Journal of Vasyl Stefanyk Precarpathian National University
http://journals.pnu.edu.ua
Vol. 10 (2023), 56-62

UDC 631.8:631.55:631.531]633.844
doi: 10.15330/jpnubio.10.56-62

EFFECT OF MICROBIAL PREPARATIONS ON THE YIELD AND QUALITY OF WHITE AND BLACK MUSTARD SEEDS

OLEKSANDRA VOLCHOVSKA-KOZAK, IRYNA SLUCHYK, VICTORIIA GNIEZDILOVA

Abstract: There is no doubt that microbial preparations have great potential in agriculture. However, these preparations have not yet found their wide application in the sowing and cultivation of such an important oil and spice crop as white and black mustard. The aim of the study is to investigate the effect of microbial preparations on the yield and quality of white and black mustard seeds and to develop an alternative direction in the cultivation of cruciferous crops. It was found that when using Diazophyte and Albobacterin, white mustard plants produced more seeds by 9 and 21%, respectively, and black mustard plants - by 5 and 6%, respectively. The amount of oil in the seeds of white mustard variety Pidpecheretska was ~24.5 %, and black mustard variety Sofia - ~21.6 %. In terms of fatty acid composition, seed oil from different plots differed little from each other. The oil of the experimental samples had slightly more linoleic acid and less erucic acid, but the difference was not significant. The content of glucosinolates in all samples did not exceed the norm and was ~20 mgM/g for white mustard and 15.4 mgM/g for black mustard. Thus, the introduction of bacterial preparations into the soil improves mineral nutrition, plant growth and development, which ultimately affects the growth of seed yields and crop productivity.

Keywords: white and black mustard, Diazophyte, Albobacterin, seed yield.

1. INTRODUCTION

The overall need to increase the production of edible vegetable oil in Ukraine requires a substantive approach to the cultivation and use of the economic potential of cruciferous crops, especially in the Western region, where soil and climatic conditions are favourable for their cultivation. Over the past 10 years, demand for white and black mustard seeds on the domestic and international markets has been growing steadily. The area under these crops in Ukraine is increasing year on year. Among the reasons that slow down the growth of the industry is the lack of energy-intensive cultivation technologies adapted to modern conditions [1, 9].

Taking into account the significant pollution of most territories of Ukraine with chemicals and the need for integrated use of mineral fertilisers, plant protection products, etc. to obtain stable yields of cruciferous crops, on the one hand, and numerous literature data on the positive effect of using microorganism preparations in agriculture, on the other [8, 10, 18], the problem of biologisation of cruciferous crops is becoming increasingly relevant [7, 12, 14, 17].

Previous studies have established the prospects of using microbial preparations for sowing spring and winter rape. However, these preparations have not yet found their application in the cultivation of such an important oil and spice crop as white and black mustard [13, 15, 16].

The aim of the study is to investigate the effect of microbial preparations on the yield and quality of white and black mustard seeds and to develop an alternative direction in the cultivation of cruciferous crops. The object of the study is the variety "Pidpecheretska" of white mustard and the variety "Sofia" of black mustard of the Carpathian State Agricultural Research Station of the Institute of Agriculture of the Carpathian Region (CSARSIACR) of NAAS.

White mustard (*Sinapis alba* L.) is an annual herb 100-140 cm tall, formed as a non-lodging spreading shrub-like plant. The low content of erucic acid in white mustard seeds (~1%) and glucosinolates makes it possible to use them widely in the food industry. Black mustard (*Brassica nigra* Koch) variety Sofia was bred by individual and family selection from local populations in the Carpathian region. The variety is mid-season, with a seed yield of 20-22 c/ha and an oil content of 21-27%.

2. MATERIALS AND METHODS

The research work was carried out in 2020-2021 on experimental fields in the village of Mykytyntsi of the CSARSIACR of NAAS and at the Ecological and Biochemical Laboratory of the Faculty of Natural Sciences of Vasyl Stefanyk Precarpathian National University. The soil of the experimental field is soddy podzolic. The thickness of the humus horizon is 40-60 cm. The humus content in the topsoil ranges from 2.6 to 3.2%. The amount of absorbed bases averages 11-12 mg-eq. per 100 g of soil, the degree of saturation with bases is 85%, the reaction is slightly acidic (pH of the salt extract is 4.8-5.8, hydrolytic acidity is insignificant). Soils are poorly supplied with mobile phosphorus and exchangeable potassium. The predecessor is cereals. The size of the accounting plot is 50 m^2.

