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THE EFFICIENCY OF THE APPLICATION OF PREPARATIONS BASED ON ADHESIVE AND SURFACTANT SUBSTANCES AND DESICCANTS IN GROWING SESAME SEEDS

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Abstract

The purpose of the study was to establish the use of various desiccants, preparations based on adhesives and surface-active substances and their combination on the productivity and seed preservation of sesame plants. The research was conducted under irrigation in the arid climatic zone of the Southern Steppe of Ukraine. In these studies, the best option for the use of various desiccants and preparations based on adhesives and surface-active substances was established. Sesame seed productivity and yield structure elements were established; correlation analysis was conducted.

***Key words**: sesame, seeds, desiccant, adhesives and surfactants, yield.*

INTRODUCTION

Sesame (*Sesamum indicum* L.) (2n = 26) is one of the oldest and early-ripening oil crops in the world. Belongs to the order Tubiflorae, family Pedaliaceae, genus Sesamum, and is the most commonly cultivated species of oilseed out of more than 30 species in this genus (Zhang et al., 2013). Predominantly considered a self-pollinated plant, although a low percentage of cross-pollination has been reported (Ashri, 2007).

The world sown area of sesame is about 10.5 million hectares with an annual production volume of about 6.0 million tons (Sharaby & Butovchenko, 2019). The average yield varies from 300 to 500 kg/ha, but with proper care and the use of modern agricultural technologies, it can reach 3000 kg/ha (Abadi, 2018). The world's leading countries in sesame production are India, Myanmar, China, Sudan, Tanzania, Ethiopia, Uganda and Nigeria. Japan is the largest importer of sesame in the world due to sesame oil being an important ingredient in Japanese food, followed by China, which is the second largest importer of sesame in the world, although it is one of the largest producers of sesame seeds. In addition, there are many other major sesame importing countries such as USA, Netherlands, Turkey, Canada as well as France. Recently, the consumption of products and oil from sesame seeds has been steadily increasing both in Europe and the USA (Abate, 2015).

Sesame is widely known as the king of oil crops due to the high content of oil in the seeds (50-63%), 17-32% protein (rich in sulfur containing amino acids), and 80% of sesame oil consists of unsaturated fatty acids, (Eskandari et al., 2015), it is grown for food, medical purposes or used for biodiesel production (De Lima et al., 2020). The seeds are highly stable and resistant to rancidity and are used in pasta, candies, pies, paints, soaps, cosmetics and medicines, as well as ingredients in breads, crisps and health foods (Dias et al., 2017). Sesame has high therapeutic and nutritional value (Anastasi et al., 2017), and has been recognized as a good source of high-quality oil with a high proportion of unsaturated fatty acids, proteins and antioxidants (Bahrami et al., 2012). In addition, sesame seeds are rich in minerals (calcium, iron, phosphorus) and vitamins (vitamin A, thiamin and riboflavin). Due to its high quality, sesame is also called the "queen of oil crops" (Deepthi et al., 2014). Sesame oil is highly valued for its nutritional value associated with health benefits, and the quality index (ratio of unsaturated fatty acids to saturated fatty acids) for edible oil in sesame varies from 83-87% in the seed (Wei et al., 2015; Eskandari et al., 2015).

The consumption of sesame seeds or oil has numerous pharmacological properties, such as lowering blood lipids and arachidonic acid levels, lowering cholesterol (Visavadiya & Narasimhacharya, 2008), providing antiproliferative activity (Yokota et al., 2007) and anti-inflammatory function (Hsu et al., 2005), increasing fatty acid oxidation enzymes in the liver, showing antihypertensive (Nakano et al., 2008) and neuroprotective effects against hypoxia or brain damage (Cheng et al., 2006). Currently, sesamin is the most powerful food known to effectively improve the bioavailability of γ-tocopherol (Cooney et al., 2001). Such characteristics have expanded the use of sesame in antiseptics, bactericides, functional food products, pharmaceutical and cosmetic preparations (Namiki, 2007).

