per hectare to maximize revenue and yield while adhering to best management practices is achievable.

# COMPETING INTERESTS

Authors have declared that no competing interests exist.

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