For pre-sowing processing seeds, bacterial preparations developed by the Institute of Agricultural Microbiology of the Ukrainian Academy of Agricultural Sciences, Albobacterin and Diazophyt, were used. The bacterisation was carried out manually on the day of sowing or by applying it under the seedlings. Before application, the preparation was dissolved in water at the rate of 2 % water relative to the weight of seeds. The prepared solution was evenly distributed on the seeds, which were air-dried to a loose state and sown in the soil.

Phenological observations were carried out in all experimental variants according to the generally accepted method. The plant density was determined by the method of accounting plots [4].

The seed yield was recorded by continuous threshing of a pre-calculated number of plants from each plot and weighing them. Seeds were analysed for oil content by the method of S.V. Rushkovsky [5]; glucosinolates (quantitative) - by photocolourimetric method with palladium reagent [2, 3]; erucic and other fatty acids - by gas-liquid chromatography [5, 6].

The results were statistically processed using the method of analysis of variance according to B.O. Dospekhov (1985).

3. RESULTS AND DISCUSSION

The size of the harvest is the main feature of any crop. The potential yield of white mustard is about 250-300 kg of green mass and 25-27 kg of seeds per hectare. Ukraine's leading farms harvest high and sustainable yields of white mustard almost every year in main and intermediate crops. Intensification of crop rotations with intercrops of this crop allows for a second harvest in a year without allocating additional land.

Albobacterin is a bacterial preparation developed on the basis of *Achromobacter album 1122* і *Bacillus polymyxa KB* bacterial strains that actively dissolve soil phosphates, thereby improving plant phosphorus nutrition. These microbial preparations can reduce the application of mineral phosphate fertilisers by up to 30 kg/ha, increase plant productivity and produce environmentally friendly products. In addition, these bacteria produce growth stimulants and contribute to an increase in seed yield by 1.9-2.6 c/ha (15-20%) with an increase in oil content by 1.2 c/ha (23.5%). Diazophyte is a bacterial preparation based on beneficial soil bacteria *Agrobacterium radiobacter* 204, designed to

increase crop yields. According to the published invention, the isolated culture is able to form associative nitrogen-fixing biocenoses with plants. It replaces up to 50 kg/ha of mineral nitrogen, which makes it possible to reduce the amount of fertiliser applied and increase rice and wheat yields by 10-12%. The bacteria are able to compete with natural microflora [17]. The results of the effectiveness of the preparations on the yield and quality of mustard seeds are not available in the literature.

During the research on the influence of Albobacterin and Diazophytes on the yield of mustard seeds, a positive effect of these preparations was found (Table 1).

Table 1. Influence of biological preparations on the yield of white mustard seeds of the Pidpecheretska variety

No.	Variant	Number of plants from 4 plots, pcs.	Weight of harvested seeds, g	Seed weight from 1 plant			
				by structural analysis		by weight method	
				g	% to control	g	% to control
1	Control (H_2O)	1361	4 532	3,52		3,33	
2	Diazophyte	1202	4 363	4,03	114	3,63	109
3	Albobacterin	1348	5 419	4,83	137	4,02	121
	$SSD_{0,5}$			0,15		0,13	

According to the structural analysis, the weight of seeds per plant ranged from 3.52 to 4.83 g. When threshing plants from the plots, losses did not exceed 17% (4-17%), and the weight of the harvested seeds was 3.33-4.02 g per plant. Each of the preparations increased the total yield and the yield per plant. According to both calculations and the actual material obtained, the plots inoculated with Albobacterin had the highest yield. It exceeded the control by 37% according to structural analysis and by 21% when harvesting from the experimental plots by continuous threshing of the listed number of plants. The plots inoculated with Diazophyte also had a positive effect on the yield, but this preparation was less effective than Albobacterin. The yield increase in this variant was 9-14%.

Thus, bacterial fertilisers increase the yield of white mustard seeds. Based on the results of the accounting and calculations, we can talk about the positive effect of bacterial preparations on the formation of vegetative mass, structure and yield of white mustard. At the same time, the plants grew and developed better, created more green mass and accumulated more dry matter, and produced a higher yield of green mass and seeds.

