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INFLUENCE OF SOIL ACTINOMYCETES ON THE GROWTH AND DEVELOPMENT OF OILSEED FLAX IN THE CONDITIONS OF NORTHERN KAZAKHSTAN

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Abstract
Oilseed flax is a rather new crop for Kazakhstan, as it has recently been cultivated there. Cultivation of oilseed flax has been growing in Kazakhstan for some years. The article presents the data on the study of soil actinomycetes on the growth and development of oilseed flax, as well as the spread of root rot, depending on the use of various biologics based on different cultures of actinomycetes. It has been found that many cultures can limit the spread of root rot in the initial stages of growth and development of oilseed flax by 34-65%. It has been noted that biologics based on actinomycetes can increase the immunity and the yield of oilseed flax. S. pratensis 15 culture in pure form and the consortium of actinomycetes *S. ambofaciens 40 strain + S. platensis strain 44 + Act. spp. strain 46* are recommended to create biologics.

Keywords: soil microorganisms, actinomycetes, oilseeds, oilseed flax, biologics.

INTRODUCTION

Nowadays the government of the Republic of Kazakhstan takes measures to expand oilseed crops in order to produce plant raw materials in the amount needed for the domestic market. Expanding the range of oilseeds is an important direction in the stabilization of zonal crop production. Sunflower has been the leading oilseed crop in Kazakhstan for many decades. However, its sowing exhaust the soil and it leads to negative consequences. Oilseed flax can become an alternative to sunflower. Such biological features as a short growing season and drought resistance make this crop suitable for growing in Northern Kazakhstan. The main producers of vegetable oil in the Northern region are Kostanay, Akmola and North Kazakhstan regions. The Karabalyk experimental station and some farms in the Fedorovskiy, Karabalyk, Karasuskiy and Enbekshilderskiy districts of the Northern region annually receive 10-15 C / ha of oilseed flax seeds. It should be noted that even with a yield of 2-3 C/ha, flax production justifies itself [1-4].

Oilseed flax has a high level of profitability of production: it retains high prices, both on the domestic and global markets, compared to other oilseeds. A short growing season significantly reduces the natural risks of crop failure, and also allows farms to receive cash proceeds from sales in July-August. Getting a good crop depends on the skilful and implementation of measures to protect the crop from pests, diseases, weeds, losses from which can be very significant.

The recommendations prepared by scientists of Konstaninskiy Agricultural Research Institute, Ural agricultural experimental station, and A.I. Barayev research and production center of grain farming set out the main elements of the technology of cultivation of oilseed flax, the characteristics of flax varieties of domestic and foreign selection [1, 5, 6]. However, the issue of the spread of particularly dangerous diseases of oilseed crops, their biology, ecology and etiology remains unstudied in Kazakhstan. So far, no chemical preparation has been registered in the register of recommended chemicals for the control of diseases of oilseed flax in the conditions of Northern Kazakhstan, since the study of diseases of these crops has not even begun. There is no research data on oilseed flax diseases depending on agrotechnical methods of cultivation. There is no information about the stability of cultivated varieties of oilseed flax, since today there are no zoned varieties in the Akmola region.

The use of biologics based on antagonists is one of the most promising and environmentally safe directions in reducing the spread of fungal diseases of oilseed flax and safflower. It necessary to carry out complex works on the creation, biological assessment and introduction into production of Kazakhstan's highly effective biologics to suppress the spread of harmful diseases of oilseeds and safflower crops.

RESEARCH MATERIALS AND METHODS

The objects of research have been the strains of actinomycetes, and oilseed varieties.

The experiments have been conducted in field conditions and in the laboratory of Microbiology of S.Seifullin Kazakh Agrotechnical University and in Akmola-Phoenix LLP in Tselinograd district of the Akmola region.

In laboratory conditions, growth-stimulating properties of actinomycete culture filtrates (CF) in relation to oilseed flax seedlings were determined using the method of O. A. Berestetskiy [7]. The seeds were treated with the CF within 24 hours. In each variant, 30 seeds were taken without any signs of the disease. At the end of the time, the seeds were rinsed with tap water, transferred to filter paper in Petri dishes, where they were cultivated for 7 days at a temperature of 20-22°C. The following parameters have been analyzed: the number of sprouted seeds, the length of the sprout and root.

