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# NITROGEN FERTILIZATION AND BIOSTIMULANTS EFFECT ON SAFFLOWER CROP

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## ABSTRACT

*Carthamus tinctorius* species or safflower as it is referred to by its common name is a plant that grows and thrives in dry heat climates. Due to climate change and the medicinal properties of the plant, this study was prepared to draw conclusions on the response of the crop to nitrogen enrichment and to study the effects of the application of bio-stimulants on its seed yield in Thessaly, Greece. A split-plot experimental design was used with two different nitrogen fertilization levels being the major factor (N1: 0 and N2: 80 kg $ha^{-1}$) and four different bio-stimulants as the sub-factor (C: control, A: *Ascophyllum nodosum* algae extract, S: plant amino acids, and A+S: a combination of previous two). The data analysis found no statistically significant difference between the study factors or their interactions on seed yield. Nitrogen fertilization (N2) almost doubled the seed yield, reaching up to 1.3 t $ha^{-1}$, with a harvest index of 0.2. In the case of biostimulants, the S treatment resulted in a numerically higher yield (1.2 t $ha^{-1}$), while interactions (N2xS) recorded a seed yield of 1.5 t $ha^{-1}$. Finally, a statistically significant difference was found in biostimulants treatments when measuring seed oil content. In addition to providing the rural population with a crop that is resistant to climate change, the aforementioned results provide the foundation for future study into the yield of safflower in dry-thermal conditions that will generate positive results in the manufacturing of oil with medicinal characteristics.

**Keywords:** *Safflower, Carthamus tinctorius, N-fertilization, biostimulant, yield.*

## INTRODUCTION

The plant species known as *Carthamus tinctorius*, or safflower as it is commonly called, is a dry heat-loving plant, which has contributed to its widespread distribution and cultivation over the planet. Today, regions of Asia, North-East Africa, Europe, America, and Australia cultivate spindles for commercial use (Ren et al., 2017). In 2018, the global production of safflower seed was 627,653 tons, with Kazakhstan being the primary producer, contributing 34% of the total production. The United

States and India combined accounted for the remaining 26% of the global production (Oleynikova et al., 2021).

In the data items of the "Production Yearbook" published in 1993, the United Nations Food and Agriculture Organization formally recognized safflower as a dual-purpose medical oil (Peng, 1999). Furthermore, safflower exhibits promising prospects for use in food, cosmetics, new oil, industrial resources, and natural pigment additives (Liu, 2017; Zhang et al., 2016).

The plant produces long, delicate, light green leaves with tiny teeth or smooth surfaces during the initial phases of vegetative growth. However, the leaves do not acquire any kind of spines during the early stages of rosette formation and germination. Once the central stem has grown to its full height, the leaves turn a dark green hue and become leathery. Bract leaves, which are leathery, spine-adorned, and significantly shorter than the plant's other leaves, sprout at the base of each inflorescence. The stem of the plant is made up of a primary stem on which lateral branches grow. Depending on the growing environment, the capability of each variety, and the cultivation practices, the stem length of the various plant kinds ranges from 30 to 150 cm. The plant produces spherical inflorescences on top of both the main stem and the secondary stems. Depending on the cultivating method and the variety, the inflorescences can have a diameter of 1.3–1.4 cm and can produce from 3 up to 50 inflorescences in total.

Safflower seeds are classified as achenes. The seeds are rarely mottled or gray; they are typically white in appearance. A thousand seeds have a weight of between 30 and 45 g and a dimension of between 6 and 10 mm. They are greasy and contain nutritious and high-quality oil (Popov A.M. and Kang D., 2011). For the majority of types, ripe seed contents include around 30% dry weight oil content, 5-8% moisture content, 14–15% protein content, 32-40% crude fiber content, and 2-7% ash (Bijanzadeh et al., 2022; Günç Ergönül and Aksoylu Özbek, 2020). Similar to sunflower and olive seeds, safflower has a 20%–40% seed oil content (Kumar et al., 2016).

