Scientific Papers. Series A. Agronomy, Vol. LXVIII, No. 2, 2025
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH ON THE BIOLOGY AND PRODUCTIVITY OF THE *Carthamus tinctorius* L. SPECIES IN THE CLIMATE CONDITIONS OF CENTRAL MOLDOVA

Oana MÎRZAN[1], Alexandra Andreea BUBURUZ[1], Margareta NAIE[1], Doru STANCIU[1], Mihai STAVARACHE[2]

[1]Agricultural Research and Development Station Secuieni, 337 Principala Street, Secuieni, 617415, Neamţ County, Romania
[2]Development Station and Meadows Development Vaslui, 256 Ştefan cel Mare Street, Vaslui, 730006, Vaslui County, Romania

Corresponding author email: naie.marieta@yahoo.com

Abstract

Safflower (Carthamus tinctorius) is an annual herbaceous plant in the Asteraceae family. Safflower was previously cultivated for its seeds and flowers, which were used to add colour and flavour to food, in dyes, and medicine. Recently, the plant has been cultivated mainly for the vegetable oil extracted from the seeds. Saffron flowers are sometimes used as a substitute for safflower. Safflower is one of mankind's oldest crops but remains a minor crop compared to other oilseeds. Today, safflower is mostly cultivated for the production of vegetable oil. The main objective of the present research was to study the biology and productivity of the species Carthamus tinctorius L. with the aim of understanding its adaptability to the climatic conditions in Central Moldova. Safflowers matures 110-150 days after sowing; the optimal harvest time is when the seeds are matte white. Under the conditions of S.C.D.A. Secuieni, the highest seed production was obtained in the variant sown in the first decade of April at a distance of 70 cm between plants/row.

Key words: *safflower, productivity, biology.*

INTRODUCTION

Safflower has been cultivated since ancient times in China, Egypt and India. In the Middle Ages it was grown in Europe, Central America and South America. In the United States safflower started to be cultivated in the year 1925 (Walsh et al., 2008).

Safflower (*Carthamus tinctorius* L.) seed is an important source of oil also its flowers are an important source of spice. Safflower flowers can be in red, orange, yellow and rarely white colors (Erbas and Baydar, 2017; Hüseyin et al., 2018). With global demand, there is a need to develop varieties that have higher oil content, higher productivity, and are resistant to different challenging environments (Weselake, 2016; Zafar et al., 2019; Kotecka-Majchrzak et al., 2020; Hassani et al., 2020; Dobrin et al., 2021).

Safflower oil contains linoleic, palmitic and oleic acids with admixtures of stearic, arachidic, and meristic acids (Sazhin et al., 2017; Norov, 2019). The predominant acid in safflower oil is linoleic acid, the content of which is 78.5% (Mateev et al., 2017; Smetneva et al., 2020; Rathaur et al., 2023). Vegetable oils help reduce diseases of the cardiovascular system and metabolic diseases and help normalize painful human conditions (Smetneva et al., 2020). Growing safflower for use in feeding cattle and small ruminants, poultry farming also has a positive effect in the summer in eliminating the deficiency of protein and fat in animal diets (Belikina et al., 2021; Muscalu et al., 2022; Belyakov and Nazarova, 2023; Rathaur et al., 2023).

Safflower culture has importance to agriculture, the main reason of this cultivation being the following: high resistance to drought and soil salinity; tolerance to high temperatures and drought; mature seeds are not shaken and cannot be eaten by birds because of their specific inflorescence; it can be introduced into crop rotation in any agricultural system, including organic, having a deep root system; cultivation and harvesting can be fully mechanized; and it has lower production costs

(Gilbert, 2008; Cucu, 2014). Safflower seeds are used in food industry for the production of oil. Depending on the variety there are two kinds of oil: oil with a high content of linoleic acid, and oil with a high content of oleic acid. Safflower seeds are used both in the pharmaceutical industry, because of their therapeutic properties, and in varnish and paint industry (O'Brien, 2008; Dajue and Mündel, 1996).

