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SAFFLOWER – AN OILSEED CROP WITH POTENTIAL: OPTIMIZATION OF CULTIVATION TECHNOLOGIES AND CHEMICAL ANALYSIS OF SEEDS

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Abstract. *Safflower (Carthamus tinctorius L.) is an annual oilseed plant, adapted to drought conditions, cultivated for its oil-rich seeds and used in the food, pharmaceutical and textile industries. Throughout history, this crop has been appreciated for the extraction of natural dyes, and today it is valued due to its high content of unsaturated fatty acids, as well as for its resistance to difficult climatic conditions. In this paper, the influence of the sowing season and the distance between the rows on the chemical composition of safflower seeds, cultivated in the pedoclimatic conditions of the Timisoara area, was analyzed. Parameters such as the content of mineral substances, crude protein, total fat and saturated fatty acids were monitored, in the context of agricultural years with above-average temperatures and uneven distribution of rainfall. The results highlighted that the sowing season is an essential agronomic factor for maximizing production and improving seed quality. Sowing in Epoch I favored a better vegetative development, leading to significant increases in production compared to Epoch II. Also, a longer row spacing (50 cm) had a positive impact on production, leading to an average increase of about +26% compared to the 30 cm spacing. The chemical composition of the seeds was also influenced by these agronomic factors. It has been found that both the sowing time and the distance between rows significantly influence the fat content and the proportion of saturated fatty acids. These data underline the importance of choosing the right cultivation technology to achieve higher quantitative and qualitative safflower production, especially in the context of current climate change.*

Keywords: *sowing time, row spacing, chemical composition of seeds*

INTRODUCTION

In the current context of sustainable agriculture and accelerated climate change, the cultivation of *Carthamus tinctorius* L., commonly known as saffron, is gaining increasing importance, both from an agronomic and economic point of view.

This oilseed is particularly appreciated for its ability to adapt to restrictive pedoclimatic conditions, particularly drought and nutrient-poor soils (Bilmez-Özçınar, 2021). Thus, *Safflower* is emerging as a viable alternative crop for arid and semi-arid areas, where other oilseed crops register poor yields.

In terms of current agronomic research, numerous studies have focused on optimizing cropping technologies: choice of sowing time, density and row spacing, nutrition and water management (Gupta et al., 2024; G. P. Sathwika 2023; IJECC, 2024). For example, early sowing and longer row spacing, have been shown to be favourable for fat accumulation and higher yields, while late sowing may favour the lipid profile by reducing saturated fatty acid content.

Safflower seeds contain between 25% and 40% oil, with a valuable lipid profile, ranging between linoleic acid-rich types (polyunsaturated fatty acids – PUFAs) and oleic acid-rich types (monounsaturated fatty acids – MUFAs), depending on the cultivar. This gives the plant versatile use in the food, pharmaceutical, and industrial industries (Delshad et al., 2018; Zhou et al., 2023, Raju TJ et al. 2019). Seed oil is recognized for its cardiovascular health benefits, being increasingly used in modern diets. In addition, varieties with high oleic acid content exhibit superior thermal stability, making them suitable for roasting or industrial applications (Li et al., 2024). Recent research has also highlighted important variations between genotypes in terms of lipid composition and tocopherol content, thus contributing to the valuable nutritional profile of this crop (B Matthaus et al. 2023).

From a genetic point of view, *Carthamus tinctorius* L. is an interesting species for breeding, as it presents an important variability of agronomic and biochemical characters. Sequencing of the plant genome allowed the identification of genes involved in the biosynthesis of unsaturated fatty acids, thus providing concrete opportunities for marker-assisted improvement (Gupta et al., 2024). In particular, the aim is to increase the oil content, tolerance to drought and salinity, but also to reduce the vegetation period, for efficient integration into short crop rotations.

In addition to use for oil production, safflower culture has multiple secondary applications. Its flowers have been used for centuries to obtain natural dyes (yellow and red), being in the past an important source of pigment for the textile industry (Zhou et al., 2023, Weiss, 2000, cited by R.A. Samale et al. 2024). The petals are also used in traditional Chinese and Persian medicine, for their anti-inflammatory, antithrombotic, and antioxidant effects (Delshad et al., 2018).