In order to maximize plant output and improve nitrogen absorption, growers primarily apply safflower fertilization to irrigated crops (Santos et al., 2018). Nitrogen is the primary inorganic element for plant growth since it directly influences the growth of the plant and the increase in biomass. Additionally, fertilizer with nitrogen helps plants produce more by encouraging the development of more flower heads per plant. The crop's nutritional needs begin at the rosette stage when the plant begins to adsorb nitrogen from the soil on a small scale. A higher rate of nitrogen uptake by the plant is observed during the central stem elongation stage, however the highest uptake rate is observed at the full flowering stage. From the stage of full flowering onwards, the nitrogen needs gradually decrease at a constant rate and the greater percentage of the absorbed nitrogen is channeled into the seeds.

In many crops, the usage of biostimulants has increased recently. Biostimulants are compounds that promote growth and fortify a plant's resistance to both biotic and abiotic stresses, such as a shortage of nutrients and water. When applied in modest amounts, biostimulants also aid in the growth of the plant without acting as nutrients for the same purpose. Three categories can be used to categorize biostimulants: preparations containing humic acids in the first, plant hormones in the second, and amino acids in the third (du Jardin, 2015).

Applying biostimulants foliarly can strengthen the plant's defenses, raise the plant's dry biomass content, and improve crop seed output (Davari et al., 2022). In the case of safflower, the use of a biostimulants can improve plant nutrition in non-irrigated soil with low organic matter content and increase seed yield. Biostimulants use can also strengthen a plant's defenses against drought conditions in the soil substrate by preventing the entry of pathogenic microorganisms, regulating the opening of the plant's leaf stomata, and assisting in the regulation of the plant's uptake of water from the soil, according to research evaluating various biostimulants in spindle culture (Janmohammadi and Sabaghnia, 2023).

This study investigated the effects of nitrogen fertilization and biostimulants on seed yield of a rainfed safflower cultivation in Thessaly.

## MATERIALS AND METHODS

### Experimental Field

In order to estimate safflower seed yield, a field experiment was conducted on the University of Thessaly farm in Velestino, Magnesia, at coordinates 39°23'59''N and 22°45'14''E.

Sowing was carried out on November 25, 2022. At sowing, basic fertilization was carried out, where 200 kg/ha of the 15-15-15 (+5SO3) fertilizer was used. The experimental design included 24 total sowing lines with 50 cm distance between lines, and the required amount of seeds was equal to 91.6 kg/ha.

A factorial split-plot design with three replicates (blocks) and 8 plots per replication was used to accomplish the study goal. The prime-factor was the different nitrogen fertilization levels (N1: 0, N2: 80 kg N $ha^{-1}$, using 34.5-0-0), while the sub-factor was the different biostimulants (B1: control, B2: algal extract, B3: plant amino acids and B4: combination of B1 & B2). A 12 $m^2$ area, with dimensions of 6 m for width and 2 m for length, made up each trial plot. On March 20, 2023, 1 L/ha of the B1 biostimulant, and on April 25, 2023, 2 L/ha of the B2 biostimulant were sprayed to the crop.

Specifically, two complete rows of plants (the inner rows) were harvested from each plot in the experimental plot on July 24, 2023. After that, the seeds were manually removed from the heads and their weight was recorded.

### Soil Characteristics

The soil in the experimental field had organic matter levels of 1.86% at 30–60 cm and 2.91% at 0–30 cm, making it a very productive calcixerollic xerochrept soil (USDA, 1975).

### Meteorological Data and Statistical Analysis

A meteorological station located on the University of Thessaly farm in Velestino, provides the meteorological data.

Finally, an analysis of variance (ANOVA) was conducted on the collected data within the sample durations using the statistical program GenStat (7th Edition) for all measured and derived variables. Steel and Torrie (1982) employed the $LSD_{0.05}$ test criteria to assess any disparities in the main and/or interaction effect means. Statistics allowed for a thorough analysis of the data, ensuring that any differences between the variables under investigation that were discovered were statistically significant and not merely accidental.

## RESULTS AND DISCUSSION

### Climatic Data

The study region has a Mediterranean climate with distinct seasonal variations. Winters are cold and humid, while summers are hot and dry.

In contrast, the lowest average ten-day temperature value was recorded during the first decade of February, with an average temperature value of 3.3°C. The highest average ten-day temperature value was recorded during the third decade of July at 29.6°C. The greatest recorded 10-day rainfall value, 45.17 mm, occurred in the first decade of April, while the lowest recorded 10-day rainfall values, zero, occurred in the first, second, and third decade of July. Figure 1 shows that 366.2 mm of rain fell between the day of sowing and harvest.