Sesame is a drought-resistant crop (Tewelde, 2019). Studies conducted on sesame in different countries have shown that it prefers high temperatures and limited soil moisture to obtain satisfactory yields (Bahrami et al., 2012).

However, in recent decades, climate changes have been observed, the so-called "global warming", as a result of which the temperature regime is increasing, dry periods are becoming more frequent and their duration is increasing (Vozhehova et al., 2022c; Tyshchenko et al., 2020b). This significantly affects the amount of precipitation and its redistribution during the growing season and is one of the main abiotic stress factors, which leads to a significant decrease in the yield of agricultural crops (Tyshchenko et al., 2020a; Vozhehova et al., 2021b). However, in recent times, during the ripening period of late agricultural crops, which includes sesame, frequent rains with showers are observed, which increases the moisture content of seeds, prevents timely harvesting and, accordingly, leads to crop losses (Vozhehova et al., 2022a). Rainy weather combined with strong winds at maturity negatively affects the yield of sesame due to the cracking of pods and the spilling of seeds. Seed shedding is a serious cause of crop losses (Abadi, 2018; Dissanayake et al., 2017).

Therefore, we decided to conduct research on seed preservation using surface-active and adhesive substances and desiccants.

The purpose of the work. Investigate the effect of surface-active and adhesive substances and desiccants on the preservation and productivity of sesame seeds.

MATERIALS AND METHODS

The research was conducted during 2019-2021 at the experimental field of the Askanian State Agricultural Research Station in the village of Tavrychanka, Kherson region (46°33'12"N; 33°49'13"E; 39 m above sea level) of the Institute of Climate-Smart Agriculture of the National Academy of Agricultural Sciences of Ukraine. In terms of soil and climate, it is located in the steppe zone, on the Kakhovsky irrigated massif.

Study 1. A one-factor field experiment on the study of different desiccants (Preparation 1 - 150 g/l ammonium glufosinate - 2.0 l/ha, Preparation 2 - 150 g/l ion diquat - 3.0 l/ha and Preparation 3 - 450 g/l glyphosate in acid equivalent (551 g/l in the form of the potassium salt of glyphosate) - 2.4 l/ha) and their use in different stages of pod browning (70-75% and 80-85%) for the preservation and yield of sesame seeds.

Study 2. The two-factor field experiment is based on the method of split plots. Main areas (factor A) - application of preparations based on adhesives and surface-active substances (Raps kley with a consumption rate of 1.2 l/ha, Agrolip - 1.5 l/ha and N′yu Fylm -17-1.0 l/ha) n the browning phase of pods 70-75%; sub-sites (factor B) - application of preparations based on adhesives and surface-active substances (Raps kley - 1.2 l/ha, Agrolip - 1.5 l/ha and N′yu Fylm – 17 - 1.0 l/ha) n combination with a desiccant with active with the substance 150 g/l diquat ion - 3.0 l/ha was carried out in the browning phase of the pods 80-85%

The experiments were based on irrigation, watering was carried out with a sprinkler and maintenance of soil moisture at the level of 75-80% of the lowest moisture content. Sesame variety Husar. Wide-row sowing with 70 cm between rows. The area of the sowing area is 60 m^2, the accounting area is 50 m^2, repetition three times. The consumption of working fluid during processing was 250 l/ha.

Statistical processing of experimental data was carried out by AgroSTAT, XLSTAT, Statistica (v. 13).

RESULTS AND DISCUSSIONS

According to the results of previous studies, the indicators that determine the amount of sesame yield are the number of pods and seeds on one plant, as well as the weight of seeds from one plant. Each of these elements can vary greatly depending on agronomic practices leading to increased or decreased yields, especially the number of pods and seeds retained at harvest.