Be aware of the different stages of growth period involves the emergence, shooting, button, flowering and maturation makes to evaluate the required conditions in each stage and it is close to the plant optimal conditions to increase the crop yield (Koocheki and Sarmadnia, 2000). Different investigation among safflower genotypes as terms of the phonological duration and time of phonological stages had difference because of genetic characteristics and environmental factors (Behdani et al., 2008). Increasing the plant density due to reducing the light absorption inside the plant canopy and creating competition among plants, caused to increase the plant height and early flowering (Dadashi, 2001). With the increasing of planting row interval, due to more light absorption into the plant canopy, the number of sub branches increased (Azari, 2001).

Different experiments results on safflower (Zareian, 2001: Azari, 2001), Soybean (Khadem Hamzeh, 1995), Chickpea (Gan et al., 2003) represents the reducing, sub branches is influencing of increasing plant density. Number of head in per plant is one of the main components of seed yield in safflower which high vegetative growth and plant ramifications are the reasons of the increasing yield (Pourdad, 1999; Omidi Tabrizi et al., 2002).

The plant growth analysis has become increasingly significant, particularly in controlled conditions, as it offers valuable insights into the physiological aspects of plant breeding (Fourcaud et al., 2008). It has been reported that through these analyses, determining the optimal planting time and plant density becomes feasible, leading to enhanced yield and quality when accompanied by timely irrigation and fertilization practices (Abbas et al., 2019). The determination of the optimal sowing time relies on the temperature and humidity conditions specific to the area. Moreover, timely sowing enhances grain retention in the field, leading to increased seed yield and high-quality oil production. Although several research have evaluated the adaptability of the safflower plant in Türkiye and in the world (Steberl et al., 2020; Culpan, 2023; Kamle et al., 2023; Yılmaz et al., 2023), comprehensive research focusing on its growth and development period remains scarce. Furthermore, there is a limited understanding of the physiological growth and development patterns exhibited by safflower plants.

This research was conducted to determine the effects of planting time on the growth parameters of the safflower plant, considering the effects of cultivation techniques on the growth parameters of the safflower plant.

The purpose of the research carried out during 2021-2023 period was to determine the influence of meteorological conditions on the biology, yield and quality of safflower seeds in the center of Moldova region.

MATERIALS AND METHODS

The Agricultural Research and Development Station (A.R.D.S.) Secuieni is located in the S-E part of Neamţ County, being located between the geographical coordinates of 26°51'00" east longitude and 46°51'15" north latitude. From an agro - ecosystem point of view, the territory belongs to the Central Moldavian Plateau, and from a morphostructural point of view, most of it is identified with the Moldavian platform. The area where the unit is located has a temperate continental climate (D.f.b.x. Köppen), characterized by short springs, cool summers and harsh winters, with an average annual temperature of 10.1°C and an annual amount of precipitation of 537 mm (Trotuş et al., 2020). In the conditions of A.R.D.S. Secuieni we experimented three sowing epochs: V1 (control) - sown in the first decade of April; V2 - sown in the second decade of April; V3 - sown in the third decade of April.

To establish the optimal nutrition space, a bifactorial experiment was set up according to the subdivided plot method with the following factors: A - the distance between rows with graduations: a1 - 25 cm, a2 - 50 cm and a3 - 70 cm and B - the distance between plants per row

with graduations: b1 - 15 cm, b2 - 25 cm and b3 - 35 cm.
During the safflower vegetation period, phenological observations were made, also establishing the required thermal degrees for its growth and development for the species under study.
From a thermal point of view during the safflower growing season, in 2021 there were monthly deviations from the multi-year average between -2.0°C (April) and 1.8°C (July). The spring was cool and the summer months were normal (June and August) and hot (July). In 2022, the safflower growing season was warm, with monthly deviations from the multi-year average ranging from 0°C (April) to 3.2°C (August) (Figure 1).