The economic importance of the crop is supported by the possibility of integrating it into organic and conservative farming systems, due to its low requirements for chemical inputs. It can also contribute to the diversification of oil crops and the reduction of economic risks for farmers in conditions of accentuated climate variability (Salera et al., 2021, Rafiquzzaman, M.,2007, Sirel Z, Aytac Z.2016). However, widespread adoption of the crop is limited in some regions by relatively low yields and a lack of infrastructure for processing and recovery, compared to other major oilseeds such as sunflower or rapeseed).

In conclusion, Safflower represents a valuable agricultural resource, with multiple applications and a high potential for integration into sustainable agriculture strategies. Its expansion depends largely on progress in genetic breeding, the development of value chains and the increase in market interest in natural, functional and sustainable products.

MATERIALS AND METHODS

The experiment was carried out in an experimental field located in the Timisoara area, characterized by a temperate-continental climate, with sub-Mediterranean influences, specific to western Romania. The experimental site in Timișoara is located within the Banato–Crișana Plain, part of the western Romanian lowlands. It lies in the Timiș Plain, specifically within the interfluve area between the Bega and Beregsău rivers, at the transition zone to the High Plain.

The landscape is predominantly flat to slightly undulating, favoring uniform field experiments.

The soil at the experimental site is classified as a cambic chernozem, weakly gleyed and weakly decarbonated, developed on loess-like deposits with a clayey-loam to loamy-clay texture.

The groundwater level is relatively shallow, ranging between 2 and 3 meters. The soil reaction varies with depth: it is slightly acidic in the 0–20 cm layer, neutral between 20–57 cm, and slightly alkaline from 57 to 200 cm. Calcium carbonates are absent in the upper 0–57 cm, present in low amounts between 57–67 cm, and in moderate amounts from 67–200 cm.

In terms of fertility indicators, the humus content is low in the 0–57 cm layer; however, the humus reserve within the first 50 cm is considered high, which contributes positively to soil organic matter. The nitrogen content (expressed by the C:N ratio) is moderate, supporting balanced nutrient cycling. The soil is moderately supplied with available phosphorus and potassium, essential for plant development. Furthermore, the base saturation degree confirms that the soil is well saturated with exchangeable bases, indicating good nutrient retention capacity.

The topography is generally flat to slightly undulating.

The experimental field was established on a cambic chernozem soil, characterized as weakly gleyed and weakly decarbonated, formed on loess-like deposits with a clayey-loam to loamy-clay texture. The groundwater table is relatively shallow, with a depth ranging between 2 and 3 meters.

The biological material used was represented by a local population of safflower (Carthamus tinctorius L.), adapted to the ecoclimatic conditions of the area. The experimental structure was bifactorial, according to the subdivided model, with the following factors:

Factor A – Sowing season, with 2 variants:
A1 - Epoch I - sown on March 18
A2 - Epoch II - sown on April 1

Factor B – Distance between rows, with 2 variants:
B_1 – 50 cm
B_2 – 30 cm

Each variant was carried out in 3 repetitions, and the sowing was carried out manually.

The agrotechnical works were applied uniformly over the entire experimental field, according to the technology recommended for safflower cultivation.

The harvest was carried out manually, at full physiological maturity.

The following biochemical parameters were determined in the paper: mineral content, crude protein content and fat content. The pedoclimatic conditions in the Timisoara area are favorable for the cultivation of saffron, but the sowing period significantly influences the level of production. (Niţă Simona et al. 2013; Popa Dorin et al. 2013).

RESULTS AND DISCUSSIONS

In 2024, Timisoara recorded average annual temperatures of 12.99°C, being the warmest year in the history of meteorological records in Romania, with a thermal deviation of +2.71°C compared to the 1991–2020 average. This period of extreme heat was accompanied by intense heat waves, with temperatures exceeding 30°C in southern Europe, including Romania.