In summary, the research area experiences chilly, humid winters and hot, dry summers due to its Mediterranean climate. Temperatures and precipitation data collected throughout harvest seasons show different weather patterns all year round. Increased precipitation in other seasons counteracts the scarcity of the summer, making the environment more conducive to cultivation.

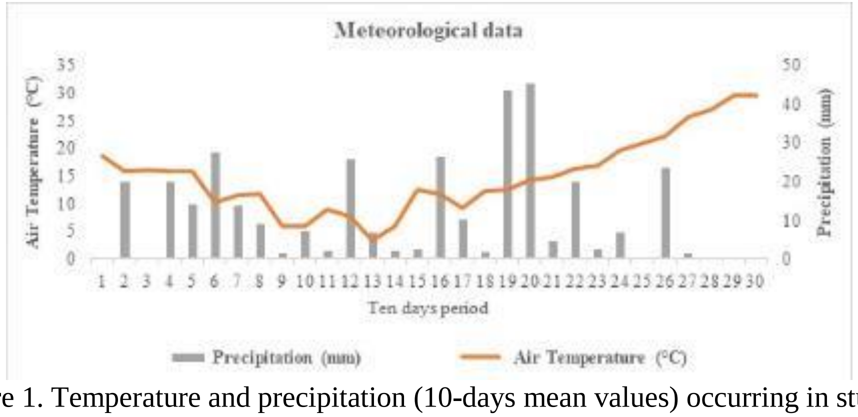


Figure 1. Temperature and precipitation (10-days mean values) occurring in studied site during the growing period of safflower (October 2022 - July 2023).

The data analysis conducted on the study factors and their interactions yielded a statistically insignificant difference in seed yield. Notably, nitrogen fertilization (N2) had a profound impact on seed yield, almost doubling it to reach a maximum of 1.3 tons per hectare, with a corresponding harvest index of 0.2. In contrast, the results of biostimulants treatments showed that the S treatment numerically outperformed the other treatments, yielding a seed output of 1.2 tons per hectare. Furthermore, the interaction between nitrogen fertilization and biostimulants (N2xS) resulted in an impressive seed yield of 1.5 tons per hectare. Interestingly, the analysis also revealed a statistically significant difference in seed oil content among the biostimulants treatments. This finding contradicts existing research that has demonstrated that nitrogen fertilizer can have a significant impact on plant biomass and seed production (Jaffar and Al-Refai, 2021; Mohamed et al., 2012). The discrepancy between the current study's findings and previous research may be attributed to differences in experimental design, environmental conditions, or genetic variability among plant species.

Table 1. Safflower seed yield (kg/ha) and harvest index.

| | **Seed Yield (kg/ha)** | **Harvest Index** |
|---|---|---|
| **Fertilization** | | |
| 0N | 651 | 0,15 |
| 8N | 1258 | 0,20 |
| **LSD.05** | **ns** | **ns** |
| **Biostimulants** | | |
| Control | 906 | 0,18 |
| A | 761 | 0,15 |
| S | 1217 | 0,21 |
| A+S | 933 | 0,18 |
| **LSD.05** | **ns** | **ns** |
| **Interaction** | | |
| 0N*Control | 563 | 0,16 |
| 0N*A | 416 | 0,10 |
| 0N*S | 942 | 0,20 |
| 0N*(A+S) | 682 | 0,16 |
| 8N*Control | 1249 | 0,20 |
| 8N*A | 1106 | 0,20 |
| 8N*S | 1492 | 0,22 |
| 8N*(A+S) | 1185 | 0,20 |
| **LSD.05** | **ns** | **ns** |
| **CV (%)** | 43,1 | 24,3 |

## CONCLUSIONS

In summary, a Mediterranean climate characterizes the study region, with hot, dry summers and chilly, damp winters. Based on the data analysis, it was shown that nitrogen fertilization significantly increased seed output. Treatments with biostimulants also showed encouraging results, but the combination of biostimulants and nitrogen fertilization produced the maximum seed yield. Furthermore, the study's conclusions ran counter to earlier studies on the effects of nitrogen fertilizer on plant biomass and seed yield.

Based on the facts above, it can be concluded that safflower cultivation is not only climate change resistant but may also prove to be beneficial cultivation in the future. in the process of producing oil with therapeutic qualities, a fact that will become clear from more studies.

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