IJABR

International Journal of Advanced Biotechnology and Research (IJABR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-10, Issue-1, 2019, pp341-347
http://www.bipublication.com

Research Article

УДК 633.854.78 : 631.87

Modern Biological Products and Growth Stimulators in the Technology of Cultivation of Sunflower for Oilseeds

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[Received: 09/12/2018; Accepted: 22/01/2019; Published: 24/01/2019]

ABSTRACT.

Sunflower shows low production efficiency in the conditions of a forest-steppe zone of the Middle Volga region, which taken along with high cost of mineral fertilizers, fuel and lubricants, seeds, etc results in high prime cost of oily raw materials. The study is focused on the issues of application of biological products and plant growth stimulators for the increase in sunflower efficiency and reducing cultivation costs. The research was carried out as a two-factor field experiment in four replications, which was followed by observations, accounts, and analyses. During the study, the efficiency of sunflower seed coating with a biological product Flavobakterin at the rate of 0.3 kg of liquid culture per hectare seed rate. Materials of this article can be useful to the managers of the agricultural enterprises, agronomic specialists, graduate students, and students that major in agronomy.

Key words: biopreparations, LFSC 1, mineral fertilizers, yield, vegetable oil, head and root rot, cost-cutting.

INTRODUCTION:

The major part of the prime cost for crop production, including oilseeds production, is the expenses on mineral fertilizers and chemicals for crop protection [1,2]. Besides, the application of agricultural chemicals in excessive amounts disturbs the biological balance, pollutes the environment and has a negative impact on the health of the population [3,4]. Thus, the application of liquid complex fertilizers and biological methods of crop protection is a relevant issue of modern APC in Russia and has great practical significance [5,6,7,8].

Aim and tasks of the study.

The aim of the study was to develop practical approaches to the creation of agrocenosis based

on the application of biological products and liquid fertilizer and stimulator preparations for sunflower seed coating.

The tasks of the study were the following:

1. To evaluate the influence of biological products on the seeds germination, on formation of the root system and invasion of the head and root rot pathogens.
2. To assess the yield and oil outcome depending on the method of seed material preparation.
3. To calculate the replacement ratio of NPK with the studied products and the potential cost cut. The studies were conducted according to the "Strategy of biotechnological development of the Russian Federation to 2020".

Conditions and methods of field and laboratory trials.

Field and laboratory trials were performed on the experimental fields of the Agronomy Department of the Kazan State University, which are 15 km from Kazan.

Agrochemical characteristic of the trial plot corresponded to the typical gray forest soils that occupy around 38% of the cultivated lands in the Middle Volga region. Thus, the baseline humus content by Turin was 3.2-3.5%, labile phosphorus was 145-155, exchange potassium was 158-160 mg/kg of soil (by Kirsanov). The acidity of soil was close to neutral (pH of salt extract was 5.7). The density of soil was within the norm – 1.20-1.21 g/cm^3, the lowest water holding capacity was quite high (the soil could hold up to 28-29% of moisture in its structure).

Agrometeorological conditions were the following: In May-September 2011, there were 223 mm of precipitants, which was 16% less as compared to long-term average annual values. At the same time, the average daily temperature was 6°C higher than the norm. Further years of the study were not different from the year 2011 by the level of precipitants and the temperature pattern (the level of precipitants was lower by 24-45 mm and the temperature was higher by 8-13%). The trials were performed in 4 replicates by the following ploughing plan: 3 rows with 70 cm inter-row spacing. The trial plot length was 30 m (Figure 2). Agrotechnological approach to sunflower cultivation was conventional and consisted of the main, pre-ploughing soil cultivation, pre-germination and post-germination harrowing and inter-row cultivation.

Records, observations and analyses were performed according to the methods proposed by Dospekhov B.A. [9], Moiseichenko V.F. [10] and Lukomets V.M. [11]. The objects of the study were Rodnik variety and Sanmarin 444 hybrid.

RESULTS AND DISCUSSION.

Biological preparations, growth stimulators and mineral fertilizers do not influence the seeds vigor and field germination significantly. Their positive influence is observed on sprouts growth energy and acceleration of plants development into autotrophic feeding [12,13,14,15,16,17,18]. Thus, additional seed coating with Flavobacterin at the rate of 0.3 kg/norm seed rate per hectare on the day of ploughing increased Rodnik variety sprouts growth energy by 11.8% as compared to the control (Table 1).