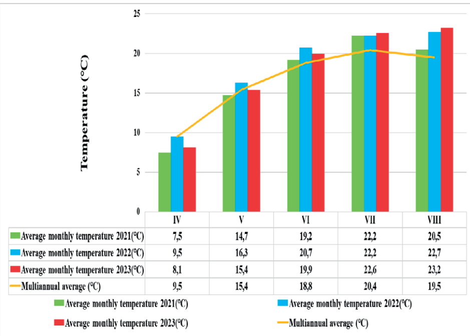

Figure 1. Temperatures recorded during the safflower growing season in the period 2021-2023

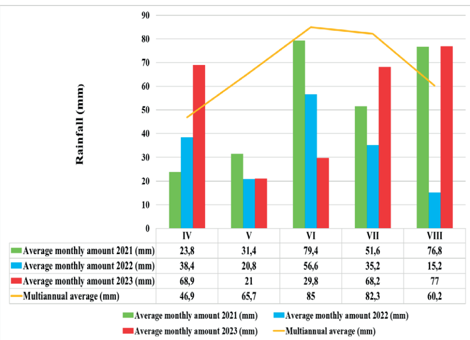

Figure 2. Precipitation recorded during the safflower growing season in the period 2021-2023

With regard to the rainfall recorded during the safflower growing season, in 2021 there were monthly deviations from the multi-annual monthly amount between -36.5 mm (September) and 16.6 mm (August). The safflower growing season in 2022 was characterized as dry. The recorded precipitation had deviations from the multiannual average between -47.1 mm (July) and -8.5 mm (April) (Figure 2). The precipitation that fell in 2023 characterized the safflower growing season as dry (Naie et al., 2024). Meteorological data comes from the unit's own weather station, located in the experimental field of ARDS Secuieni.

RESULTS AND DISCUSSIONS

In the case of the species *Carthamus tinctorius* L. sown in first decade of April, on average over three years, the plants emerged after 16 days from sowing, accumulating a sum of degrees of 128.5°C and the sum of precipitation totaling 14.6 mm. From emergence to the appearance of the flowering stem, 38 days were totaled, requiring a sum of degrees of 452.3°C and 29.6 mm of precipitation (Table 1).
From the appearance of the flowering stem to the beginning of flowering, 31 days were needed, the sum of thermal degrees recorded for this period was 534.5°C and 32.2 mm of precipitation (Table 1).
The seeds were harvested 32 days after the beginning of fruiting, accumulating 795.2°C and 26.2 mm of precipitation (Table 1).
From sowing to harvest, plants sown in the first epoch needed an average of 150 days, with a degree sum of 2498.9°C and 158 mm of precipitation.
Due to the higher temperatures during the vegetation period, the plants sown in the second and third epochs had a faster evolution. In the second epoch, from sowing to seed harvesting, 134 days were required, the sum of the accumulated temperatures was 2426.9°C and the precipitation amounted to 149 mm (Table 1).
In the third epoch, the plants had a vegetation period of 110 days to reach maturity. The sum of the temperatures recorded for this epoch was 2138.4°C and the precipitation amounted to 129.4 mm (Table 1).

Table 1. Growth phenophases of the species *Carthamus tinctorius* L.
under the conditions of A.R.D.S. Secuieni in the period 2021-2023

Phenological observations	Average growing season duration in the period 2021-2023 (days)	Σ average temperature (^{0}C)	Σ average precipitation (mm)
	Epoch I		
Sowing	-	-	-
Emergence	16	128.5	14.6
The appearance of flowering rods	38	452.3	29.6
The beginning of blooming	31	534.5	32.2
The beginning of fructification	33	588.4	55.9
Harvesting for seeds	32	795.2	26.2
TOTAL	150	2498.9	158.5
	Epoch II		
Sowing	-	-	-
Emergence	15	131.3	22.2
The appearance of flowering rods	35	526.6	30.8
The beginning of blooming	28	529.3	40.9
The beginning of fructification	30	621.9	26.4
Harvesting for seeds	26	617.8	28.7
TOTAL	134	2426.9	149.0
	Epoch III		
Sowing	-	-	-
Emergence	11	145.8	14.2
The appearance of flowering rods	30	522.5	31.4
The beginning of blooming	23	477.9	33.4
The beginning of fructification	26	616.1	26.4
Harvesting for seeds	21	376.1	24.0
TOTAL	110	2138.4	129.4