On the control version (without the use of a desiccant), the smallest number of 4732 seeds per plant, seed weight of 12.73 g per plant, and seed yield of 0.85 t/ha were recorded during harvesting. However, the mass of 1000 seeds was the largest - 2.69 g. When desiccants were used in the 70-75% phase, browning of the pods contributed to obtaining the largest number of 5264-5910 seeds per plant, seed mass of 13.32-15.37 g per plant, and yield seeds 1.02-1.18 t/ha. However, the mass of 1,000 seeds was the smallest - 2.53-2.61 g. The best result when processed in the phase of 70-75% browning of pods was shown by Preparation 2 with a seed yield of 1.18 t/ha, which was higher than the control variant by 0.33 t/ha (Table 1).

Table 1. Elements of the yield structure and seed productivity of sesame depending on the application of desiccants

Variants of the experiment	Number of pods on 1 plant (n_c), pcs.	Number of seeds on 1 plant (n_s), pcs.	Seed weight from 1 plant (m_s), g	Weight of 1000 seeds (m_{1000}), g	Yield (Y), tons/ha	Yield increase relative to control, t/ha	Average yield by desiccants, t/ha
Control (without treatment)	91	4732	12.73	2.69	0.85	-	-
Preparation 1 (with browning 70-75%)	88	5632	14.70	2.61	1.02	0.17	0.96
Preparation 2 (with browning 70-75%)	93	5910	15.37	2.60	1.18	0.33	1.07
Preparation 3 (with browning 70-75%)	94	5264	13.32	2.53	1.11	0.26	1.03
Preparation 1 (with browning 80-85%)	92	4804	12.73	2.65	0.89	0.04	
Preparation 2 (with browning 80-85%)	90	5045	13.27	2.63	0.96	0.11	
Preparation 3 (with browning 80-85%)	89	4987	12.92	2.59	0.94	0.09	
LSD_{05}	1.01	15.2	0.2	0.03	0.02		

The use of desiccants in the phase of 80-85% browning of pods increased the weight of 1000 seeds by 0.03-0.04 g, but decreased the weight of seeds per plant to 0.40-2.10 g and, accordingly, the yield of sesame seeds by 0.13-0.22 t/ha. Of the three desiccants when processed in the phase of 80-85% browning of the pods, the highest yield of 0.96 t/ha was obtained with the use of Preparation 2.

The correlation analysis between the elements of the crop structure and the seed productivity of sesame plants was carried out. The correlation between the number of pods on one plant and seed yield was 0.442, between the number of seeds on one plant and seed yield was 0.890, the weight of seeds on one plant and seed yield was 0.795, and the weight of 1000 seeds and seed yield was -0.738 (Figure 1).

