

# The manifestation of diseases and phytophages of weeds associated with the cultivation of flax, the possibility of their use as biological plant protection agents

O.A. Savoskina, S.I. Chebanenko, I.A. Zavertkin, A.V. Shitikova\*, and N.A. Kudryavtsev  
Federal Scientific Center of Fiber Crops, Komsomolsky Avenue, 17/56, 170041, Tver, Russia

**Abstract.** Materials on the study of diseases and phytophages of weeds associated with flax cultivation and on the results of their use in biological plant protection are presented. It has been established that the developed biopreparation (a mixture of inoculum of smut / urocystosis / couch-grass (the disease causative agent - *Urocystis agropyri* / P./ S.) and rust /puccinia / yellow thistle (pathogen - *Puccinia suaveollens* /Pers./) - reduces the sowings contamination with these weeds. When sowing flax in regions new to this crop (for example, in the Tula region), phytophages unusual for this crop (for example, rapeseed flea) can significantly damage not flax, but cruciferous weeds. Studies have established that *Cirsium setosum* in flax sowings is often affected by a specific rust /puccinia / (pathogen - *Puccinia suaveollens* /Pers./ R. [= *P. obtegens* /Lk./ Tul.]), causing on average about 20% of cases of its destruction without the formation of seeds.

## 1 Introduction

In 2022, only 36.2 thousand hectares of Russian fields were sown with flax. Oilseed flax – about 1.5 million hectares. In addition to replacing imported cotton in the production of fabrics, explosives, rocket and torpedo fuel, flax is necessary for the workwear of astronauts, divers, military men [1]. Increasing the volume and efficiency of flax production in the Russian Federation is the most important task aimed at ensuring the strategic independence of the country. The solution of this problem is possible with the involvement of innovations.

In flax growing, as a rule, plant protection measures are necessary, which should ensure sufficiently healthy and weed-free sowings. They should form a full-fledged crop of flax products with the necessary quantitative and qualitative indicators [2].

The progress of flax growing in parallel with other branches of plant growing in the phytosanitary direction can be ensured by improving the quality and yield of products by reducing their losses due to various pathologies, damage, and clogging of cultivated plants. But, on the other hand, it is necessary to reduce the previously permissible environmental and hygienic risk of old phytosanitary measures (obviously, by modernizing the integrated

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\* Corresponding author: [plant@rgau-msha.ru](mailto:plant@rgau-msha.ru)

plant protection system while maintaining and using self-regulation mechanisms of agrobiocenoses.

Biologization of the approach to the problem apparently begins with scientifically based: phytosanitary monitoring, prognosis, phytopathological, entomological, and herbological objective assessment of the situation. Regarding flax growing, our research carried out in the past years is a priority in this direction [2; 3].

Prior to the beginning of our work, research on biological plant protection practically did not apply to flax growing, although there was a high demand for the use of biometod in this crop production branch. Immunological and breeding work with flax also needed development. Thus, the scientific novelty and relevance of our experiments are obvious.

The purpose of our research work is to study the diseases and phytophages of weeds associated with the cultivation of flax, the possibilities of their use in biological plant protection.

## 2 Materials and Methods

Field experiments were conducted in 2017-2019 on the basis of the Flax Institute (since 2018 SD FRI FSBSI FSC FC) in the Torzhok district of the Tver region.

Experiments on the development of biological flax protection measures were carried out in accordance with the classical methodological recommendations on biological and agricultural sciences [4].

The priority search object of the tests was a new biological product being developed by us with, presumably, herbicidal and protective-stimulating properties: a mixture of smut / urocystosis/ couch-grass and rust / puccinia / yellow thistle spores.