Table 2. Influence of the interaction between row spacing and plant spacing
on average seed production at *Carthamus tinctorius* L. (safflower) in the period 2021-2023

Distance between rows (A)	Distance between plants (B)	Production (kg/ha)	%	Diff.	Significance
a1 - 25 cm	b1-15 cm	623	53.75	-536	ooo
	b2-25 cm	718	61.95	-441	oo
	b3-35 cm	802	69.20	-357	oo
a2 - 50 cm	b1-15 cm	1124	96.98	-35	-
	b2-25 cm	1368	118.03	209	*
	b3-35 cm	1278	110.27	119	-
a3 - 70 cm	b1-15 cm	1498	129.25	339	**
	b2-25 cm	1589	137.10	430	**
	b3-35 cm	1436	123.90	277	**
Average		1159	100	Ct.	
LSD 1% 131.3 kg/ha LSD 0.1% 259.6 kg/ha LSD 5% 489.4 kg/ha					

Under the conditions at SCDA Secuieni, the interaction of the studied factors influenced the average seed production of the safflower species. Compared to the average of the experience (1159 kg/ha), production increases ranging from 209 to 430 kg/ha were obtained, being statistically assured and interpreted as distinctly significant positive. The interaction a3xb2 (70 cm row spacing and 25 cm between plants per row) with an average production of 1589 kg/ha was noted (Table 2).

The average seed production ranged between 1241 kg/ha for the variant sown in the III[rd] decade of April and 1593 kg/ha for the variant sown in the I[st] decade of April (control). Compared to the control, the production deficits were statistically confirmed and interpreted as negatively significant and distinctly significant and were obtained for the variants sown in the second period (210 kg/ha) and the third period (352 kg/ha) (Table 3).

Tabel 3. Average seed production at safflower obtained depending on the sowing season at A.R.D.S. Secuieni in the period 2021-2023

Variant	Production			
	kg/ha	%	Diff.	Sign.
V1 - I[st] decade of April	1593	100	Ct.	
V2 - II[nd] decade of April	1383	86.81	-210	o
V3 - III[rd] decade of April	1241	77.90	-352	oo
	LSD 5% 123.5 kg/ha LSD 1% 243.6 kg/ha LSD 0.1% 384.7 kg/ha			

CONCLUSIONS

Safflower has the ability to capitalize on poorly productive soils, unsuitable for sunflowers. The average production of safflower varies widely depending on climatic conditions, the sowing season and the varieties cultivated.

It is recommended to sow safflower in the first decade of April and at a distance of 70 cm between rows. Ensuring the nutrition space is very important for obtaining high productions for safflower. On safflower yields are strongly influenced by the conditions of experimental time of sowing.

REFERENCES

Abbas, G., Younis, H., Naz, S., Fatima, Z., Hussain, S., Ahmed, M., Ahmad, S. (2019). Effect of Planting Dates on Agronomic Crop Production. *Agronomic Crops, 1*, 131-147.

Azari, A. (2001). Determination of optimum planting pattern for safflower, variety Kooseh, at early and late planting dates in Isfahan. M.Sc. thesis. *Department of Agronomy and Plant Breeding. Isfahan University of Technology*. Isfahan, Iran.

Behdani, M.A., Jami Al-Ahmadi, M. (2008). Evaluation of growth and yield safflower cultivars in different planting dates. *Iranian Journal of Field Crops Research 6*(2), 245-254.

Belikina, A.V. (2016). Strategic scenarios for the development of oilseeds production in the Volgograd region. *Bulletin of the APC of Stavropol, 4*, 139-143.

