AF-868
[1-5]

RESEARCH ARTICLE Indian Journal of Agricultural Research

The Effect of Fertilizers and Growth Regulators on the Productivity of Safflower (*Carthamus tinctorius* L.) in the Dry Climate of Russia

Andrey Valerevich Solonkin[1], Elena Petrovna Sukhareva[1], Anna Vasilievna Belikina[1] 10.18805/IJARe.AF-868

ABSTRACT

Background: Safflower is an oilseed crop capable of forming seeds in extreme conditions, so it can be used as an alternative to sunflower, because their growing technologies are similar. Increasing the yield of safflower seeds can be achieved intensively using agrochemicals. The proposed research results provide information on the use of mineral, micro fertilizers and growth regulators.

Methods: Research was carried out in the dry steppe zone of chestnut soils. In the spirit-factor experiment, which was located on a field with an area of 300 m^2, in triplicate, using two sorts of safflower. Mineral fertilizers were applied to the soil during sowing and by foliar treatment during the “budding” phase. The obtained yield results were processed by analysis of variance.

Result: As a result of the research, elite safflower seeds were obtained using one of the experimental options Ultamag Bor 30 g + Biostim Growth 30 g/10 liters of water of the Alexandrite variety with a yield of 1.8 t/ha with the highest profitability of their production of 414.2%. Analysis of variance of the yield data from the experiment showed that 87% of the yield of safflower seeds depended on the use of mineral fertilizers, 0.62% on the plant variety and agro technical measures for growing safflower plants-11.8%.

Key words: Economic efficiency, Growth regulators, Micro fertilizers, Mineral fertilizers, Safflower dye.

INTRODUCTION

The cultivation of safflower (*Carthamus tinctorius* L.) is aimed at stabilizing the collection of oilseeds in the arid zone of chestnut soils of the Lower Volga region of Russia for the production of vegetable oils. The center of origin of safflower is the Mediterranean (Leus, 2020; Gatske *et al.*, 2023), the climatic conditions are characterized as hot and dry. This explains the peculiarities of the biology of safflower plants and its ability to tolerate hot and dry weather, so it is suitable for cultivation in the dry steppe climate of chestnut soils. Safflower is capable of forming a seed harvest in the driest conditions with a light yellow semi-drying oil content of about 37%, protein up to 19%, starch up to 25%. The resulting cake from safflower seeds contains 18 amino acids and can be supplemented in diets when feeding small and large ruminants and birds (Vasilenko *et al.*, 2018). Currently, the demand for safflower seeds is increasing. Major consumers of safflower seeds in world food markets are China (60.7 thousand tons), the USA (12.2 thousand tons), European countries 77 (thousand tons).

The technologies for growing safflower and sunflower are in many ways similar, since both crops belong to the Asteraceae family (Eskova *et al.*, 2015). Increasing the productivity of safflower in the technological cycle of seed production is inextricably linked with innovation and resource conservation, which will help improve their economic efficiency. In the direction of increasing the productivity of safflower, the seed production techniques using mineral, micro fertilizers and growth regulators in various ways is intended (Hiremath *et al.*, 2023; Vidyashree *et al.*, 2021; Amare *et al.*, 2020). An analysis of the scientific literature on the use of fertilizers and growth regulators in technologies for growing safflower seeds in arid climates allowed us to conclude that the maximum effective dose of nitrogen fertilizers was N_{50}, seed yield 1.3 t/ha (Eskova *et al.*, 2015). It has also been established that the use of nitrogen fertilizers in various doses in safflower crops does not greatly affect the yield of safflower (Polyakov *et al*., 2020) and the natural nitrogen content in the soil will make it possible to obtain 0.92 t/ha of safflower seeds and a dose of nitrogen of 0.25-0.5 kg/ha

[1]Federal State Budget Scientific Institution “Federal Scientific Center of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences” (FSC of Agroecology RAS), Volgograd, Russia.

Corresponding Author: Anna Vasilievna Belikina, Federal State Budget Scientific Institution “Federal Scientific Center of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences” (FSC of Agroecology RAS), Volgograd, Russia. Email: belikina-a@vfanc.ru

How to cite this article: Solonkin, A.V., Sukhareva, E.P. and Belikina, A.V. (2024). The Effect of Fertilizers and Growth Regulators on the Productivity of Safflower (*Carthamus tinctorius* L.) in the Dry Climate of Russia. Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.AF-868.