The objects of research are weeds with their diseases and phytophages associated with flax sowings: – significantly manifested in 2017-2019 - yellow thistle /soft thistle/ (*Cirsium setosum* M.B. / = *C. arvense* var. *mite* Wimm. et Grab. / = *C. arvense* var. *setosum* Koch./), purposefully infected by us with rust / puccinia/ (pathogen - *Puccinia suaveollens* /Pers./ (Figure 1); - dominant wheatgrass (*Elytrigia repens* P. B.) - a problematic plant for flax growing, against which we are developing chemical and biological control measures, in particular, the use of smut damage caused by the fungus *Urocystis agropyri* /P./ S. (Figure 2).



**Fig. 1.** *Cirsium setosum*, affected by *Puccinia suaveollens*.



**Fig. 2.** *Elytrigia repens*, affected by *Urocystis agropyri*.

One-factor experiment, 4 options:

- 1 - Control (without treatment of seeds and sowings),
- 2 – Standard (herbicides: Cortes (0.005 kg/ha) + Harmony (0.01kg/ha) + Targa Super (1.5 l/ha)),
- 3 - Biopreparation: *U. adgorugi* and *P. suaveollens* (1:1; 0.1 kg/ha) + Cortes (0.005 kg/ha) [according to *U. adgorugi* and *P. suaveollens* seed treatment background (1:1; 0.1 kg/t)],
- 4 - Biopreparation: *U. adgorugi* and *P. suaveollens* (1:1; 0.1 kg/ha) [according to *U. adgorugi* and *P. suaveollens* seed treatment background (1:1; 0.1 kg/t)]

It is laid in 3-fold repetition, the placement of options is systematic.

The accounting of weeds in linen flax sowings was carried out in 3 periods: 1 – 3 days before the use of plant protection products (in the linen phase - "herringbone"), 2 – 30 days after the treatment of sowings, and 3 – before harvesting crops by quantitative-specific (1 accounting) and quantitative-weight methods (2 and 3 accountings). A square frame with a side of 50 cm (S = 0.25 m<sup>2</sup>) was used for accounting.

### 3 Results

During the 1st accounting, the number of weeds in all variants exceeded the economic threshold of harmfulness by an average of 2.9 times and fluctuated in the range of 68...86 pcs/m<sup>2</sup>.

Before the use of biological and chemical herbicides, the flax sowings in the "herringbone" phase were clogged with weeds typical of the fields of the 1st zone of sod-podzolic soils with a predominance of *Elytrigia repens* (couch-grass) and *Cirsium setosum* (yellow thistle) (Table 1).

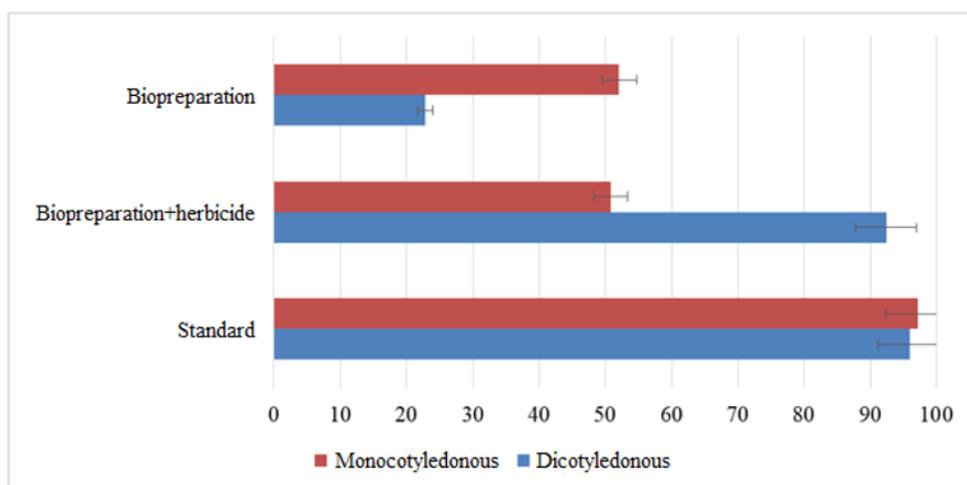
**Table 1.** Count of weeds (pcs/m<sup>2</sup>) depending on the application of biological and chemical herbicides.

