PRODUCTIVITY OF VARIETIES OF DYEING SAFFLOWER DEPENDS ON THE FACTORS INVESTIGATED IN THE CONDITIONS OF THE EASTERN FOREST STEPPE

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Abstract. The results of studies on the dependence of germination and survival of safflower cultivars on the width of interrows and seed fraction are presented. The influence of row spacing and seed fraction on safflower productivity was studied. It was established that the best variety is the Sonyachnij variety with an average fraction of seeds with a row width of 45 cm.

Keywords: safflower dye, seed material, varieties, field germination, seed fraction, plant survival

Today, oil crops are the most attractive for agricultural production, as they can give the highest profitability. There are more than 350 species of oil crops[344].

Due to its geographical position and climatic conditions, Ukraine is one of the main producers of sunflower seed oil, which determines the annual growth of its crops. Therefore, the areas occupied by sunflower greatly exceed the scientifically based ones. This forces the search for alternative oil crops for different soil and climatic zones of Ukraine. Thus, one of such promising crops for the arid conditions of eastern Ukraine is dye safflower (*Cartahamus tinctorius*, Aistrovi family), known as dye thistle, wild or American saffron[345].

Today, there is a need to create an effective mechanism for managing the efficiency of oilseed cultivation. One of such mechanisms can be the transition to the

[344] Zinchenko O. I., Salatenko V. N., Bilonozhko M. A. (2001). Roslinnictvo; Filipov Ye. G. (2014). Agrotehnichni prijomi na ekonomichnu efektivnist viroshuvannya safloru krasilnogo v umovah zroshennya pivdnya Ukrayini, p.143-149.

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production of non–traditional oil crops. Such crops include safflower, white and gray mustard, black cumin, amaranth[346].

One of the more promising crops for the arid conditions of the east is safflower. But the technology of its cultivation in Ukraine is insufficiently developed.

Although safflower is one of the most valuable oil crops, which include sunflower, mustard, rapeseed, flax, safflower, oil poppy, and others, it is a promising niche crop[347].

So, why does this culture attract agricultural producers? First, it is not picky about soils and drought resistance. Safflower grows well even on saline and saline soils.

Dyeing safflower is determined by many advantages in cultivation over other oil crops. It has a deep root system, which depletes the soil less, unlike sunflower. Safflower seedlings are resistant to spring frosts (up to –5 °C). It is an insurance crop in case of reseeding of winter crops. Specific diseases and pests of safflower did not spread widely[348].

But the technology of its cultivation in Ukraine is not sufficiently developed. There are no clear recommendations for the producer on the methods, sowing rates and requirements for the seed material, the width of the rows, as well as the fractional composition of the crop seeds[349]. Therefore, research on this issue is relevant.

In Ukraine at the beginning of the 20th century, safflower was planted on an area of 1,500-2,000 hectares, mainly in the south. Today, the area has decreased, it is grown on small areas in the Kherson Zaporizhzhya, Poltava and Kharkiv regions[350].

The homeland of safflower is Ethiopia and Afghanistan. Safflower is one of the oldest cultivated plants. The seeds were found in the tombs of the pharaohs, which are mentioned around 2000 BC. It was cultivated by the ancient Chinese, Syrians, and Arabs as an oil crop and for use in medicine[351]. Now safflower is found as an oil plant in the driest areas of Central Asia. It is grown on small plantations in India, Turkey, Iran, China, European countries, and the USA.

In many countries of the world, safflower is valued as a medicinal plant. The fat content in the seed is 32-37 %, and in the kernel – 46-50 %. Safflower oil contains carotenoids, vitamins (B1, B2, PP, E, B–tocopherol), as well as linoleic acid (up to 90

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%), which is indispensable for the human body. It is considered useful due to the high concentration of polyunsaturated fatty acids and occupies a special place. In addition, safflower oil is a natural raw material to produce conjugated linoleic acid[352].