Submitted: 06-03-2024 **Accepted:** 06-05-2024 **Online:** 18-06-2024

contributed to obtaining a seed yield of 1.18-1.3 t/ha, $NSR_{0.5}$ 0.26. The integrated use of agrochemicals will allow the yield of safflower seeds to be 20.6-35.6% higher (Amangaliev *et al*., 2023; Keteku *et al*., 2019). It has been established that the use of additional mineral nutrition together with growth regulators in various phases of plants directly affects the morphological structure of plants, growth (formation of additional branches, baskets), seed development and their filling by 10.9-26.7% (Bogosoryanskaya, 2009; Polyakov *et al*., 2020; Prahova *et al*., 2022).

Agrochemical measures to improve the mineral nutrition of safflower plants, aimed at increasing productivity, will contribute to increased economic efficiency (Andriyuk 2014; Razumnova *et al*., 2018). However, not enough scientific publications have been devoted to the use of mineral, micro fertilizers and growth regulators in the zone of chestnut soils of the Lower Volga region, therefore, our research will complement the technological issues of growing safflower in a dry climate.

Purpose of the research

Determine the effect of the use of mineral, micro fertilizers and plant growth regulators Ultamag Bor micro fertilizer and Biostim on the yield and sowing qualities of seeds and methods of their use in safflower crops.

MATERIALS AND METHODS

The experimental site is located in the right bank zone of the dry steppe of the river. Volga at 130 m above sea level. Geographical coordinates of the experimental site: 50°01′ 39″N. w. 45°07′39″E. d. The soil is medium deep, heavy loamy. The humus content is 1.8-2.4%, in the 0-30 cm layer: gross phosphorus and nitrogen 0.11 and 0.06%.

The climate of the site is sharply continental, with a maximum summer temperature of +45 and a maximum winter temperature of -41°C. Snow cover forms and reaches a height of up to 22 cm in snowy winters (Sazhin *et al.,* 2017).

In March, when the soil is physically matured, cover harrowing Is laid in two layers and pre-sowing cultivation were carried out and safflower was sown in the third ten days of April.

During the research years 2021-2023, While, the safflower growing season, an average amount was about 108.7 mm of precipitation fell and the average monthly air temperature was 19.0°C. During the growing season of 2021, the State Customs Committee amounted to 0.65; 2022 0.8; 2023 0.8., the weather conditions of the safflower growing season can be characterized as arid (Zinkovsky *et al*., 2018).

Safflower seeds, sorts Alexandrit and Volgogradsky 15 (reproduction OS) were sown during the research period in the third ten days of April. Safflower seeds of the Alexandrit and Volgogradsky 15 varieties (reproductive OS) were sown during the research period in the third ten days of April. Regional varieties were obtained as a result of breeding work at the Federal Scientific Center for Agroecology of the Russian Academy of Sciences, Volgograd, Russia. The varieties have good drought and heat resistance, so they were chosen for testing fertilizers in safflower crops. The potential yield of varieties is more than 1.3 t/ha, weight of 1000 grains is 39.9-51.5 g, oil content is 25.8-27.3% (Belyaev, 2021). When sowing safflower, complex fertilizer Nitroammofosk was applied at the rate of 50 kg/ha, containing up to 27% N to begin the growth of the safflower root system, K up to 20% and P up to 18% to maintain and stimulate metabolic processes. Before sowing safflower seeds, the seeds were treated with a tank mixture of fungicides Imidor Pro KS 10 g + Title Duo 10 g + micro fertilizer Biostim Star 10 g in 10 liters of water.

The leaves in the “budding” phase (Fig 1) were treated with safflower crops according to the following options:

1. Ultamag Bor micro fertilizer 30 g/10 liters of water.
2. Micro fertilizer Ultamag Bor 30 g + Biostim Growth 30 g/ 10 liters of water.
3. Control variant without cultivation.

All variants of the experiment and their threefold repetitions were placed in one field systematically and consistently. The area of the experimental plot is 300 m^2. The results of the experiment on the use of agrochemicals through foliar feeding in the “budding” phase were processed by the method of analysis of variance (Dospehov, 2014).