Types of weeds	Before the treatment with plant protection products				30 days after the treatment of sowings			
	Contr ol	Stand ard	Biopr eparat ion + herbic ide	Biopr eparat ion	Contr ol	Stand ard	Biopr eparat ion + herbic ide	Biopr eparat ion
<i>Chenopodium album</i>	1	1	1	2	-	-	1	-
<i>Polygonum convolvulus</i>	-	1	-	-	2	-	-	-
<i>Polygonum aviculare</i>	-	1	-	-	-	-	-	-
<i>Galeopsis, spp</i>	3	-	-	1	2	-	-	-
<i>Viola arvensis</i>	3	5	2	6	6	-	-	2
<i>Thlaspi arvense</i>	2	2	8	3	-	-	-	-
<i>Matricaria inodora</i>	3	3	-	3	-	-	-	-
<i>Fumaria officinalis</i>	1	-	-	1	-	-	-	-
<b><i>Cirsium setosum</i></b>	10	-	-	1	16	-	-	-
<i>Capsella bursa-pastoris</i>	3	9	12	12	7	-	-	-
<i>Symphytum asperum</i>	2	2	7	2	-	-	-	-
<i>Silene latifolia</i>	4	10	8	5	6	-	-	-
<i>Stellaria media</i>	5	3	7	2	-	-	-	-
<i>Mentha arvensis</i>	4	7	6	4	-	2	-	-
Other	31	22	24	25	-	-	-	2
<i>Veronica agrestis</i>	-	-	-	-	26	4	11	6
<i>Gnaphalium uliginosum</i>	-	-	-	-	6	-	-	-
<i>Glechoma hederacea</i>	-	-	-	-	-	9	4	-

<b>Total dicotyledonous:</b>	<b>72</b>	<b>66</b>	<b>75</b>	<b>67</b>	<b>71</b>	<b>15</b>	<b>16</b>	<b>10</b>
<b>Elytrigia repens</b>	9	1	4	1	15	3	5	-
Echinochloa crus-galli	1	-	-	1	9	10	14	26
Poa annua	4	1	3	3	6	-	2	-
<b>Total monocotyledonous:</b>	<b>14</b>	<b>2</b>	<b>7</b>	<b>5</b>	<b>30</b>	<b>13</b>	<b>21</b>	<b>26</b>
<b>Total count</b>	<b>86</b>	<b>68</b>	<b>82</b>	<b>72</b>	<b>101</b>	<b>28</b>	<b>37</b>	<b>36</b>

30 days after the treatment of sowings, there was a decrease in the abundance of the weed component of the linen flax agrophytocenoses according to the options for the use of plant protection products with their effectiveness of 60.9% on average for the studied options.

A more significant effect of the applied plant protection products was noted in relation to the reduction of weed biomass (Figure 3).



**Fig. 3.** Herbicidal effect of the studied plant protection products (% of reduction in weed mass).

In the control option, the biomass of weeds was 237 g/m<sup>2</sup> and 258 g/m<sup>2</sup> of dicotyledonous and monocotyledonous plants, respectively.

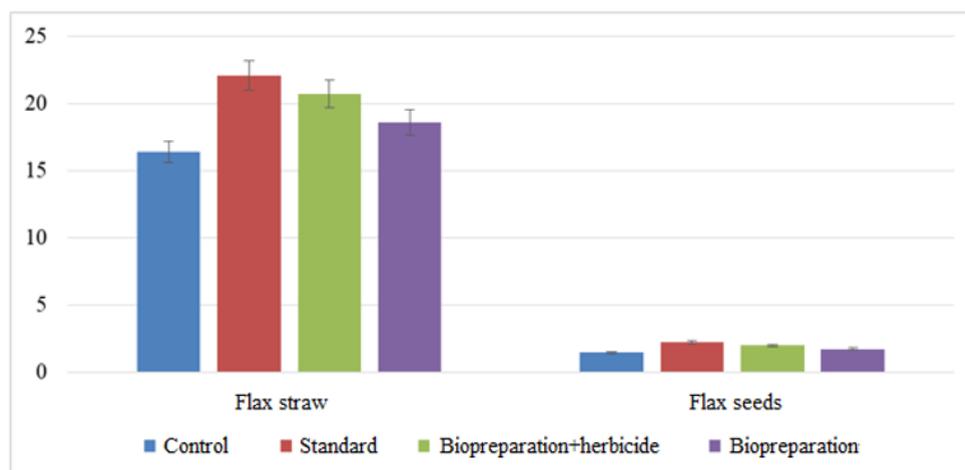
Before harvesting linen flax, changes occurred in the structure of agrophytocenoses (Table 2).