Belyakov, A. M., Nazarova, M. V. (2023). Ecological and economic efficiency of the agroforestry complex in the zone of chestnut soils of the Volgograd region. *Research Crop, 24*, 579-583.

Cucu, M.E. (2014). Research regarding oilseeds crops species growing in ecological agriculture production system, in North Dobrudja. *Scientific Papers. Series A. Agronomy*, *57*.

Culpan, E. (2023). Effect of Sowing Dates on Seed Yield, Yield Traits and Oil Content of Safflower in Northwest Turkey. *Turkish Journal of Field Crops, 28*(1), 87-93.

Dadashi, N.A. (2001). Effect of planting date on yield and yield components of safflower cultivars. *M.Sc. thesis. Department of Agronomy and Plant Breeding. Isfahan University of Technology*. Isfahan, Iran.

Dajue, L., Mündel, H.H. (1996). Safflower. Carthamus tinctorius L. Promoting the conservation and use of underutilized and neglected crops. *Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant Genetic Resources Institute*, Rome, Italy.

Dobrin, A., Popa, V. I., Potor, C.D., Georgescu, M.I. (2021). Morphological and anatomical characterization of safflower (Carthamus tinctorius L.) hypsophyls and leaves. *Scientific Papers. Series A. Agronomy*, *LXIV,1*.

Erbaş, S., Baydar, H. (2017). Aspir (Carthamus tinctorius L.) de yaprak dikenliliği ve çiçek renginin genetiği. *Anadolu Tarım Bilim. Dergisi, 32*, 245-248.

Fourcaud, T., Zhang, X., Stokes, A., Lambers, H., Körner, C. (2008). Plant Growth Modelling and Applications: The Increasing Importance of Plant Architecture in Growth Models. *Annals of Botany, 101*(8), 1053-1063.

Gan, Y.T., Miller, P.R., McConkey, B.G., Zentner, R.P., Liu, P.H., McDonald, C.L. (2003). Optimum plant population density for chickpea and dry pea in a semiarid environment. *Can. Journal Plant Sciences 83*, 1-9

Gilbert, J. (2008). International safflower production - an overview. *Proceedings of the 7th International Safflower Conference*, Wagga Wagga, New South Wales, Australia.

Hassani, S.M.R., Talebi, R., Pourdad, S.S., Naji, A.M., Fayaz F. (2020). Morphological description, genetic diversity and population structure of safflower (Carthamus tinctorius L.) mini core collection using A B 686 SRAP and SSR markers. *Biotechnology & Biotechnological Equipment, 34*(1), 1043-1055.

Hüseyin, K., Davut, A. (2018). Investigation of different tillage and seeding methods in safflower (Carthamus tinctorius L.) cultivation. *Scientific Papers. Series A. Agronomy. Vol. LXI* (1), 481-486.

Kamle, R., Gehlot, Y., Singh, V., Kamle, S. (2023). Effect of Date of Sowing and Cultivars on Growth and Yield Attributes of Safflower. *International Journal of Environment and Climate Change, 13*(11), 974-988.

Khadem Hamzeh, H.R. (1995). Determination of the best planting density for soybean (CV. Hbbit) at different planting dates. *M.Sc. thesis. Department of Agronomy and Plant Breeding*. Isfahan University of Technology. Isfahan, Iran.

Koocheki, A.R, Sarmadnia, G. (2000). Crop Plants Physiology. *Jahadeh Daneshgahi Publisher*, Mashhad.

Kotecka-Majchrzak, K., Sumara, A., Fornal E., Montowska M. (2020). Oilseed proteins – Properties and application as a food ingredient. *Trends in Food Science & Technology, 106*, 160-170.

Mateev, E.Z., Terzhokhina, A.V., Kopylov, M.V. (2017). Qualitative research on the performance of safflower oil. *VSUIT Bulletin, 3*, 115-119.

Muscalu, A., Tudora, C., Sorică, C., Vlăduț, N.V., Mîrzan, O., Naie, M. (2022). Experimental research on harvesting species of medicinal plants grown on small areas. *AgroLife Scientific Journal, 2*, 110-115.