Growth-stimulating and fungicidal properties, as well as the survival rate in the rhizosphere of plants of new actinomycete strains were studied in the field on a natural background. To create laboratory samples of biologics, actinomycetes were grown on shakers that provide shaking of flasks at a speed of 200 rpm in sterile Erlenmeyer flasks on a liquid Gause nutrient medium. The strains were cultured for 20 days, after which the spore titer was determined by seeding in Petri dishes with 4, 5, 6 dilutions.

Such oilseed flax variety as Kostanay amber was used in the experiments. 8 types of laboratory samples of biologics were tested. The experience is repeated four times, and the placement of plots is randomized. The size of plots is 1 m^2. In the control variant, the seeds are not infected with microorganisms. In the experimental variants, the seeds of agricultural crops were treated with a suspension culture of individual actinomycete and their consortia before sowing. The biologics included *Streptomyces cirratus strain 3, Streptomyces luridus strain 4, Streptomyces xantholiticus strain 7, Streptomyces sindenensis strain 11, Streptomyces pratensis strain 15, Streptomyces sindenensis strain 28, Streptomyces ambofaciens strain 40, Streptomyces platensis strain 44, and Actinomyces sp. strain 46.*

During the growing season, phenological observations were made on the growth and development of oilseed flax, determining the distribution and development of root rot.

The spread of the disease was determined by the formula [8] (1):

$$R = \frac{n\,x\,100}{N}, \quad (1)$$

where R - % crop infestations or spread of disease;

n- number of affected plants in the sample;

N- the total number of analyzed plants.

The development of the disease was determined by the formula (2):

$$P = \left(\frac{\sum (a\ x\ б)}{AK} \right) x\,100, \quad (2)$$

where P - disease development, %;

a - the number of plants with the same signs of infestation;

б - corresponding to this characteristic point of defeat;

∑ - the sum of the products of the numeric indicators on them;

A - the number of plants;

K - highest score on the accounting scale.

The intensity of infestation of oilseed flax root rot was set on a 4-point scale [8]: 0-there are no signs of infestation; 1 – on the basis of the stem and its underground part, brown strokes, spots (10% of the surface is affected); 2 – brown stripes and spots covering 50% of the surface of the organ; 3 – solid browning of the first stem and underground internode; 4 – the absence of productive stems in the presence of symptoms on the score of 3.

The biological effectiveness (BEF) of the products was determined by the formula (3):

BEF= *(Рк - Ро) x 100: Рк,* (3)

where Ро – infestation of plants in the experiment;

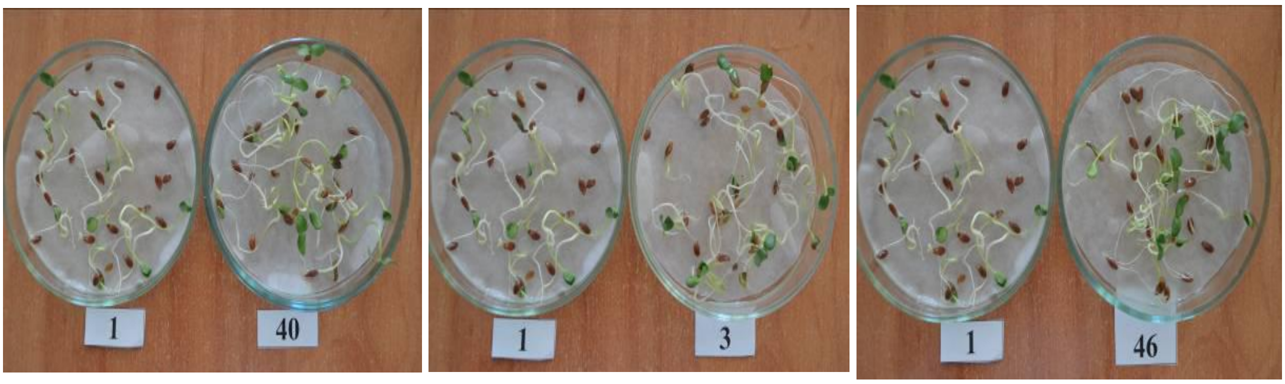
Рк – the same indicator in the control.