The nutritional value of safflower oil is determined by the content of unsaturated fatty acids in it, which are necessary for our body to build cells. Unsaturated fatty acids are easily absorbed by the body and are not deposited on the walls of blood vessels, narrowing them. This is the advantage of vegetable oils over animal oils.

Since safflower oil is very rich in unsaturated fatty acids, it permeates the skin faster and is absorbed almost instantly, has a softening and moisturizing effect, and provides a barrier (protective) function of the skin. These properties contributed to the wide use in various creams and ointments for the skin. The oil obtained from the whole seed has a bitter aftertaste and is used to produce oil, white paint, enamels, soap, and linoleum[353].

Safflower petals have two different color pigments – yellow and red. The yellow pigment is considered less valuable and is removed by washing the petal mass with water. The red substance of safflower – cartamine – is difficult to dissolve in water, but easily dissolves in alcohol and alkalis and is the most valuable natural red dye. Currently, carthamine is used in carpet production and for fabric dyeing, as well as in cooking as a substitute for saffron. Safflower petals are also used in the food industry, for example in the production of caramel[354].

Safflower seeds contain inulin, thereby contributing to the normalization of blood glucose levels. Chinese traditional medicine knew about safflower as early as 1061, using it for diseases of the heart and coronary vessels, as well as as a stimulant, antiseptic, laxative, emetic.

Safflower expands blood vessels, improves blood circulation, eliminates yellow–brown spots on the skin of the face and neck, protects the skin from premature aging, has an enzyme–regulating effect, has an antibacterial and anti–inflammatory effect on the skin, stimulates the secretion of gastric juice and pancreatic enzymes, is characterized by choleretic, antisclerotic effect, removes sand from the gall bladder, relieves intestinal spasm and flatulence. It normalizes the level of glucose in the blood, hormonal balance in mastopathy, provides a pain–relieving effect, is an expectorant and diaphoretic[355].

Safflower is of particular interest for Ukraine with its harsh continental climate and hot, dry summer. This plant is unpretentious, withstands sharp temperature fluctuations and tolerates both morning frosts in spring and summer heat. Undemanding safflower and soils. The plant is resistant to weeds, does not die even in conditions of strong clogging. In Ukraine, the area of crops is still not significant.

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Expanding safflower production is a very attractive thing. The areas of saline soils in Ukraine are increasing annually. These are primarily irrigated lands and on the banks of reservoirs, for their reclamation and prolongation of use, safflower culture is suitable. Therefore, the cultivation of safflower on an area of up to 1 million hectares will not have a negative impact on the production of other crops. Even if we count on crop rotation and other circumstances, the safflower area in Ukraine should be at least 100,000 hectares. This will provide an additional 100,000 tons of oil raw materials[356].

The modern climate is characterized by frequent and anomalous changes with a persistent tendency to increase average annual temperatures, which negatively affects the yield of agricultural crops. Safflower is advantageously different from traditional cultures for Ukraine. Therefore, safflower dye is a valuable oil and medicinal crop that can be grown in the conditions of the Eastern Forest Steppe[357].

The starting material for laboratory and field research was taken as two varieties Lahydnyi and Sonyachnij. Field research was conducted in 2020–2021 in the conditions of the educational and experimental field of the department of agricultural technologies and ecology based on the "Central" NDP of the Kharkiv Technical University of Agriculture named after P. Vasylenko.

Sonyachnij variety. Year of registration – 2001. Recommended for the Steppe zone. Productivity is average. Resistance to drought – 6, lodging – 7, shedding – 7, diseases – 5 points. Forms a basket with a diameter of 2,5-3,0 cm. 10–25 baskets are formed on one plant. The leaves are covered with sharp small spines. The flowers are yellow–orange, light yellow in color, turning red by the end of flowering. The weight of 1000 seeds is 44-45 g. The oil content of the seeds reaches 33 %. The growing season of the Sunny variety lasts 120–125 days. The yield in the fields in the Kherson and Zaporizhzhia regions was recorded at 1,6–1,8 t/ha.