Table 1. The influence of biopreparations, growth stimulators and NPK on the sprouts growth energy and the intensity of sunflower root system development

Factor A (varieties and hybrids)	Factor B (seed treatment)	Air-dry weight of plants at the stage of 2 pairs of true leaves, g	Dynamics of the root system development, cm			
			Drilling – sprouting	Sprouting – budding	Budding – flowering	Flowering – ripening
Rodnik	Apron 3 kg/t seeds (control)	3.4	4.8	28.3	50.7	52.4
	Control + $N_{105}P_{50}K_{106}$	3.6	5.5	34.4	60.3	63.2
	Control + Albit 40 g/t seeds	3.4	5.3	29.8	52.8	53.0
	Control + Flavobacterin 0.3 kg per seed unit	3.8	5.4	31.6	58.9	59.1
	Control + Azotovit 2 kg/t seeds	3.5	4.8	29.9	53.6	54.7
	Control + LFSC 1 2 kg/t seeds	3.4	4.7	29.1	51.1	53.0

Sanmarin 444	Apron 3 kg/t seeds (control)	3.5	4.9	30.2	53.7	54.7
	Control + $N_{105}P_{50}K_{106}$	3.9	5.8	36.9	62.9	63.8
	Control + Albit 40 g/t seeds	3.5	5.5	32.1	54.1	55.3
	Control + Flavobacterin 0.3 kg per seed unit	4.1	5.6	33.8	59.8	61.0
	Control + Azotovit 2 kg/t seeds	3.7	5.1	30.7	55.1	56.8
	Control + LFSC 1 2 kg/t seeds	3.6	5.0	31.0	53.4	54.3
HCP_{05}	A	0.12	0.32	1.2	1.9	2.1
	B	0.18	0.48	1.7	2.2	2.4
	AB	0.21	0.61	2.1	3.6	3.8

The hybrid Sanmarin 444 showed the highest sensibility to Flavobacterin and the calculated doses of NPK for the planned 2.5 t/he yield of oil seeds. Sprouts growth energy of the hybrid Sanmarin 444 was higher by 7.9-8.3% as compared to the Rodnik variety.

The most significant influence of Flavobacterin and the calculated doses of NPK was observed on the formation of strong deeply penetrating root system of sunflowers. By the end of budding, more than 50% of sunflower roots were located in the soil profile from 34.4 to 36.9 cm deep depending on the variety and the hybrid. During the stage of "budding-flowering", under the influence of Flavobacterin, the depth of the Rodnik variety root system penetration increased by 1.8 times and of the Sanmarin 444 hybrid – 1.77 times as compared to the previous stage of vegetation.

The efficiency of Flavobacterin during the development of sunflower root system proved to be very high. Its efficiency parameters values were not lower than those of the calculated NPK doses for the planned 2.5 t/ha yield of sunflower oil seeds.

According to the specialists on crop protection [19], sunflower crops are can be infected by up to 44 pathogens of bacteriological or viral nature. The most dangerous of them in the soil-climate conditions of the Volga Region are gray, dry and charcoal heat rot, as well as false mildew and root rot. Infectious pathogens of the majority of the diseases inhabit sunflower seeds. Hence, seed coating with Apron at the rate of 3 kg/t and additional seed treatment with biological products and growth stimulators are very significant in the production of oilseed sunflowers (Table 2).

Table 2. The results of the seeds phyto-assessment and plant stand at harvest, % (2011-2014)

Factor A (varieties and hybrids)	Factor B (seed treatment)	Gray rot (Botrytis cinerea)	White rot (Whet-zelinia sclero-tiorum)	Root rot (Fusarium sp., Rhizoctonia sp.)	Plant stand at harvest
Rodnik	Apron 3 kg/t seeds (control)	1.31	0.98	2.1	72.6
	Control + $N_{105}P_{50}K_{106}$	1.34	0.95	1.8	75.3
	Control + Albit 40 g/t seeds	1.02	0.82	1.5	77.3
	Control + Flavobacterin 0.3 kg per seed unit	1.11	0.84	1.5	78.6
	Control + Azotovit 2 kg/t seeds	1.22	0.86	1.6	77.8
	Control + LFSC 1 2 kg/t seeds	0.83	0.79	1.3	79.4
Sanmarin 444	Apron 3 kg/t seeds (control)	1.21	0.97	2.0	73.4
	Control + $N_{105}P_{50}K_{106}$	1.24	0.97	1.7	76.0
	Control + Albit 40 g/t seeds	0.81	0.80	1.4	79.8
	Control + Flavobacterin 0.3 kg per seed unit	0.93	0.81	1.4	81.6
	Control + Azotovit 2 kg/t seeds	1.12	0.83	1.6	80.0
	Control + LFSC 1 2 kg/t seeds	0.68	0.72	1.3	85.6