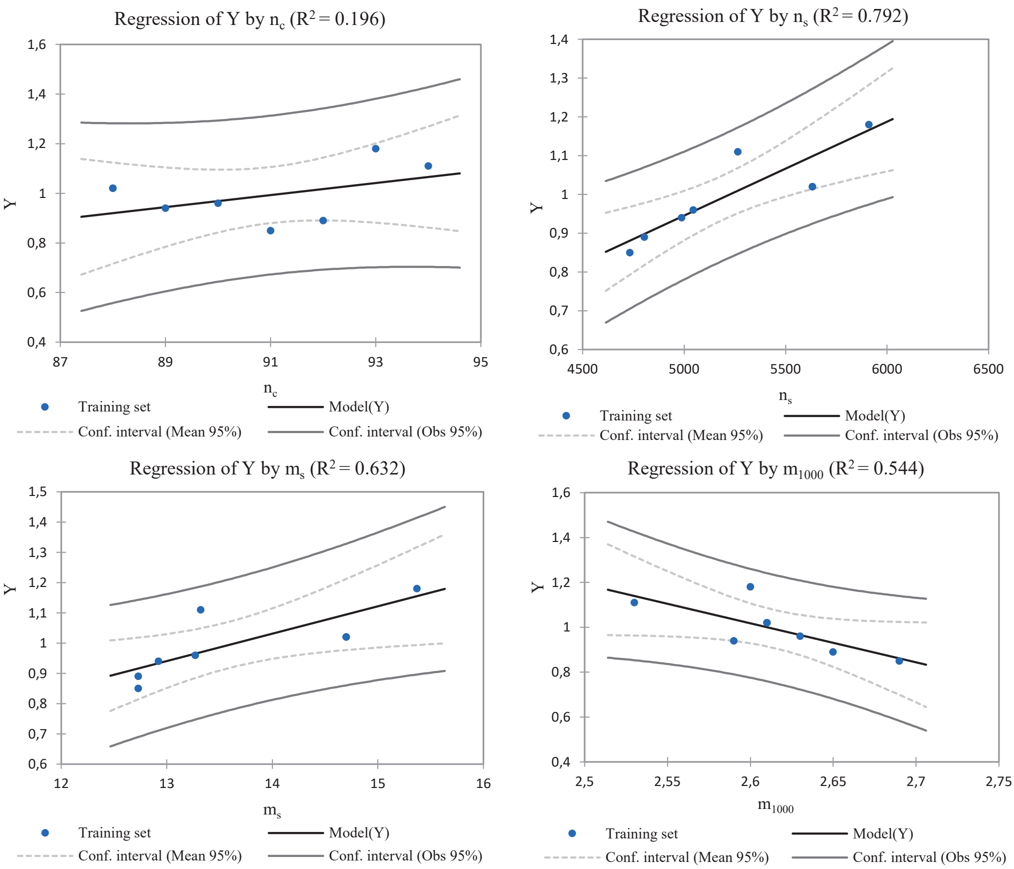

Figure 1. Regression diagrams of the number of pods per 1 plant (n_c) and seed yield (Y) (top left), the number of seeds per 1 plant (n_s) and seed yield (Y) (top right), seed weight per 1 plant (m_s) and seed yield (Y) (bottom left), weight of 1000 seeds (m_{1000}) and seed yield (Y) (bottom left)

The inverse relationship between the weight of 1000 seeds and seed yield is explained by the fact that the weight of 1000 seeds is greater in the control variant than in the variants with the use of desiccants, and the yield is lower. The same is observed on the options when treated with desiccant in the phase of 80–85% browning of the pods, compared to the treatment in the phase of 70-75%. That is, on the control variant, or on the variants treated with desiccant in the phase of 80-85%, the browning of the seed pods was more complete and was characterized by a higher mass of 1000 seeds.
Uneven ripening of sesame pods is a biological feature of the crop that leads to seed loss. According to our research, the use of preparations based on adhesives and surface-active substances prevents the premature cracking of pods, increases the yield and improves its quality, is not washed away by rain, reduces pre-harvest losses of the crop and allows collecting uniform ripe seeds.
As a result of the research, the smallest number of seeds was 3080 pcs. from one plant, seed mass of 8.75 g from one plant and seed productivity of 0.81 t/ha were obtained on the control variant (without treatments). During the first treatment with preparations based on adhesives and surface-active substances in the phase of 70-75% browning of the pods, an increase in the number of seeds by 245-461 pcs/plant, the weight of seeds per plant by 0.69-1.52 g, and seed productivity is observed by 0.05-0.12 t/ha compared to the control variant. The largest number of seeds of 3541 per 1 plant, seed weight per plant of 10.27 g and seed productivity of 0.93 t/ha during the first

treatment was obtained with the use of Agrolip (Table 2).

During the second treatment with a desiccant with the active substance 150 g/l diquat ion in the phase of 80-85% browning of the pods, an increase in the number of seeds by 165 pcs/plant, seed weight per plant by 0.04 g, and seed productivity by 0.07 t was observed /ha with a decrease in the weight of 1000 seeds by 0.13 g compared to the control variant. While treatment with preparations based on adhesives and surface-active substances in combination with a desiccant increases the number of seeds by 265-404 pcs/plant, the weight of seeds per plant by 0.52-1.04 g, and seed productivity by 0.12-0.17 t/ha with a decrease in the weight of 1000 seeds by 0.03-0.07 g compared to the control variant.