**Table 2.** Quantitative and specific composition of the weed component in agrophytocenoses of linen flax before harvesting, pcs/m<sup>2</sup>.

Types of weeds	Control	Standard	Biopreparation + herbicide	Biopreparation on
Chenopodium album	3			
Polygonum convolvulus	2			1
Polygonum aviculare	1			
Galeopsis, spp	14			
Viola arvensis	9			
Thlaspi arvense	3			
Matricaria inodora	4			
Fumaria officinalis	2		1	

<b>Cirsium setosum</b>	22			1
Capsella bursa-pastoris	9			2
Silene latifolia	1			
Stellaria media	25			1
Mentha arvensis	5			
Other	7			
Veronica agrestis	30		5	5
Gnaphalium uliginosum	2			
Glechoma hederacea	6			
<b>Total:</b>	<b>145</b>	<b>0</b>	<b>6</b>	<b>10</b>
<b>Elytrigia repens</b>	17	-	8	5
Echinochloa crus-galli	9	3	8	25
Poa annua	8	1	1	10
<b>Total:</b>	<b>34</b>	<b>4</b>	<b>17</b>	<b>40</b>
<b>Overall</b>	<b>179</b>	<b>4</b>	<b>23</b>	<b>50</b>

The use of biopreparation based on infection of weed diseases and the herbicide Cortes (in a reduced rate of use) positively (compared with the control) affected the yield of flax products (Figure 4).



**Fig. 4.** Yield of flax products, c/ha

## 4 Discussion

In agrobiocenoses associated with flax cultivation, as in communities of organisms, there are weeds, phytopathogens and phytophages, traditionally defined as “harmful organisms”, but they have complex, multi-valued relationships. Weeds, in addition to competing with cultivated plants for the elements of fertility, moisture, and light, also have indirect harm, since they are reserves of harmful objects – diseases. *Centaurea cyanus*, *Vicia* spp., etc. are naturally affected by *Ozonium vinogradovi* and contribute to the spread of infection and the

pathology development on flax plants. On weeds, the disease symptoms manifest in the same way as on crop: blood-red strokes and spots form on seed seedlings. Severe infestation of *Ozonium vinogradovi* leads to the death of weeds. In addition to ozoniosis, both on flax and on many types of weeds, aureobasidiosis / polysporosis/ (the disease causative agent is *Aureobasidium pullulans* f. Lini /Arnaud./Cooke), and rhizoctoniosis (the causative agent is *Rhizoctonia solani* Kuehn., syn. *Rh. violaceae* Tul. pr. hfrt.).

Obviously, a positive role for flax growing will be played by diseases that manifest only on weeds. Of these, directly in flax crops, we have repeatedly diagnosed smut (urocystosis) on *Elytrigia repens* (caused by the fungus *Urocystis agropyri* /P./S.), characterized by the formation of black /sometimes black-brown/ short pustules on its leaves. At first, they merge under the epidermis, and after the latter is torn, the smut chlamydospores (in suroses of 2, rarely 3-4 pcs., black-brown, angular, 10-12 microns in diameter) spill out. Some specimens of couch-grass plants died due to severe smut damage (complete destruction of plant tissues).