In terms of rainfall, Timisoara recorded an annual average of about 600 mm, with an irregular distribution throughout the year. June was the wettest, with 76 mm of rainfall, while the summer months, July and August, had lower rainfall, of 64 mm and 50 mm, respectively.

In Table 1. and Figure 1. the harvest dates obtained in Șofrănel are presented according to the distance between the rows and the sowing time.

In the first sowing era, the average yield was higher (1750 kg/ha), this suggests that plants sown earlier benefited from: better soil moisture, more balanced temperatures during the growing season and a complete development cycle, less affected by summer heat stress.

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Table 1.

Harvest results in Şofrănel according to the sowing time and the distance between rows recorded in 2024.

Epoch	Row spacing (cm)	Production kg/ha	Production Relative %
Epoch I	50	2100	83
Epoch I	30	1400	80
Mid-Period I		**1750**	100
Epoch II	50	1416	91
Epoch II	30	1166	90
Medium Epoch II		**1291**	100

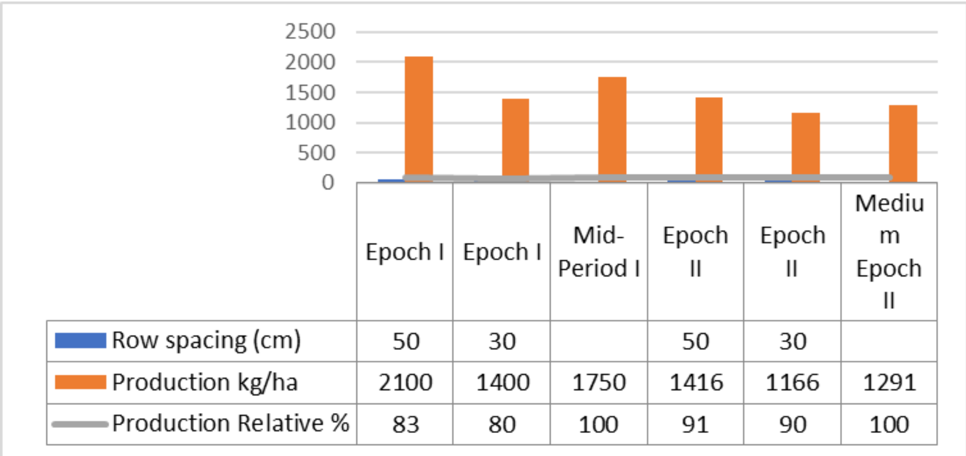

Figure 1. Harvest results in Şofrănel according to the sowing time and the distance between rows

In the Second Era, there was a significantly lower average production (1291 kg/ha), this suggests that: temperatures were higher in the critical phases of development (flowering, fruit formation), water stress in the July-August period (confirmed by climatic data), shorter vegetation period, possibly affecting the accumulation of biomass. In this case, we see a significant decrease in average production in Epoch II compared to Epoch I (a decrease of 459 kg/ha, i.e. about 26% more in favor of Epoch I). Absolute production decreases in Epoch II, relative production decreases from 83% in the first variant of Epoch I, to 90% in Epoch II.

This difference is significant and justifies the choice of early sowing in years with dry and hot summer forecasts, such as 2024. In both eras**,** the longer row spacing (50 cm) provides higher yields.

Although the relative values are close, the actual yield (kg/ha) is higher in Epoch I, which makes it more efficient in terms of yield.

The distance of 50 cm between rows registered an average production of 1750 kg/ha, higher than the distance between the rows.

This greater distance allows for better aeration between plants, a higher degree of branching, less competition for light and nutrients, a more favorable microclimate in the vegetation layer, better access to mechanized work (herbicide, weeding, etc.).

At the distance of 30 cm between rows**,** the average yield was 1291 kg/ha, about 459 kg/ha (−26%) lower. Possible disadvantages would be: the plants are more crowded, which can lead to: greater competition for water (especially in drought conditions), difficulties in ventilation, increased risk of diseases, a denser vegetation layer, less efficient in the use of light.