That is, the use of a desiccant contributes to uniform drying of the herbage, ripening, improved harvesting, but its use does not prevent crop loss. Therefore, the use of preparations based on adhesives and surface-active substances in the first treatment, and their combination with a desiccant in the second, allows to reduce crop losses.

The best option turned out to be when using Agrolip in the first treatment and Desiccant + Agrolip in the second. On this variant, 4,085 seeds were formed per 1 plant, the weight of seeds from one plant was 11.72 g, and the seed productivity was 1.14 t/ha with a weight of 1,000 seeds - 2.87 g.

A somewhat lower seed productivity of 1.13 t/ha, the number of seeds 3887 per 1 plant, the weight of seeds from one plant 11.04 g with the weight of 1000 seeds - 2.84 g was characterized by the variant when applied in the first treatment of N′yu Fylm-17 and second - Desiccant + Agrolip.

Table 2. The influence of the use of preparations based on adhesives and surface-active substances, desiccants on productivity elements and seed productivity of sesame plants

First processing (when browning pods 70–75%)	Second processing (when browning pods 80–85%)	Number of pods on 1 plant (n_c), pcs.	Number of seeds on 1 plant (n_s), pcs.	Weight of seeds from 1 plant (m_s), g	Weight of 1000 seeds (m_{1000}), g	Yield (Y), tons/ha	Average yield after the second processing, t/ha
Control (without treatments)	Control (without treatments)	70	3080	8.75	2.84	0.81	0.81
	Desiccant	72	3245	8.79	2.71	0.89	0.95
	Desiccant + Raps kley	71	3345	9.27	2.77	0.93	1.00
	Desiccant + Agrolip	70	3484	9.79	2.81	0.98	1.07
	Desiccant + N′yu Fylm-17	74	3389	9.46	2.79	0.97	1.03
	Average	**71**	**3309**	**9.21**	**2.78**	**0.92**	
Raps kley	Control (without treatments)	70	3325	9.44	2.84	0.86	
	Desiccant	72	3452	9.53	2.76	0.90	
	Desiccant + Raps kley	71	3554	9.95	2.80	0.95	
	Desiccant + Agrolip	69	3672	10,.36	2.82	1.01	
	Desiccant + N′yu Fylm-17	70	3586	10.08	2.81	0.98	
	Average	**70**	**3518**	**9.87**	**2.81**	**0.94**	
Agrolip	Control (without treatments)	71	3541	10.27	2.90	0.93	
	Desiccant	69	3682	10.31	2.80	1.02	
	Desiccant + Raps kley	72	3854	10.87	2.82	1.07	
	Desiccant + Agrolip	74	4085	11.72	2.87	1.14	
	Desiccant + N′yu Fylm-17	72	3996	11.39	2.85	1.09	
	Average	**72**	**3832**	**10.91**	**2.85**	**1.05**	
N′yu Fylm-17	Control (without treatments)	72	3474	9.94	2.86	0.89	
	Desiccant	70	3598	10.00	2.78	0.97	
	Desiccant + Raps kley	73	3698	10.35	2.80	1.05	
	Desiccant + Agrolip	71	3887	11.04	2.84	1.13	
	Desiccant + N′yu Fylm-17	72	3754	10.62	2.83	1.08	
	Average	**72**	**3682**	**10.39**	**2.82**	**1.02**	
LSD_{05}	A	0,93	10,29	0.05	0.11	0.02	
LSD_{05}	B	0,82	5,91	0.04	0.06	0.04	

The correlation analysis between the elements of the crop structure and the seed productivity of sesame plants was carried out. The correlation between the number of pods on one plant and seed yield was 0.311, between the number of seeds on one plant and seed yield was 0.939, the weight of seeds on one plant and seed yield was 0.901, and the weight of 1000 seeds and seed yield was 0.251 (Figure 2).