As in the experiment with white mustard, black mustard plants grew and developed better in the experimental plots when using bacterial preparations. This resulted in a higher seed yield. There was no big difference between the experimental and control plots and it was not visually detectable. However, according to the results of both structural analysis and the weight method, a higher yield per plant was obtained from the experimental plots. Thus, Diazophyte increased the yield of seeds from one black mustard plant by 5-6%, and Albobacterin - by 6-9% (Table 2).

Thus, inoculation of mustard seeds before sowing with microbial preparations stimulated the growth and development of plants and increased the yield of green mass and seeds. The amount of increase in yield depends on the type of bacteria, culture and growing conditions. The best results were obtained when using Albobacterin.

Table 2. The effect of biological preparations on the yield of black mustard seeds of Sofia variety

No.	Variant	Number of plants from 4 plots, pcs	Weight of collected seeds, g	Seed weight per plant			
				by structural analysis		by weight method	
				g	% to control	g	% to control
1	Control (H_2O)	1 180	2 986	2,85		2,53	
2	Diazophyte	1 251	3 312	3,03	106	2,65	105
3	Albobacterin	1 152	3 076	3,11	109	2,67	106
$SSD_{0,5}$				0,12		0,09	

Since mustard is first of all an oil crop, the main indicator of the commercial value of the seed is the content of oil in it and its quality. Oil quality is determined by fatty acid composition. Therefore, this feature is extremely important for breeders and product manufacturers. Their goal is to obtain a larger amount of oil per unit area. Oil content within certain limits is genetically determined. At the same time, it is a parameter that is affected by many factors, so it is quite difficult to achieve a significant increase in its quantity.

We analyzed the researched material for the amount of oil in the seeds of white mustard. The obtained results (Table 3) showed a slight variability of the samples according to this indicator.

Table 3. Chemical composition of white mustard seeds of the Pidpecheretska variety from sites with different bacterial backgrounds

No.	Variant	Oiliness,% (+)	Fatty acid content, %						Glucosinolates, μM/g (—)
			palmitic $C_{16:0}$	oleic $C_{18:1}$	linoleic (+) $C_{18:2}$	linolenic $C_{18:3}$	eicosenoic $C_{20:1}$	erucic (—) $C_{22:1}$	
1	Control (H_2O)	24,67	4,06	47,32	15,00	17,15	12,93	3,63	19,8
2	Diazophyte	24,42	5,90	43,25	17,59	17,59	13,68	1,94	20,0
3	Albobacterin	24,31	4,74	42,66	16,25	20,33	14,98	1,08	20,7
$SSD_{0,5}$		0,8							1,3

The oil content varied between 24.31% and 24.67% in different variants. No significant difference was found between the experimental and control samples. Some differences between the samples in the fatty acid composition of the oils were noted. The oil of plant variants inoculated with diazophyte and albobacterin contained a lower amount of oleic (43%) compared to the control (47%), but a higher amount of valuable linoleic (16-17% in the experiment and 15% in the control) acids.

The amount of saturated palmitic acid was 4-6%, and the content of unsaturated linolenic acid varied between 17% and 20%, and it was more compared to the control of eicosenoic acid - 13-14%. The content of unwanted erucic acid was lower when using bacterial agents and ranged from 1% to 2%.

Thus, during the study, a tendency to improve the quality of oil under the influence of bacterial preparations was revealed, but these results require further verification.

An important feature of mustard is the content of glucosinolates in the seeds. Glucosinolates accumulate in mustard seeds during formation and ripening gradually. The amount of glucosinolates in the seeds continuously increases until full ripening. The possibilities of using mustard cake as pet food are limited by the presence of thioglycosides in the seeds. The decomposition products of these substances, formed during enzymatic hydrolysis, which occurs at the moment of destruction of the seed structure and its hydration, are harmful to animals [3, 11].

The results of chemical analysis indicate a low content of glucosinolates in the seeds of white mustard of the Pidpecheretska variety (~20 μM/g), no difference between the research options was found.

The amount of oil in the seeds of black mustard of the Sofia variety was ~21.6%. There was no difference between the variants of the experiment (Table 4). The fatty acid composition of seed oil from different sites also differed little from one another. The oil of the experimental samples had slightly more linoleic acid and less erucic acid, but the reliability of these differences has not been proven. The content of glucosinolates in all samples did not exceed the norm and amounted to 15.4 μM/g.