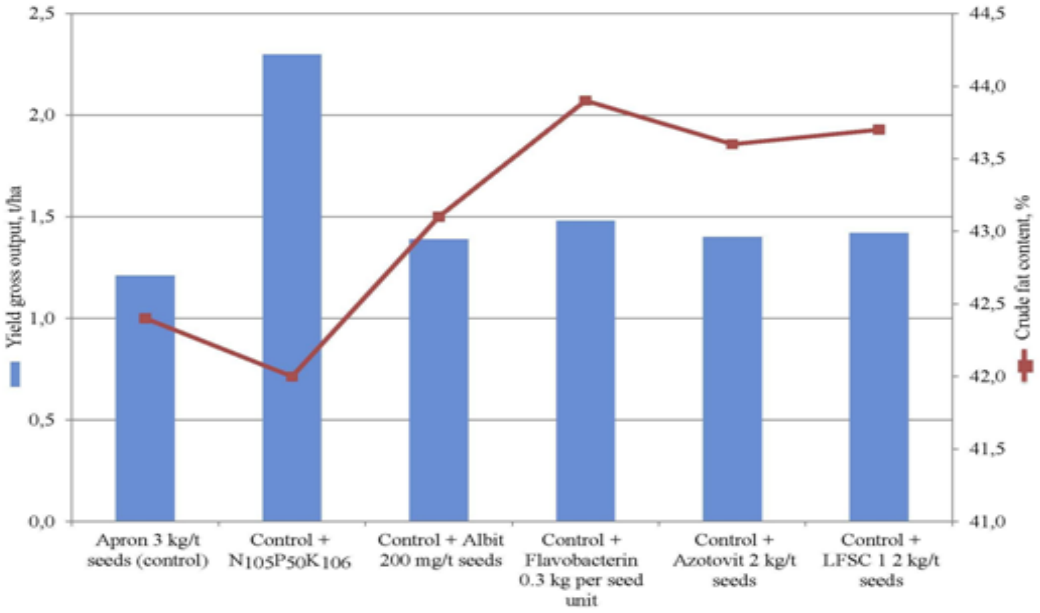
The conducted phyto-assessment of the seeds showed that the best pest control of the above mentioned pathogens was observed in the trial variant "Apron 3 kg/t + LFSC1 2 kg/t" (plant stand at harvest was 79.4-85.6%). High efficiency of LFSC1 is explained by the presence of chelate copper in its content.

It should be mentioned that *Flavobacterin* is efficient against gray head rot and reduces the disease rate by 17% due to flavacin expression.

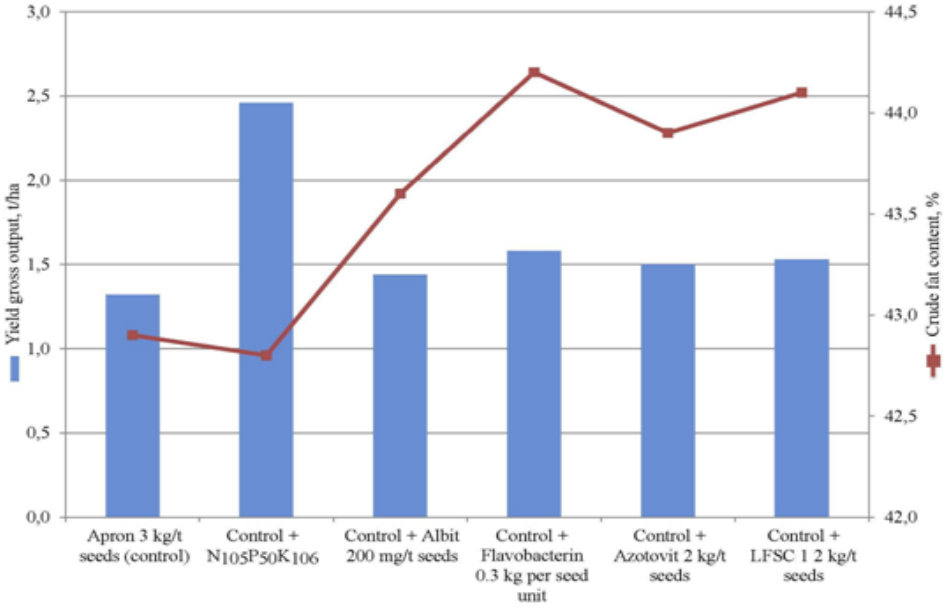
Varietal peculiarities of Sanmarin 444 should also be noted in all the trial variants. It showed to be more resistant to the diseases and provided the best crop protection (81.6-85.6%).

Development of highly productive agrocenosis depends not only on the total plant stand at the harvest, but also on the availability of nutrient elements. Sunflower head production parameters (productive area, number of kernels, TKW, etc) depend on the soil fertility.