RESULTS AND DISCUSSION

Intensification is the most cost-effective way to improve seed quality and increase crop yields. One of the ways to

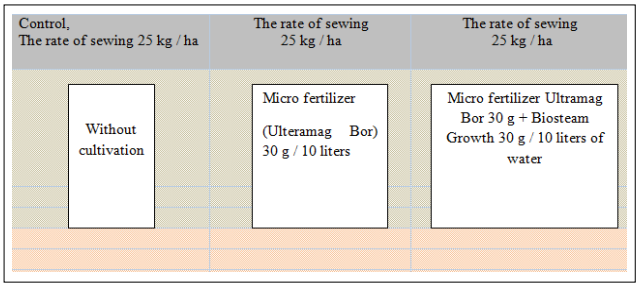

Fig 1: Layout of experimental plots testing the use of mineral, micro fertilizers and growth regulators.

Fig 2: Safflower crops in the control version of the experiment, without treatments.

increase and improve the quality and quantity of agricultural products is the use of mineral, micro fertilizers and growth regulators. As a result of the research, the influence of agrochemicals on plant height, changes in yield indicators and the quality of safflower seeds of the Volgogradsky 15 and Alexandrite varieties were clarified. Elements of the yield structure of safflower varieties are reflected in Table 1.

The highest height of the safflower plant 15-76.1 cm was found in the Volgogradsky sort in the variant with foliar treatment with preparations in the "budding" phase with a tank mixture of Ultamag Bor 30 g+Biostim Growth 30 per 10 liters of water sown with the preliminary pre-sowing application of mineral fertilizers Nitroammofoska. In the Alexandrite sort, the tallest safflower plant- 63 cm was the same variant of foliar crop cultivation.

The largest number of baskets was found after using Ultamag Bor 30 g + Biostim Growth 30 g per 10 liters of water, for the Volgogradsky sort 15-412 pieces. The best indicator of the number of baskets for the Alexandrite sort was in the same variant of foliar treatment of crops - 410 pieces. Also, the number of grains per plant in this variant of foliar treatment was the best in the safflower variety Volgogradsky 15-115, in Alexandrit-124. The quality indicators of safflower seeds weighing 1000 grains in the experiment were in the Ultamag Bor 30 g + Biostim Growth 30 g per 10 liters of water, for the Volgogradsky 15 variety 36.7 g, for the Alexandrit variety 36.5 g. However, the highest biological yield of safflower seeds was for the Alexandrit variety with the foliar treatment option Ultamag Bor 30 g + Biostim Growth 30/10 liters of water-1.8 t/ha.

According to the research results, it was found that the best results of the structural elements (Table 1) of the yield of tinting safflower were in the variant with foliar treatment Ultamag Bor 30 g/l + Biostim Growth 30 g/10 liters of water, the biological yield of the sorts was Volgogradsky 15 -1 .7 t/ha, number of seeds per plant 115 pcs. and grain weight per 1 m^2 is 253.5 g, for the Alexandrit variety the seed yield is 1.8 t/ha, 124 pcs and 293.7 g, respectively (Fig 2, Fig 3).

The obtained results of the experiment on testing mineral, micro fertilizers and growth regulators were processed by the method of analysis of variance and are presented in Table 2.

Analysis of variance showed that 87% of the experimental effects on safflower yield were caused by foliar fertilizing with mineral and micro fertilizers with growth regulators in the "budding" phase. In the study, the "sort" factor had an effect of only 0.62%; other agro technological conditions had an impact on seed yield of 11.8%. The small difference in the seed yield of safflower varieties can be explained by the fact that the properties of the seeds did not have a large influence on the results of the experiment (0.62%).

Calculations on the economic efficiency of using mineral, micro fertilizers and growth regulators are presented in Table 3.

Table 1: Elements of the harvest structure of safflower varieties in 2021-2023.