RESEARCH RESULTS AND DISCUSSIONS

The results of studying the species diversity of actinomycetes selected from the soils of Northern Kazakhstan were presented in early studies [9]. The selected actinomycete cultures were evaluated for their cellulolytic activity with subsequent genetic identification based on analysis of a fragment of the 16S rRNA gene. As a result of genetic analysis of 19 active cultures of actinomycetes, it was revealed that the soils of Northern Kazakhstan are dominated by actinomycetes belonging to the genus *Streptomyces*. Such species as *S. cirratus, S. parvus and S. xantholiticus* are common on saline soils; in dark chestnut soils - *S. sindenensis, S. microsporus, S. badius, S. pratensis, S. staurosporininus, S. griseus;* in chernozems - *S. ambofaciens, S. auratus, S. natalensis* and *S. platensis.*

Growth-stimulating properties of actinomycete strains were determined in laboratory conditions (Picture 1). As a result of the experiment, it has been found that among the tested strains, such strains as №2, 3, 7, 10, 28, 31, 32, 37, 40, 44, and 46 can stimulate the germination of flax seeds by 30-48%. Twenty five percent of the total number of actinomycete cultures is able to increase this indicator by 20-27%. The inhibitory effect of some cultures on the germination of flax seeds was noted. Stimulation of the growth of flax roots occurs under the influence of cultural filtrate *S. ambofaciens. No. 31*, *S. pratensis strain 15* and *Actinomyces spp. strains 4, 32, 33 (Table 1).*

1 – control; 40 - *Streptomyces ambofaciens* strain 40; 3 – *Streptomyces cirratus* strain 3; 46 - *Actinomyces* spp. strain 46



Picture 1. – Influence of CF of actinomycetes on the growth of oilseed flax seedlings

Table 1. Influence of CF of actinomycetes cultures on the growth and development of oilseed flax

Variant	Seed germination, %	In relation to control, %	Root length, cm	In relation to control, %	Length of sprouts, cm	In relation to control, %	Number of sprouts with primary leaves, %
Control	44,0	100	5,1±0,3	100	3,2±0,2	100	82
Actinomyces sp. strain 1	42,0	95	4,3±0,1	84	3,2±0,1	100	71
Actinomyces sp. strain 2	61,0	139	4,4±0,2	86	3,0±0,2	94	90
Str. cirratus strain 3	62,0	141	4,8±0,1	94	3,5±0,05	109	100

Str. luridus strain 4	42,5	96,5	6,0±0,05	118	3,9±0,1	122	96
Str. parvus strain 5	41,5	94	5,3±0,1	104	4,0±0,1	125	100
Str. xantholiticus strain 7	62,5	140	4,6±0,2	90	3,1±0,2	97	100
Str.sindenensis strain. 11	56,5	127	4,5±0,1	88	3,3±0,1	103	100
Str. microsporus strain 12	40,0	91	5,5±0,2	108	3,3±0,05	103	100
Str. badius strain 13	45,0	102	4,6±0,3	90	3,0±0,2	94	96
Str. pratensis strain 15	51,0	116	6,5±0,1	127	3,5±0,1	109	96
Str. Staurosporininus strain 16	53,0	120	5,1±0,3	100	2,9±0,1	90	100
Actinomyces sp. strain 18	54,7	124	4,9±0,1	96	3,1±0,03	97	100
Actinomyces sp. strain 19	53,0	120	3,9±0,2	76	3,4±0,1	106	100
Actinomyces sp. strain 23	54,0	123	4,3±0,3	84	2,8±0,2	87	100
Actinomyces sp. strain 25	52,0	118	3,2±0,1	63	2,4±0,1	75	100
Str. sindenensis strain 28	62,5	141	4,4±0,05	86	2,8±0,1	87	80,5
№ culture 30	53,5	121	3,9±0,1	76	2,7±0,1	84	100
Str. ambofaciens strain.31	63,2	144	10,1±0,2	199	2,9±0,2	90	100
Actinomyces sp. strain 32	61,0	139	5,7±0,1	118	3,6±0,1	112	100
Actinomyces sp. strain 33	36,5	85	6,2±0,06	121	3,7±0,2	116	100
Str. griseus strain 35	53,0	120	4,8±0,1	94	3,3±0,2	103	88,5
Str. Ambofaciens strain 40	63,5	144	4,6±0,3	90	2,7±0,1	84	100
Str. sioyaensis strain 41	37,0	84	3,7±0,07	72	2,7±0,2	84	100
Str. auratus strain. 42	54,0	123	4,6±0,1	90	3,1±0,3	97	100
Str. natalensis strain 43	51,0	116	4,6±0,1	90	2,7±0,05	84	96
Str.platensis strain 44	65,0	148	3,3±0,2	65	2,7±0,1	84	94
Str. ambofaciens strain 45	49,0	111	5,5±0,2	108	3,6±0,05	112	100