Lagidnij variety. Year of registration – 2011. Created by the Institute of Oil Crops of the National Academy of Sciences together with the Dryad Scientific Research Fund. Cultivation zone – Steppe and forest–steppe. Resistance against drought is very high, against shedding, lodging – high, resistance against major diseases – 8 points, against pests – 6 points. The height of the plants is up to 99 cm, the weight of 1000 seeds is 44 g, and the oil content is 31,5 %. The flowers are orange-red, characterized by a change in color during flowering from orange to red. The plant has rounded upper leaves without teeth along the edge of the leaf plate. There are no spines. The duration of the growing season is 105–110 days, the average duration of flowering is 14 days. The variety is characterized by strong drought resistance. According to the variety tests, the seed yield is 2,1 t/ha.

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Experiments were carried out in compliance with the requirements of scientific agronomy.

Field studies, observations of phenological signs during the growth and development of plants were conducted in accordance with generally accepted methods[358].

Placement of plots is randomized. The registered area of the experimental plot is 25 m^2. The predecessor is winter wheat.

Sowing was carried out manually, with different widths between rows and fractions: (70 cm – large seeds, 45 cm – medium and 30 cm – small seeds).

Pre–sowing treatment was carried out to a depth of seed wrapping up to 4 cm, at a soil temperature of 4,3...4,8 °C, mineral fertilizers were not applied.

Field studies, observations of phenological signs during plant growth and development were conducted in accordance with generally accepted methods.

The mass of 1,000 safflower seeds was determined according to the method of the State DSTU 3484–96 (GOST 170–81–97).

The yield was determined separately by threshing each variant.

Everyone has known for a long time that the primary task of farmers when growing any crop is to ensure high seed germination. In our studies with safflower dye for 2020-2021, the similarity was within 80,0-87,2 % (Figure 1).

It should be noted that, comparing the two varieties, the highest seed germination was achieved in 2020 by the Sonyachnij variety, 87,2 %, and by the Lagidnij variety, 84,1 %, with a row width of 45 cm and an average seed fraction.

Regarding the survival of the dyer's safflower, it should be noted that with a greater density of standing plants, there is more competition, while some may not survive. The best result was shown by the Sonyachnij variety of 96,3 % with a row width of 45 cm and an average seed fraction in 2021 compared to the Lagidnij variety with a row width of 45 cm and a small seed fraction of 94,0 %.

The duration of the growing season of the dye safflower in our studies on the varieties Sonyachnij and Lagidnij ranged from 116 to 118 days in 2020 and 2021 and ranged from 115 to 120 days from full germination to full maturity for all interrows and seed fractions.

Safflower can be sown both in the usual row method and in wide rows with a row spacing of 45 to 70 cm. Preference is given to the wide row method of sowing when the soil is heavily soiled with weed seeds, and it is impossible to use soil herbicides. Considering the small seeding rate of 10–15 kg/ha, preference should be given to units with a high distribution capacity. Seed drills with disc coulters provide the best results of uniformity of seed wrapping in the soil. The depth of seed wrapping should be 4–6 cm, and when the top layer of the soil dries out – up to 6-8 cm.