MINERAL CONTENT (%)

The analysis of the variability of mineral content (%) according to two agronomic factors — sowing time (Epoch I and Epoch II) and row spacing (50 cm and 30 cm) — was carried out on the basis of the data presented in Table 2 and Figure 2.

Table 2.

Mineral content (%) in Safflower according to sowing time and distance between the lines.

Epoch	Row spacing (cm)	Minerals (%)
Epoch I	50	2,56
Epoch I	30	2,43
Epoch II	50	2,31
Epoch II	30	2,40

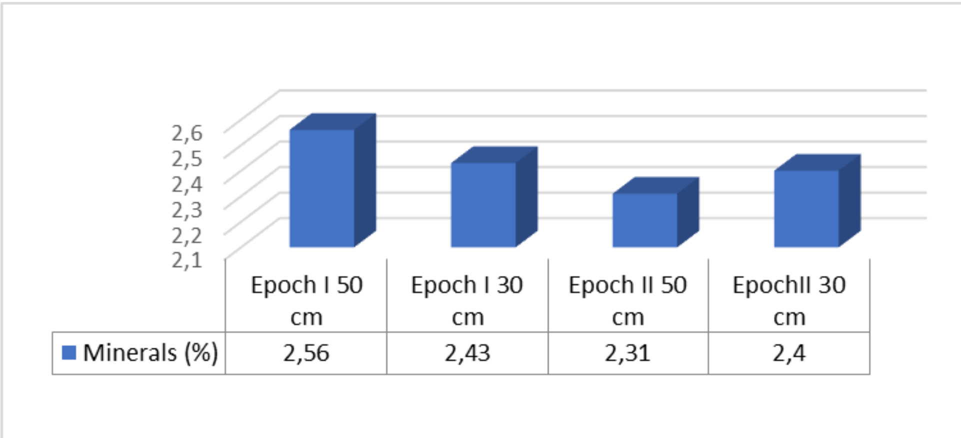

Figure 2. The content of mineral substances (%) in Saffron according to the sowing time and the distance between rows.

For Epoch I, characterized by earlier sowing, the mineral content values were 2.56% and 2.31%, with an average of 2.435%. In the case of Epoch II, with later sowing, values of 2.43% and 2.40% were recorded, and the average was 2.415%. The differences between the averages of the two eras are small (0.02%), indicating a negligible influence of the sowing season on the accumulation of mineral substances under the studied conditions.

Also, the more pronounced variability observed during Epoch I suggests a higher sensitivity of the plant to environmental factors such as rainfall or temperature, but this difference does not prove to be statistically significant.

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Regarding the distance between rows, the difference in mineral content is minimal (0.02%), but there is a slight trend of increasing the concentration of mineral substances at the distance of 50 cm between rows. This situation can be explained by the fact that the greater space available for the development of the root system favors a more efficient absorption of minerals from the soil.

CRUDE PROTEIN CONTENT (%)

In the context of modern agriculture, where quantitative objectives are balanced with production quality requirements, crude protein content is an essential indicator of the nutritional value of oilseeds, including safflower (*Carthamus tinctorius L.)* (Table 3 and Figure 3).

Table 3.

Crude protein content (%) of Safflower by sowing time and row spacing

Epoch	Row spacing (cm)	Brute protein (%)
Epoch I	50	15,07
Epoch I	30	15,42
Epoch II	50	15,32
Epoch II	30	17,06