No variant	Sheaf weight, g	Number of plants, pcs./m^2	Weight of grain per sheaf, g	Stem height, cm	Number of bolls, w/m^2	Number of branches, pcs per 1 plant	Number of grains per 1 plant,c 1	Weight of 1000 grains, g 1000	Biological yield, t/ha
Safflower sort volgogradsky 15									
Control, no treatments	1366	44	197.1	72	279	8	79	36.2	0.7
Ultramag bor 30 g/10 liters of water	1758	49	215.6	74.5	400	10	110	36.5	1.6
Ultamag bor 30 g + Biostim growth 30 g/10 liters of water	2010	53	253.5	76.1	412	11	115	36.7	1.7
Safflower sort alexandrite									
Control, no treatments	1346	43	144.5	46	301	7	84	35.8	0.9
Ultramag bor 30 g/10 liters of water	1780	46	263.1	54	406	11	113	36.1	1.6
Ultamag bor 30 g+Biostim growth 30 g/10 liters of water	1983	46	293.7	63	410	12	124	36.5	1.8

Table 2: Results of analysis of variance of yield in testing the use of mineral and micro fertilizers in crops of tinting safflower varieties.

Variant	Share of factor influence, %	Degree of freedom (df)	Average square (ms)	Fisher criterion (F)	P-value	$F_{critical}$
Factor A (Precipitation)	87.5	2	0.167317	7.387049301	0.119231444	19
Factor B (Air temperature)	0.62	1	0.0024	0.105960265	0.775691138	18.51282051
Random deviations	11.84	2	0.02265	-	-	-

Table 3: Economic efficiency of growing safflower seeds using mineral and micro fertilizers with growth regulators 2021-2023.

Feature	Mean of measure	Sorts	
		Alexandrit	Volgogradsky 15
Control			
Productivity	t/ha	0,9	0,7
Selling price 1t	USD/ha	440,5	440.5
Revenuefrom sales	USD/ha	396.47	308.37
Expenses	USD/ha	151.43	151.43
Net income	USD/ha	245.0	156.94
Profitability	%	161.8	103.6
Ultramag bor 30 gr/10 liters of water			
Productivity	t/ha	1.6	1.6
Selling price 1t	USD	440,5	440,5
Revenuefrom sales	USD/ha	704.84	704.84
Expenses	USD/ha	152.8	1252.8
Net income	USD/ha	552.0	552.0
Profitability	%	361.2	361.2
Ultamag bor 30 g + Biostim growth 30 g per 10 liters of water			
Productivity	t/ha	1,8	1,7
Sale price 1t	USD	440,5	440,5
Revenuefrom sales	USD/ha	792.95	748.9
Expenses	USD/ha	154.2	154.2
Net income	USD/ha	638.8	594.7
Profitability	%	414.2	385.7

Fig 3: Sowing safflower using Ultamag Bor 30 g + Biostim Growth 30 g/10 liters of water.

Information on the economic efficiency of growing safflower using mineral and micro fertilizers in the Lower Volga region is presented in Table 3, where you can see that the most economically profitable option is the third one with treatment during the “budding” phase with a tank mixture of Ultamag Bor 30 g + Biostim Growth 30 g per 10 liters of water- the economic efficiency of seed production obtained with this option for the Alexandrit variety is 414.2%, Volgogradsky 15-385.7%. Using the Ultramag Bor treatment option, a harvest of safflower seeds was obtained from the Alexandrit and Volgogradsky 15 varieties with an economic efficiency of 361.2%.

CONCLUSION

Research in 2021-2023 on the use of mineral, micro fertilizers and growth regulators for the production of safflower seeds has established that the best option is to treat the leaf with a tank mixture of Ultamag Bor 30 g + Biostim Growth 30 g per 10 liters of water in the “budding” phase “ The best option yielded a yield of safflower seeds from the Alexandrit variety of 1.8 t/ha with a profitability of 414.2%, Volgogradsky 15 yield of 1.7 t/ha, a profitability of 385.7%.

ACKNOWLEDGEMENT

The work was carried out within the framework of the State assignment FNFE-2022-0010 “Creation of new competitive forms, varieties and hybrids of cultivated, tree and shrub

plants with high levels of productivity, quality and increased resistance to adverse environmental factors, new innovative technologies in seed production and nursery farming, taking into account varietal characteristics and soil and climatic conditions of arid territories Russian Federation".

Conflict of interest

The authors declare no conflict of interest. All authors made equivalent contributions to the preparation of the article for publication.

REFERENCES

Aleminew, A., Melkamu, A. (2020). Soil fertility depletion and its management options under crop production perspectives in Ethiopia: A Review. Agricultural Reviews. 41(2): 91-105. doi: 10.18805/ag.R-136.