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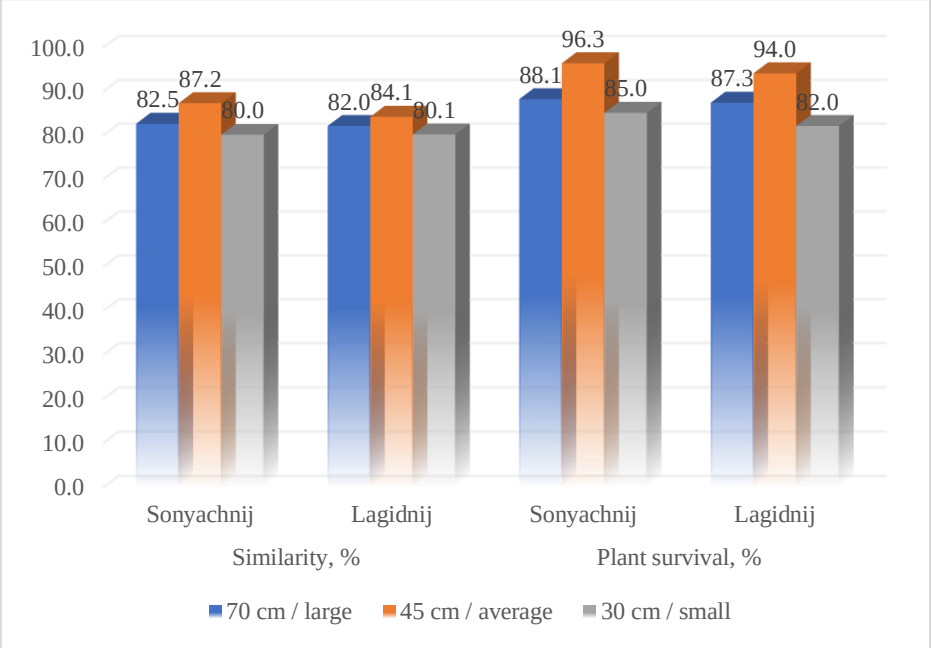

Fig. 1. Similarity and survival of dyeing safflower plants depending on the width of the rows and the seed fraction, % (2020–2021 years)

Laboratory and field studies were used to determine the regularity of the productivity of safflower dye depending on the size of the sown seeds. It is known that the yield reduction of many agricultural crops can be 10–12 % when using seed material with the content of small, weak, and underdeveloped seeds. The best yield is provided by well–formed seeds, not thin, but not too large, which have a fairly high germination energy and germination.

In our research, we studied the growth, development and productivity of safflower depending on the width of the rows and (Figure 2) the seed fraction. In the field experiments, the main phases of plant vegetation were determined: seedlings, formation of baskets, flowering, ripening.

After the measurements, at the full onset of the vegetation phases, the dynamics of plant growth was determined. When determining the productivity of dyeing safflower by varieties, it was determined by sampling plants from 12 of each repetition for each variant.

Thus, the best result for the Sonyachnij variety (Figure 2) was shown by the variant with a row width of 45 cm and an average seed fraction, the height of the plants in the phase of full maturity was 100,7 cm, which is 14,3 cm and 19,7 less than with the variant with a row width of 70 (large) and 30 (small) cm seeds, respectively. Slightly lower indicators of the height of plants with an average fraction of seeds and a row width of 45 cm were shown by the Lagidnij variety.

It should be noted that in the variant with the width of the rows and the average fraction of seeds, both in the Sonyachnij variety and in the Lagidnij variety, the thickness of the stem and the height of the laying of the side shoots and the length of the roots were observed to be the greatest.