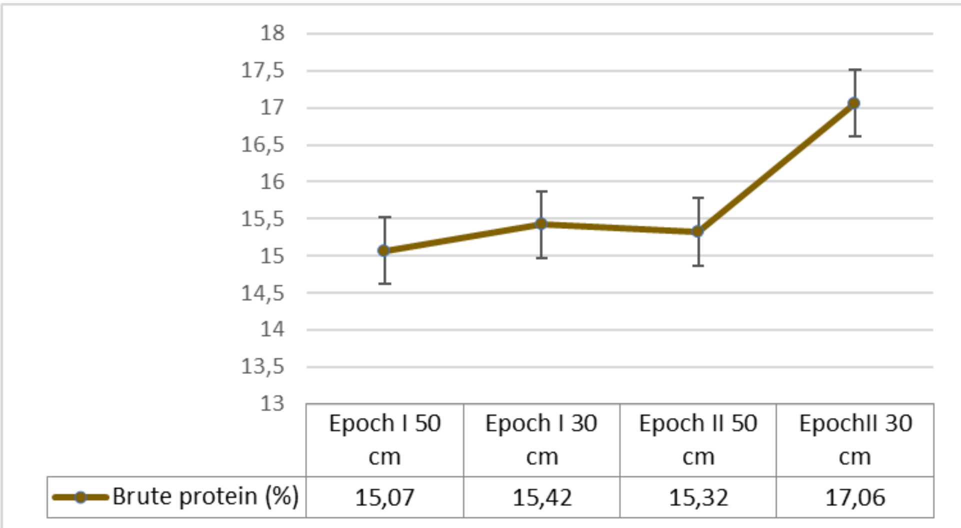

Figure 3.Crude protein content (%) of Safflower according to the sowing time and the distance between rows

The present study analyzes the influence of four technological variants, resulting from the combination of two agronomic factors — the sowing season (Epoch I and Epoch II) and the row spacing (30 cm and 50 cm) — on the accumulation of crude protein in the climatic conditions specific to 2024, characterized by notable meteorological peculiarities in the Timisoara area

The year 2024 was marked by favorable weather conditions for the development of safflower sown in Epoch II (late March – early April), this period providing an optimal

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vegetation window for the accumulation of proteins in seeds. In contrast, early sowing (Epoch I – early March) was negatively influenced by the low temperatures in the budding period, which led to a delay in the initial growth and development of plants, affecting the potential for protein synthesis and accumulation in the later phases of vegetation.

The results show that the highest values of crude protein content were obtained in Epoch II of sowing and at a distance of 30 cm between rows, with a level of 17.06%, which suggests a favorable synergistic effect of these factors on the protein quality of the seeds.

In contrast, the lowest values were recorded in Epoch I and at a distance of 50 cm between rows (15.07%), which indicates a negative influence of too early sowing combined with a low plant density.

From an agronomic point of view, a shorter distance between rows (30 cm) can lead to faster soil cover, more intense competition for light and nutrients, but also a better use of resources in favorable climatic conditions. Also, the delayed sowing (Epoch II) coincided in 2024 with a more stable period in terms of thermal and hydration, which favored the accumulation of protein substances in the seeds.

FAT CONTENT (%)

In Table 4. and Figure 4. The fat content of safflower is shown.

Safflower (Carthamus tinctorius L.) is a valuable oilseed crop, appreciated for its high fat content, especially for the oil extracted from the seeds, used both in food and in the cosmetic and pharmaceutical industries (Table 4. and Figure 4.).

Table 4.

Fat content (%) in Safflower according to sowing time and row spacing

Epoch	Row spacing (cm)	Grasime (%)	Of which saturated fatty acids
Epoch I	50	20,19	10,19
Epoch I	30	18,02	10,12
Epoch II	50	17,89	9,79
Epoch II	30	18,78	9,36