Thus, the application of bacterial preparations into the soil improves mineral nutrition, growth and development of plants, which ultimately affects the growth of crop productivity. Microbial preparations increase the yield of both green mass and seeds of black mustard and white mustard plants, which is ecologically and economically beneficial.

Table 4. Chemical composition of white mustard seeds of the Sofia varietyfrom sites with different bacterial backgrounds

No.	Variant	Oiliness, % (+)	Fatty acid content, %						Glucosinolates, μM/g (—)
			palmitic $C_{16:0}$	oleic $C_{18:1}$	linoleic (+) $C_{18:2}$	linolenic $C_{18:3}$	eicosenoic $C_{20:1}$	erucic (—) $C_{22:1}$	
1	Control (H_2O)	21,75	6,18	40,36	19,90	16,40	16,36	2,63	15,7
2	Diazophyte	21,52	6,34	41,90	24,12	14,33	11,71	1,87	15,1
3	Albobacterin	22,51	5,11	38,63	29,54	13,63	10,52	1,54	15,6
$SSD_{0,5}$		0,5							0,9

4. CONCLUSIONS

Bacterial preparations increase the yield of mustard seeds. Against the background of Diazophyte and Albobacterin, white mustard plants produced more seeds by 9 and 21%, respectively, and black mustard plants by 5 and 6%, respectively. The highest yield was obtained in the areas where Albobacterin was used.

The amount of oil in the seeds of the white mustard of the Pidpecheretska variety was ~24.5%, and the black mustard of the Sofia variety was ~21.6%. There was no difference between the variants of the experiment. The fatty acid composition of seed oil from different sites also differed little from each other. The oil of the experimental samples had slightly more linoleic acid and less erucic acid, but the reliability of these differences has not been proven. The content of glucosinolates in all samples did not exceed the norm and was ~20 μM/g for white mustard and 15.4 μM/g for black mustard.

Thus, the application of bacterial preparations into the soil improves mineral nutrition, growth and development of plants, which ultimately affects the growth of crop productivity. Microbial preparations give an allowance to the yield of black and white mustard plants, which is ecologically and economically beneficial.

Conflict of interest: The authors declare that they have no conflict of interest.

REFERENCES

[1] Arkhipenko, F.M. (2006). *White mustard - a culture of a wide range of use.* K: Nora. (in Ukr.)

[2] Demyanchuk, G.T. (1989). Determining the content of glucosinylates in feed. *Veterinary medicine*, 8, 61-62. (in Ukr.)

[3] Demyanchuk, G.T., Melnyk, M.V., & Mikitin, N.S. (1987). Determination of glucosinolates by palladium reagent. *Olive crops*, 5, 25-26. (in Ukr.)

[4] Dospekhov, B.A. (1985). *Field experiment methodology*. M: Agropromizdat. (in Ukr.)

[5] Ermakov, A.I. (1987). *Methods of biochemical research of plants.* M: Agropromizdat. (in Ukr.)

[6] Horodniy, M.M., Lisoval, A.P., Bikin, A.V., et al. (2005). *Agrochemical analysis*. K: Aristei. (in Ukr.)

[7] Kurdysh, I.K. (2010). *Introduction of microorganisms into agroecosystems*. K: Naukova Dumka. (in Ukr.)

[8] Mosa, W.F.A.E.-G., Sas-Paszt, L., Frac, M., & Trzciński, P. (2016). Microbial products and biofertilizers in improving growth and productivity of apple. *Polish Journal of Microbiology*, 65(3), 243-251. http://dx.doi.org/10.5604/17331331.1215599

[9] Oksymets, O.L. (2005, November 29-30). *The effect of fertilizers and sowing dates on the oil content of white mustard seeds.* Latest technologies for the production of competitive plant products: Materials of the scientific and practical conference of young scientists and specialists, Chabany: Institute of Agriculture of the Ukrainian Academy of Sciences, 69-70. (in Ukr.)

[10] Samet, M., Ghazala, I., Karray, F., Sayadi, S., & Gargouri-Bouzid, R. (2022). Isolation of bacterial strains from compost teas and screening of their PGPR properties on potato plants. *Environmental Science and Pollution Research*, 29(50), 75365-75379.

[11] Schumann, W. (2003). *Glucosinolate content of rapeseed and rapeseed products in Germany.* Proceedings of 11th International Rapeseed Congress. Copenhagen, 4, 1265-1267.