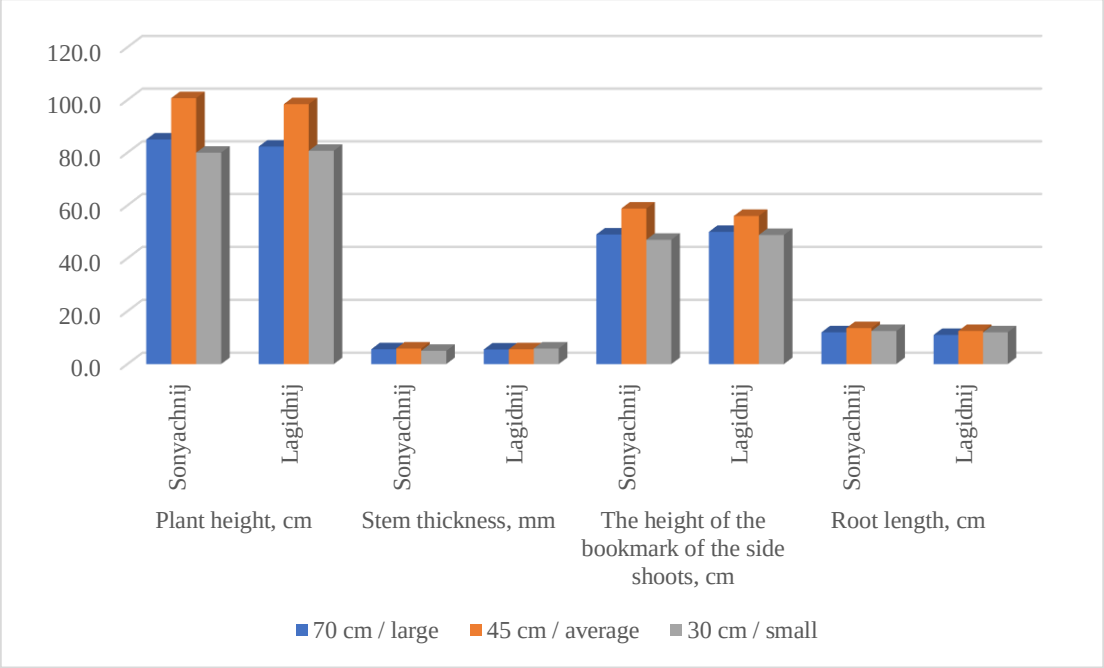

Fig. 2. Morphological indicators of plants of safflower varieties depending on the width of the rows and the seed fraction

The thickness of the stem is a sign of a sufficient amount of all nutrients for the plant.

In our research, we determined the structural analysis of the harvest and the yield of safflower under experimental conditions. As a result of the research, it was established that the size of the seeds affects the structural indicators of crops, including the number of baskets and the number of grains from one plant, as well as the weight of 1000 seeds (Table 1).

As can be seen from the data in Tabl. 1, the plants in the variant with (a small fraction of seeds and a row width of 30 cm) had the best indicators of the crop structure in both varieties (the number of productive baskets and the number of seeds from 1 plant, the weight of 1000 seeds), but the biological yield was lower than that of plants of the medium fraction and with a row width of 45 cm. This can be explained by the fact that the plants of the small fraction had thinned crops, and the stand density indicator, which significantly affects the yield level, was the smallest among the options in both varieties. And plants with a width of 70 cm between rows and a large fraction of seeds in both varieties had the lowest indicators of crop structure and yield.

Thus, the plants with the width of the rows and the average seed fraction, although they were inferior to the plants of the average fraction in terms of these indicators but exceeded them in yield.

Table 1 – The structure of the yield of varieties of safflower dye depending on the width of the rows and the fraction of the seeds under the conditions of the experiment

Row spacing / seed fraction	Number of baskets for 1 plant, pc.	Diameter of baskets from 1 plant, cm	Number of seeds from 1 plant, pc.	Mass 1000 seeds, g	Productivity (biological), t/ha
Sonyachnij					
70 cm / large	6,5	2,9	109,0	37,9	2,7
45 cm / average	7,6	3,0	118,0	39,2	3,2
30 cm / small	6,0	2,1	118,0	39,5	3,0
Lagidnij					
70 cm / large	6,2	2,6	107,0	38,0	2,9
45 cm / average	7,0	2,9	112,0	39,1	3,0
30 cm / small	8,2	2,4	119,0	39,0	2,7

Comparing the two varieties, the highest seed germination is the best result for the Sonyachnij variety of 87,2 %, with a row width of 45 cm and an average seed fraction. In terms of survival, the best indicators were also shown by the Sonyachnij 96,3 % variety with a row width of 45 cm and an average seed fraction.

Considering the morphological indicators of growth and development, the structure of the harvest and yield, which were obtained when growing the seeds of dyeing safflower of two varieties with different fractions of seeds, should be noted. As for the thickness of the stem and the height of laying lateral shoots, the length of the roots was observed to be the greatest in plants with a width of 45 cm between the rows and an average fraction of seeds for both varieties of safflower dye.

The conducted research on the dependence of the germination and survival of safflower plants on the width of the rows and the seed fraction showed that the size of the seed affects both the morphological indicators of the crop and the indicators of the crop structure.

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