For this reason, the highest yield increase in oily seeds, as compared to the control, was observed after the application of the calculated rates of mineral fertilizers for the planned yield of 2.5 t/ha. The yield increase in the Rodnik variety was 1.11 t/he 9+91%), in the Sanmarin 444 hybrid – 1.14 t/ha (Figure 1).



a) Rodnik variety



b) Sanmarin 444 hybrid

Figure 1. Yield gross output and content of crude fat in the trial variants (2011-2014)

Significant increase in the yield was recorded for Rodnik variety after Flavobacterin application (+0.27 t/ha), Azotovit (+ 0.19 t/ha), Albit (+0.8 t/ha) and LFSC 1 (+ 0.21 t/ha), the lowest significant increase was 0.16 t/ha of oil seeds.

For Sanmarin 444, hybrid parameters values were 0.26; 0.18; 0.12 and 0.21 t/ha, respectively.

The benefits of Sanmarin 444 hybrid were also in the high content of crude fat in commercial crops. Its increase varied from 42.9% in the control variant to 44.2% in Flavobacterin trial variant as compared to 42.4% and 43.9% in oilseeds of the Rodnik variety. Along with that, gross output of oil per 1 ha of the Sanmarin crop exceeded 1,000 kg threshold (1,052.9 kg/ha in Apron variant + NPK for the planned yield of 2.5 t/ha).

In general, the calculated doses of NPK, biological products, and growth stimulators application was inefficient, when it came to the gross output of oil. Additional 86.1 – 453.0 kg/ha of high quality oil can be obtained from the Rodnik variety and 61.5 – 468.6 kg/ha – from the Sanmarin hybrid.

Apart from the yield and oil gross output, the farmers are interested in the ratio of possible replacement of NPK fertilizers with biological preparations and growth stimulators. And what is more important, what the economic benefit would be.

According to the authors' estimations, the ratio of NPK fertilizer replacement with the studied preparations for the Rodnik variety varied from 19.0% in the trial variant "Apron + Albit" to 32.0% in the trial variant "Apron + Flavobacterin" (Table 3).

Table 3. Economic efficiency of biological products and growth stimulators application on sunflower crop

Factor A (varieties and hybrids)	Factor B (seed treatment)	Replacement ratio		Cost cut on the application of NPK, rub/ha	Cost of biological products application, rub/ha	Total cost cut, rub/ha
		%	kg/ ha			
Rodnik	Apron 3 kg/t seeds (control)	-	-	-	-	-
	Control + $N_{105}P_{50}K_{106}$	-	-	-	-	-
	Control + Albit 40 g/t seeds	19.0	49.6	1,500	125	1,375
	Control + Flavobacterin 0.3 kg per seed unit	30.2	78.8	2,400	346	2,045
	Control + Azotovit 2 kg/t seeds	21.5	56.1	1,800	225	1,475
	Control + LFSC 1 2 kg/t seeds	23.7	61.8	1,900	237	1,663
Sanmarin 444	Apron 3 kg/t seeds (control)	-	-	-	-	-
	Control + $N_{105}P_{50}K_{106}$	-	-	-	-	-
	Control + Albit 40 g/t seeds	12.6	32.9	1,000	136	864
	Control + Flavobacterin 0.3 kg per seed unit	27.1	70.7	2,100	368	1,732
	Control + Azotovit 2 kg/t seeds	18.9	49.3	1,500	260	1,240
	Control + LFSC 1 2 kg/t seeds	22.3	58.2	1,800	252	1,448

The same range for the Sanmarin 444 hybrid did not exceed 12.6 and 27.1%. In other words, the efficiency of Albit was 49.3 and 56.1; LFSC 1 – 58.2 and 61.8 kg, respectively, depending on the variety and hybrid. The highest ratio of NPK replacement in percent or kilos was observed in Flavobacterin trials and was equal to 27.1 and 30.2%, respectively, i.e. the bioproduct replaced 88.8 kg of NPK for Rodnik variety crop and 70.7 kg of NPK for Sanmarin 444 hybrid without any damage to oil gross output.

Replacement of such volume of mineral fertilizers with biopreparations contributes to the cost cut for Rodnik variety cultivation from 1,375 to 2.045 rub/he and for Sanmarin 444 hybrid – from 684 to 1,32 rub/ha.

CONCLUSION.

The efficiency of seed couting with biological product Flavobacterin at the rate of 0.3 kg/norm

seed rate per ha was confirmed during the study. More intensive development of plant green mass (by 12%) was observed. The rate of gray mold, white mold and root rot decreased (20.5%), the yield increased by 30.2%, oil content – by 3.3%; production cost reduced by 1.7 – 2.0 thousand rub/ha. More than that, it was shown that the Sanmarin 444 hybrid had better productivity than the Rodnik variety.

Abbreviations:

LFSC - Liquid fertilizer and stimulant composition

NPK – nitrogen, phosphorus, potassium

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