Amangaliev, B.M., Zhusupbekov, E.K., Zhapaev, R.K., Kunypiyaeva, G.T., Baytarakova, K.Z. (2023). The effectiveness of different rates of mineral fertilizers against the background of different methods of basic processing when cultivating safflower in the subzone of light chestnut soils of the Southeast region. Bulletin of Korkyt Ata Kyzylorda University. 2(65): 208-222.

Andriyuk, A.V. (2014). Survival of safflower plants as an indicator of yield. AVU. 7(125): 6-9.

Bogosoryanskaya, L.V. (2009). The influence of macro-and micro fertilizers on the yield and quality of safflower seeds. Fertility. 2: 14-15.

Belyaev, A.I., Pugacheva, A.M., Solonkin, A.V., Kryuchkov, S.N., Pitonya, A.A., Pitonya, V.N., Igolnikova, L.V., Kuleshov, A.M., Markova, I.N., Shatrykin, A.V., Sharko, N.S., Neymysheva, A.N., Smutnev, P.A. and Sukhareva, E.P. (2021). Catalog of breeding achievements of the federal scientific center of agroecology of the russian academy of sciences. Volgograd: Federal Scientific Center of Agroecology RAS: p.72.

Dospekhov, B.A. (2014). Methodology of field experience (with the basics of statistical processing of research results). Moscow, Alliance, pp. 257-353.

Eskova, O.V., Eskov, S.V. (2015). The influence of doses of nitrogen fertilizers on the yield of safflower crops (*carthamus tinctórius*) in the foothills of the Crimea. News of Agricultural Science of Tavrida. 3(166): 29-35.

Gatske, L.N., Kenebaev, A.T., Didorenko, S.V., Abaev, S.S. (2023). Breeding assessment of safflower varieties and hybrids in the conditions of South-East Kazakhstan. Agricultural Sciences. 2: 124-126.

Hiremath, K., Kavera, B.B. (2023). Effect of organic sources and nutrient levels on the growth, yield and economics of safflower (*Carthamus tinctorius* L.). Crop Research. 58: 163-169. 10.31830/2454-1761.2023.CR-911.

Keteku, A.K., Intanon, P., Terapongtanakorn, S., Intanon, R. (2019). Economic production of maize under chemical and granular organic fertilizer with hormone mixed formula, NPK and organic fertilizer. Indian Journal of Agricultural Research. 53(5): 560-565. doi: 10.18805/IJARe.A-422.

Leus, T.V. (2020). Manifestation of the maternal effect in the inheritance of leaf color in safflower. Scientific and Technical Bulletin of the Institute of Oil Crops of the National Academy of Sciences. 29: 16-22.

Polyakov, A.I., Alieva, O.Y.U. (2020). Productivity of safflower under the influence of mineral fertilizers and growth regulators. Bulletin of the Belarusian State Agricultural Academy. 4: 51-55.

Prahova, T.Y.A., Druzhinin, V.G. (2022). The influence of micro fertilizers on the productivity of safflower. In Innovative technologies in the agro-industrial complex: Theory and practice: Collection of articles of the X International Scientific and Practical Conference, Penza, March 14-15, 2022, Penza: Penza State Agrarian University, 2022. pp. 148-151.

Razumnova, L.A., Kamenev, R.A., Turchin, V.V. (2018). The effectiveness of mineral fertilizers and bacterial preparations on safflower. Resource saving and adaptability in technologies for cultivating agricultural crops and processing crop products: Materials of the international scientific and practical conference. Village Persianovsky: Don State Agrarian University, pp. 69-72.

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

Vasilenko, V.N., Frolova L.N., Teryokhina A.V., Dragan I.V., Mikhailova, N.A. (2018). Safflower cake as an object for feeding agricultural animals. Feed Production. 3: 41-43.

Vidyashree, B.S., Arthanari, M.P. (2021). Customized fertilizers-An artefact in Indian agriculture: A review. Agricultural Reviews. 42(1): 105-110. doi: 10.18805/ag.R-1886.

Zinkovsky, V.N., Zinkovskaya, T.S. (2018). Accounting for atmospheric precipitation in agromeliorative calculations. International Scientific Research Journal. 5: 130-135.