Naie, M., Mîrzan, O., Bărcan, M.D., Stavarache, M., Dumitriu, S., Stavarache, E., Muscalu, A., Batîr Rusu, D., Lungoci, C. (2024). Productivity and Vegetation Structure Evolution of Complex Mixtures of Perennial Forage Grasses and Leguminous Species, in the Conditions of the Center of Moldova, Romania. *Romanian Agricultural Research, 41*, 241-252.

Norov, M.S. (2019). Productivity of different varieties of safflower in rained conditions of Central Tajikistan. *Oilseeds, 3*, 60-63.

O'Brien, R.D. (2008). Fats and Oils: Formulating and Processing for Applications. *Third Edition, Editor CRC Press*.

Omidi Tabrizi, A.H., Gannadha, M.R., Peygambari, S.A. (1999). The study of important characters of spring safflower genotypes by multivariate analysis. *Iran Agriculture Science Journal, 30*(4), 817-826.

Pourdad, S. (1999). Primary evaluation of safflower germplasm in rainfall condition. *Dry land Agriculture Research Institute of Iran, 87*, 650: 2.

Rathaur, A., Rai, C.D., Agarwal, A. & Tripathi, D.A. (2023). Effect of Dietary Supplementation of Safflower (Carthamus tinctorius L.) Seed on the Growth Performance, Blood Lipid and Meat Quality of Broiler Chickens. *Indian Journal of Animal Research, 57*, 742-748.

Sazhin, A.N., Kulik, K.N., Vasiliev, Y.I. (2017). Weather and climate of the Volgograd region; 2nd edition, revised and additional (81-134). Volgograd. Federal Scientific Center for Agroecology RAS.

Smetneva, N.S., Pogozheva, A.V., Vasilyev, Y.L., Dydykin, S.S., Dydykina, I.S., Kovalenko, A.A. (2020). The role of optimal nutrition in the prevention of cardiovascular diseases. *Nutrition Issues, 3*, 114-124.

Steberl, K., Hartung, J., Munz, S., Graeff-Hönninger, S., (2020). Effect of Row Spacing, Sowing Density, and Harvest Time on Floret Yield and Yield Components of Two Safflower Cultivars Grown in Southwestern Germany. *Agronomy, 10*(5), 664.

Trotuş, E., Mîrzan, O., Naie, M., Leonte, A., Buburuz, A.A., Isticioaia, S.F., Popa, L.D., Lupu, C., Pintilie, P.L., Pleşcan, I.D. (2020). *Cultivation technologies of some field plants for the central area of Moldova.* Ed. „Ion Ionescu de la Brad", Iaşi, 2020.

Walsh, V., Chaplin, T., Eastaugh, N. (2008). *Pigment Compendium: A Dictionary and Optical Microscopy of Historical Pigments*. Editor Routledge.

Weselake, R.J. (2016). *Chapter 15 - Engineering Oil Accumulation in Vegetative Tissue*, Editor(s): Thomas A. McKeon, Douglas G. Hayes, David F. Hildebrand, Randall J. Weselake, Industrial Oil Crops. AOCS Press, 413–434.

Yılmaz, M., Geçgel, Ü., Apaydin, D., Culpan, E. (2023). Impact of Development Periods on Chemical Properties and Bioactive Components of Safflower (Carthamus Tinctorius L.) Varieties. *Journal of the American Oil Chemists' Society, 100*(9), 723-732.

Zafar, S., Li, Y.L., Li, N.N., Zhu, K.M., Tan X. L. (2019). Recent advances in enhancement of oil content in oilseed crops. *Journal of Biotechnology, 301*. 35-44.

Zareian, A. (2001). Yield, yield components and 208 Vaghar et al. Int. J. Biosci. 2014 growth characterstics of safflower genotypes under varying plant densities. M*.Sc. thesis. Department of Agronomy and Plant Breeding. Isfahan University of Technology*. Isfahan, Iran.