The following cultures of oilseed flax were selected to confirm the growth - stimulating properties of the strains in the field: *S. cirratus* strain *3, S. pratensis* strain *15, S. luridus strain 4, S. xantholiticus* strain *7, S. sindenensis* strain *28, S. ambofaciensculture 40+ S. platensis* strain *44+ Act. spp.* strain *46* and the following safflower cultures: *S. xantholiticus* strain *7, Streptomyces sindenensis* strain *11, S. luridus strain 4, S. sindenensis* strain *28* in the consortium or in pure form. The increase in the germination of flax seeds was observed in the field on experimental samples. On average, the germination rate of oilseeds increased by 7.8% for the variants. The use of a biological product based on the *S. luridus* strain 4 increased seed germination on safflower crops by 16%. In other cases, this indicator was at the control level.

According to FAO, about 3.0 million hectares of oilseed flax are cultivated nowadays. Oilseed flax is cultivated in all continents, but about 70% of the world's oilseed production is concentrated in 4 countries. Canada accounts for 26.3%, China for 15.6%, Argentina for 14.3% and India for 12.9%. In all countries, the complex of measures to protect against diseases of oilseed flax is dominated by the chemical method, including the use of pesticides [10, 11, 12]. Currently, the attention of the world scientific community is growing to the creation and widespread introduction of biological plant protection products into industrial crop production. The system of plant protection from pests and diseases with the predominant use of chemicals has led to the emergence of sanitary and economic problems. The environmental situation is getting worse: the atmosphere, water, soil and products are polluted with toxic substances [13, 14]. In this regard, it is important to expand the research in the direction of finding useful, biologically active microbes, plant substrates and creating highly effective and safe biologics based on them.

The biological effectiveness of products, limiting the spread of root rot in various phases of growth and the development of oilseed flax, was determined (Table 2). This indicator was 34-65% at the initial stages of flax growth and development, and in the experimental safflower variants.

Table 2. Biological effectiveness of biologics against root rot of oilseed flax at the initial stages of plant growth and development

Variant	**R**	**BEF**
sprouts		
Control	10,0	-
S. cirratus strain 3	3,7	63,0
S. pratensis strain 15	13,3	-
S.luridus strain 4 +*S.xantholiticus* strain 7 +*S. Sindenensis* strain 28	6,6	34,0
S. ambofaciens strain 40+ *S.platensis* strain 44+ *Act.* spp. strain 46	3,5	65,0
blossoming		
Control	11,8	-
S. cirratus strain 3	-	100
S. pratensis strain 15	6,7	43,2
S.luridus strain 4 +*S.xantholiticus* strain 7 +*S. Sindenensis* strain 28	6,3	44,6
S. ambofaciens strain 40+ *S.platensis* strain 44+ *Actinomyces* spp. strain 46	-	100
Note-R-disease spread, %; BEF. - biological effectiveness against root rot, %		

ELEMENTS OF FLAX CROP STRUCTURE

The worldwide interest to the use of linseed oil in food has recently increased due to its medicinal properties, as it contains linolenic acid in high proportion (58%) [15-16]. According to the statistics agency of the Republic of Kazakhstan, the acreage of oilseed flax has increased from 58.3 thousand to 410 thousand hectares in the Republic of Kazakhstan for last 2 years [17, 18]. The simplicity of cultivation technology and economic efficiency are the important factors contributing to the increase in acreage for this crop. Oilseed flax is not particularly demanding on soil fertility, except for heavy floating, easily forming a thick crust and saline soils. But despite its simplicity, flax has certain conditions for cultivation: the cleanliness of the fields from weeds and diseases and pests that develop on its crops.