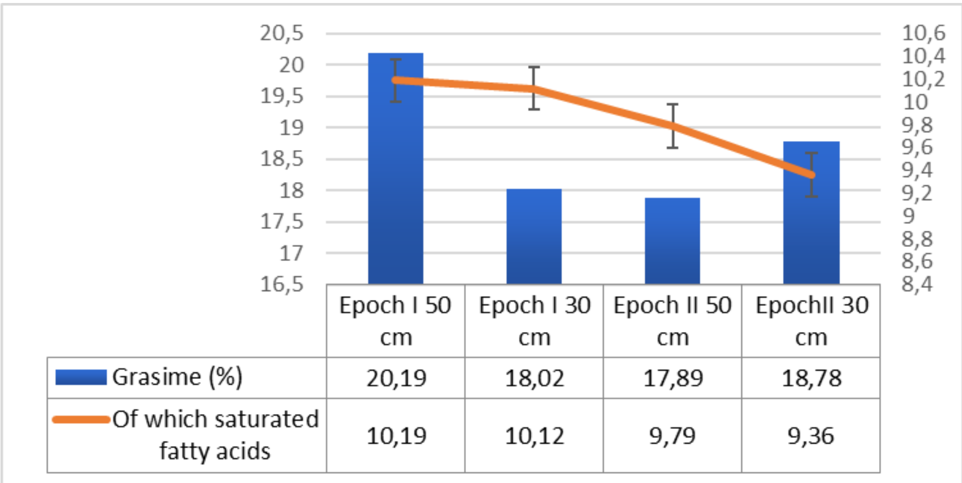

Figure 4. Fat content (%) in Safflower according to sowing time and row spacing

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The quality of the oil is influenced not only by the total amount of fat, but also by its fatty acid profile, especially the saturated fatty acid content. This study follows how the sowing season and the distance between rows influence these components, in the climatic context of the 2024 agricultural year in Timișoara.

As for the total fat content, the highest values were obtained in Epoch I at the distance of 50 cm between rows (20.19%). This suggests that early sowing, in combination with a lower density (through greater row spacing), favors lipid accumulation in safflower seeds. At the same time, the lowest value of total fat (17.89%) was recorded at the delayed sowing (Epoch II) with a long distance between rows (50 cm), indicating a possible negative influence of this combination on lipid synthesis.

On the other hand, the analysis of saturated fatty acids shows an inverse trend with respect to total fat: the highest values (10.19%) were recorded in Epoch I at 50 cm, and the lowest (9.36%) in Epoch II at 30 cm. Thus, a later sowing and a shorter spacing between rows seem to lead not only to a reduction in saturated fat content, but also to a healthier lipid composition, from the perspective of human consumption.

This inverse relationship between total fat and the proportion of saturated fatty acids is important in the context of the current interest in functional foods and vegetable oils with superior nutritional value.

CONCLUSIONS

The sowing season significantly influences safflower production.

In the agricultural year 2024, early sowing (Epoch I) allowed a more favorable development of the crop and led to higher yields than Epoch II.

Early sowing is recommended in areas with hot and dry summers.

In regions where heat and water stress are anticipated, such as the west of the country, sowing in the first decade of March maximizes the use of climate resources in spring.

The row spacing influences the yield.

A longer row spacing (50 cm) led to an increase in yield of about 26% compared to the 30 cm spacing, due to reduced competition between plants and more efficient root development.

The content of mineral substances varies little between eras and distances.

Values ranged from 2.31% to 2.56%, with a slight tendency to grow at greater distances (50 cm), suggesting more efficient mineral absorption under better plant spacing conditions.

Epoch I shows greater variability in mineral content.

This can be associated with the influence of environmental factors in the early vegetation period, such as low temperatures or uneven rainfall.

Delayed sowing and higher density increase crude protein content.

Under the climatic conditions of 2024, the combination of Epoca II + 30 cm between rows determined the highest crude protein content in the seeds, indicating an efficient adaptation to the high temperatures of the ripening period.

Technology strategies can be adapted according to the ultimate goal of the culture.

If maximum yield is pursued, early sowing and wide spacing are recommended; On the other hand, to improve the nutritional value (protein), delayed sowing and increased density can be more effective.

Fat content and lipid profile are influenced by age and density.

Early sowing (Epoch I) and wide spacing (50 cm) favor the accumulation of a greater amount of total fat, but also a higher percentage of saturated fatty acids.

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On the other hand, delayed sowing (Epoch II) and a short row spacing (30 cm) results in a more nutritionally favorable lipid profile**,** through a lower content of saturated fatty acids.

Technological factors influence both the quantity and quality of production.

The sowing time and the distance between rows not only affect the total production, but also the biochemical composition of the seeds (crude protein, fats, saturated fatty acids and minerals), emphasizing the importance of choosing an appropriate technology according to the climatic conditions and the farmer's goals.