[12] Shuvara, I. A. (2003). *Agroecological bases of highly efficient cultivation of field crops in crop rotations of biological agriculture: Recommendations*. Lviv: LDAU. (in Ukr.)

[13] Smirnov, V.V., Patyka, V.P., Pidhorskyi, V.S., et al. (2002). Microbial biotechnologies in agriculture. *Agroecological journal*, 3, 3-8. (in Ukr.)

[14] Vasylenko, M. G. (2011). Biological preparations in organic agriculture of Ukraine. *Chemistry. Agronomy. Service*, 6(7), 46-50. (in Ukr.)

[15] Volchovska-Kozak, O.E. (2010). The effect of microbial preparations on the growth and productivity of rapeseed plants. *Bulletin of the Lviv Agrarian Academy*, 14(1), 88-95. (in Ukr.)

[16] Volchovska-Kozak, O.E. (2013, April 26-27). *The influence of bacterial preparations on the size and quality of the spring rape crop*. International scientific and practical conference "Formation of a competitive economy: theoretical, methodological and practical principles", Ternopil, 54-56. (in Ukr.)

[17] Volkogon, V.V. (2007). *Microbiological aspects of optimization of nitrogen fertilization of agricultural crops*. K.: Agrarian science. (in Ukr.)

[18] Yildirim, E., Turan, M., Dursun, A., Donmez, M.F., & Kitir, N. (2016). Integrated Use of Nitrogen Fertilization and Microbial Inoculation: Change in the Growth and Chemical Composition of White Cabbage. *Communications in Soil Science and Plant Analysis,* 47(19), 2245-2260. https://doi.org/10.1080/00103624.2016.1228955

Oleksandra Volchovska-Kozak*, PhD, Associate Professor, Associate Professor of the Department of Biology and Ecology, Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine;
ORCID ID: https://orcid.org/0009-0002-7455-1422
Iryna Sluchyk, PhD, Associate Professor, Associate Professor of the Department of Biology and Ecology, Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine;
ORCID ID: https://orcid.org/0000-0001-9289-8345
Victoria Gniezdilova, PhD, Associate Professor, Associate Professor of the Department of Biology and Ecology, Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine;
ORCID ID: https://orcid.org/0000-0002-3340-5747
E-mail: oleksandra.kozak@pnu.edu.ua, iryna.sluchyk@pnu.edu.ua, viktoria.gniezdilova@pnu.edu.ua
Received: November 10, 2023; **revised:** November 24, 2023; **accepted:** December 11, 2023; **published:** December 28, 2023.

Олександра Волчовська-Козак, Ірина Случик, Вікторія Гнєзділова. Дія мікробних препаратів на урожайність та якість насіння гірчиці білої та чорної. *Журнал Прикарпатського університету імені Василя Стефаника*, 10 (2023), 56-62.

Перспективність застосування мікробних препаратів в сільському господарстві не викликає сумнівів. Однак ці препарати ще не знайшли свого широкого застосування при посіві та вирощуванні такої важливої олійної та пряної культури як гірчиця біла та чорна. Метою роботи є дослідження дії мікробних препаратів на урожайність та якість насіння гірчиці білої та чорної та розробка альтернативного напрямку у вирощуванні хрестоцвітих культур. Встановлено, що при використанні діазофіту і альбобактерину рослини гірчиці білої утворювали більше насіння на 9 і 21% відповідно, а рослини гірчиці чорної – на 5 і 6 % відповідно. Кількість олії в насінні гірчиці білої сорту Підпечерецька становила ~24,5 %, а гірчиці чорної сорту Софія — ~21,6 %. За жирнокислотним складом олія насіння з різних ділянок мало відрізнялася одна від одної. Олія дослідних зразків мала дещо більше лінолевої кислоти та менше – ерукової, однак відмінність була недостовірною. Вміст глюкозинолатів у всіх зразках не перевищував норми і становив ~20 мкМ/г для гірчиці білої і 15,4 мкМ/г для гірчиці чорної. Таким чином, внесення бактеріальних препаратів у ґрунт покращує мінеральне живлення, ріст і розвиток рослин, що, в кінцевому рахунку, впливає на зростання урожаю насіння та продуктивність посівів.

Ключові слова: гірчиця біла та чорна, Діазофіт, Альбобактерин, урожайність насіння.