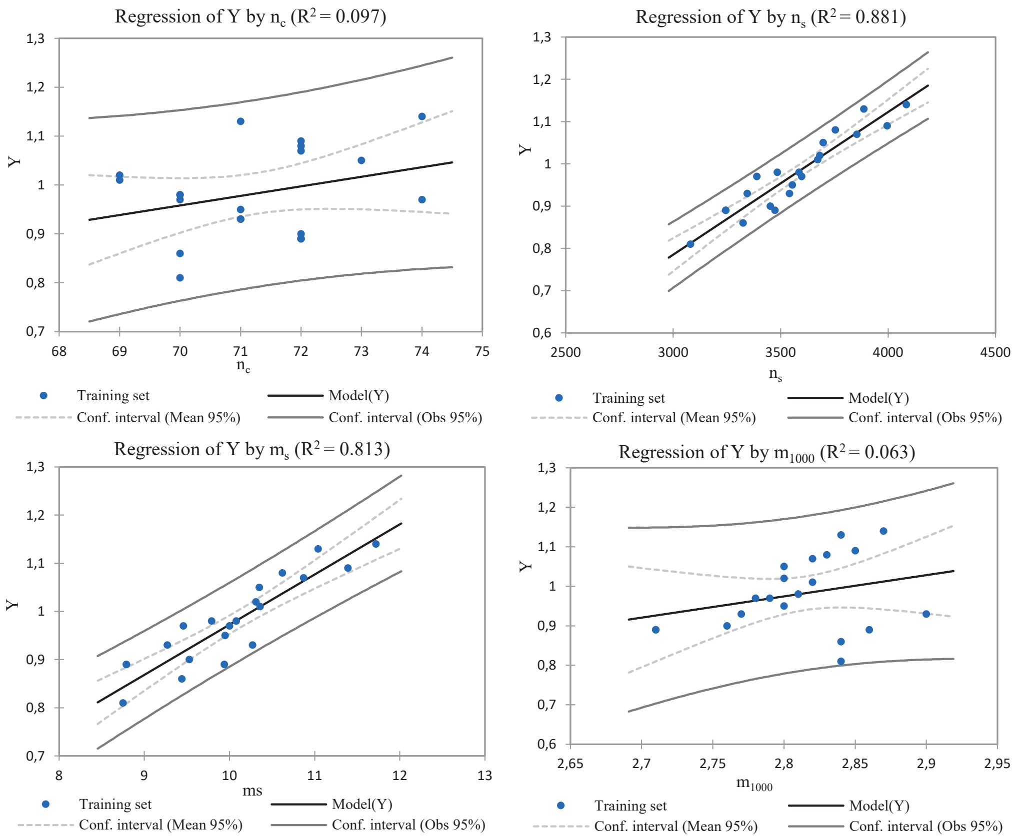

Figure 2. Regression diagrams of the number of pods per 1 plant (n_c) and seed yield (Y) (top left), the number of seeds per 1 plant (ns) and seed yield (Y) (top right), seed weight per 1 plant (m_s) and seed yield (Y) (bottom left), weight of 1000 seeds (m_{1000}) and seed yield (Y) (bottom left)

The advantage of preparations based on adhesives and surface-active substances is: prevention of premature cracking of pods, increase of seed yield and improvement of its quality due to reduction of losses during ripening, which allows collecting uniform ripe seeds. Thus, according to our observations, the best effect was precisely from the use of the drug Agrolip (Figure 3).

Figure 3. The effect of preparations based on adhesives and surface-active substances on the cracking of pods:
1 - Control, 2 - Raps kley, 3 - Agrolip, 4 - N'yu Fylm-17

CONCLUSIONS

The technology of growing sesame should be largely based on the use of potential possibilities of preparations based on adhesives and surface-active substances and desiccants and helps to preserve the seeds in the pod. The best result among desiccants was when processed in the phase of 70-75% browning of pods in Preparation 2 with a seed yield of 1.18 t/ha, which was higher than the control variant by 0.33 t/ha. The best variant when combining preparations based on adhesives and surface-active substances and desiccants turned out to be the variant when applied in the first treatment Agrolip and the second - Desiccant + Agrolip with a seed yield of 1.14 t/ha.

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