BIBLIOGRAPHY

BILMEZ-ÖZÇINAR, A**.** 2021 - Safflower (*Carthamus tinctorius L.*): Utilisation, Genetics and Agronomy. *MAS Journal of Applied Sciences*, 6(Special Issue), 1130–1136.

DELSHAD, E., YOUSEFI, M., SASANNEZHAD, P., AYATI, Z., RAKHSHANDEH, H. 2018 - Medical uses of Carthamus tinctorius L. (Safflower): a comprehensive review from Traditional Medicine to Modern Medicine. *Electronic Physician*, 10(4), 6672–6681.

GUPTA, S.K., JAT, R.A., SINGH, S.P. 2024 -Advances in safflower breeding for enhanced oil content and stress resilience. *BMC Genomics*, 25, 10405.

LI, X., XU, D., & WANG, Y**.** 2024 - Fatty acid biosynthesis pathways in *Carthamus tinctorius L*. and implications for oil quality. *Journal of Oilseed Research*, 41(2), 89–96.

MATTHAUS, B., ÖZCAN, M.M., & AL JUHAIMI, F.Y**.** 2015 - Fatty acid composition and tocopherol profiles of safflower (*Carthamus tinctorius L.*) seed oils. *PMID: 25329876*, DOI: 10.1080/14786419.2014.971316

NIȚĂ, S., TABĂRĂ, V., MATEAȘ, I.M., PANAITESCU, L., LUNGU, M. 2013 - Preliminary studies on the production capacity, several lines of safflower (*Carthamus tinctorius L.)* under conditions of Timişoara. *Research Journal of Agricultural Science*, 45(3), 123-128.

POPA, D., NIȚĂ, S., & MATEAȘ, I.M. 2013 - Influence of sowing time on production capacity a few lines of safflower (*Carthamus tinctorius L*.) under Timisoara. *Research Journal of Agricultural Science*, 45(4), 156-159.

RAJU, T.J., SULTANA, R., & KESHAVULU, K.P.K**.** 2019 - Study on relationships among seed yield components in F3:4 population in safflower (*Carthamus tinctorius L*.). *Journal of Pharmacognosy and Phytochemistry*, 8(1), 2205-2207.

RAFIQUZZAMAN, M., HOSSAIN, M.A., & HASAN, A.M. 2007 - Studies on the Characterization and Glyceride Composition of Safflower (*Carthamus tinctorius*) Seed Oil. *Bangladesh Journal of Scientific and Industrial Research*.

RA SAMALE, WANKHADE, M.P., GHUGE, S.B., RATHOD, A.H., & MISAL, A.M. 2024 - Correlation studies in M5 generation of safflower [*Carthamus tinctorius (L.*)]. *International Journal of Research in Agronomy*, SP-7(12), 154-156.

SALERA, M.J., PEÑA-VALDIVIA, C.B., FERNÁNDEZ, M.D. 2021 - Safflower: An ancient crop with modern potential under stress conditions. *Phyton*, 90(2), 355–365.

SATHWIKA, G.P., RAJANIKANTH, E., SAMPATH, O., & KRISHNA CHAITANYA, K. 2023 - Evaluation of Safflower (Carthamus tinctorius L.) Cultivars under Different Sowing Dates on Yield and Yield Attributes in Non Traditional Area of Northern Telangana Zone (NTZ). *International Journal of Environment and Climate Change*, 13(9), 3461–3466.

SIREL, Z., & AYTAC, Z. 2016 - Relationships between the seed yield and some agronomic characteristics of safflower (Carthamus tinctorius L.) under semi-arid conditions. *Turkish Journal of FIELD CROPS*, 21(1), 29–35.

WEISS, E.A. 2000 - *Castor, sesame and safflower*. London: Leonard Hill Books; pp. 529–744.

ZHOU, Y., ZHANG, M., & LI, L. 2023 - *Carthamus tinctorius L.:* A review of traditional uses, phytochemistry and pharmacological activities. *Frontiers in Pharmacology*, 14, 1143291.