There is a large number of various fungi (fusariosis, Anthracnose, polysporosis, ascochytosis, etc.) on the surface and inside the flax seeds, as well as bacteria that greatly reduce the energy of germination and germination. When flax seeds are infected by 10-15%, there is a decrease in yield. Therefore, it is useful to carry out seed and planting material treatment alongside with soil treatment. Chemical plant protection products in the overall system of disease control measures occupy the first place in terms of application and have many advantages. However, along with the advantages, it should be noted and their disadvantages, primarily toxicity to warm-blooded and human. The integrated method of plant protection is the only possible alternative to modern chemical pesticides in the conditions of environmentalization of agriculture. It means the usage of environmentally friendly biologics.

Treatment with biologics before sowing is carried out for the following purposes: to suppress surface and intra-seed infection, stimulate seed growth and strengthen their immunity, increase the energy of seed germination, increase germination. For a number of agricultural crops, the microbiological method of plant protection should take a dominant place in the fight against both pests and diseases.

In field studies, the influence of biologics on the elements of the structure of the oilseed crop yield was studied (Picture 2).

A

B

Picture 2. oilseed flax crops: A – seedlings, and B- in full ripeness of plants

The analysis of the elements of structural crop of oil flax has showed that the high safety of plants for harvesting, the

largest number of bolls per plant, seeds in one boll, the mass of 1000 seeds and seeds from one plant was established on the variant using the consortium of actinomycetes *S. ambofaciens* strain *40+ S. platensis* strain *44+ Actinomyces spp. 46*. Consequently, the yield on this variant was higher by 8.3% compared to the control (table 5).
The safety of plants for harvesting in the experimental variants was higher by 10.1-38.7% compared to the control. The number of seeds in the boll and the weight of 1000 seeds on all variants was the same. Biologics stimulated the formation of bolls and seeds of oilseed flax. None of the experiments has showed a negative effect of the biologics on the yield of seeds.

Table 5. The effect of biological products on the elements of the structural crop of oil flax

Variant	number			weight		yield, g/m²
	Plant survivability, %	boll for 1 plant, pcs.	Seeds in 1 boll, pcs.	1000 seeds, g	seeds from 1 plant, g	
Control	28,0	34,08	5,4	7,0	1,81	204,0
S. cirratus culture 3	31,0	43,14	5,3	7,2	1,78	210,0
S. pratensis culture 15	32,8	37,17	5,6	7,0	1,49	215,0
S. luridus culture 4 + *S. xantholiticus culture* 7 + *S. sindenensis* culture 28	31,4	37,25	5,3	7,0	2,6	208,0
S. ambofaciens culture 40+ *S. platensis* culture 44+ *Act.* spp. Culture 46	39,0	44,96	6,3	7,2	2,14	221,0
HCP 05	0,9	2,3	0,2	0,7	0,2	2,9

It has been found that biologics based on actinomycetes can increase immunity and yield of oilseed flax. In this regard, it is possible to recommend *S. pratensis strain 15* in pure form and a consortium of *actinomycetes S. ambofaciens strain 40 + S. platensis strain 44 + Act. spp. strain 46* to create biologics, specifically for this culture.

CONCLUSIONS

Field tests have revealed the effectiveness of some actinomycete cultures that have a pronounced stimulating effect on the growth and development of safflower and oilseed flax.
It has been found that biologics based on actinomycetes can increase immunity and yield of oilseed flax. In this regard, it is possible to recommend *S. pratensis strain 15* in pure form and a consortium of *actinomycetes S. ambofaciens strain 40 + S. platensis strain 44 + Act. spp. strain 46* to create biologics, specifically for this culture.

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