*Cirsium setosum* in flax sowings, as noted in our studies, is often affected by a specific rust/puccinia/ (pathogen - *Puccinia suaveollens* /Pers./R. [= *P. obtogens* /Lk./ Tul.]), causing on average about 20% of cases of its destruction without the formation of seeds.

*Capsella bursa-pastoris* is infected with an infection of the so-called white rust /cystopuosis/ (spores of the fungus *Cystopus candidus* Pers. /=*Albugo candida* /), diagnosed as hypertrophy of the affected tissues, covered with white shiny powdery pads. The conidia of the pathogen are rounded, 12-18 microns in diameter. The oospores in the affected tissues are spherical,  $\approx$  30-50 microns.

The study of weed diseases in flax crops in the future has become our priority, which is of interest as a possibility of biological control of crop blockages. Preliminary experiments on its implementation (related to artificial infection of unwanted vegetation) gave encouraging results [6, 7].

Spraying flax sowings in the “herringbone” phase with a composition of herbicides: Cortes (0.005 kg/ha) + Harmony (0.01 kg/ha) + Targa Super (1.5 l/ha) provided biological efficacy against dicotyledonous and cereal weeds (by reducing their weight 30 days after application) at the level of 59.4 and 62.3%, respectively.

Treatment of experimental plots with a combination of infection of weed diseases (*U. adgorugi* and *P. suaveollens* /1:1; 0.1 kg/ha) and the herbicide Cortes (0.005 kg/ha) (according to the background of U. and P. seed treatment) was effective against cereal weeds by 50.8%. The effect on *Elytrigia repens* was probably provided by an infection of the pathogen of the couch grass smut – *U. adgorugi*. Against dicotyledonous weeds, the combination of the developed biological product with a herbicide in a reduced rate of use was effective by 92.4%. These indicators, apparently, are the result of the combined action of the herbicide Cortes and the infection of thistle rust – *P. suaveollens*.

Without combination with herbicide – created biological product: U. adgorugi and P. suaveollens (1:1; 0.1 kg/ha) [according to the background of *U. adgorugi* and *P. suaveollens* seed treatment (1:1; 0.1kg/t)] - acted on cereal weeds (mainly on *Elytrigia repens*) with an efficiency of 52.1%. The weight reduction of dicotyledonous weeds (mainly *Cirsium setosum*) in this variant was 22.8%.

Insect pests, in particular the large flax flea beetle (*Aphthona euphorbiae* Schr., adequate to the Latin - Russian name of the species - *Aphthona Euphorbiaceae*), feed not only on cultivated, but also clogging plants. Damage to the named insect was noted on the seedlings of dish mustard and other dicotyledonous weeds. At the same time, the insect spreads the infectious onset of diseases not only of flax, but also of weeds, which indicates the reality of the phenomenon of self-regulation of agrobiocenoses.

When sowing flax in regions new to this crop (for example, in the Tula region in 2018), we did not see specialized pests of this crop. On flax seedlings, mainly cabbage stem flea beetle (*Psylloides chrysocephala* L.) was observed, a type of flea common in rapeseed

cultivation regions. Their density on the shoots of oilseed flax reached 20 beetles/m<sup>2</sup>. Considering that the size of a cabbage stem flea beetle is 2-3 times larger than a large flax flea beetle, this made a frightening impression. Nevertheless, this new phytophagus for us practically did not damage flax, unlike *Aphthona euphorbiae*, significant damage to which we have repeatedly seen on flax sowings in the regions traditional for this crop - in the Tver, Smolensk, and other regions of the Russian Federation (Figure 5).



**Fig. 5.** On the left - almost absence of damage to flax seedlings in the presence of *Psylloides chrysocephala* L. (cabbage stem flea beetle) (Tula region), on the right - damage with *Aphthona euphorbiae* Schr. (large flax flea beetle) of cotyledonous flax leaves on a control plot of sowings (Tver region).

The cabbage stem flea beetle fed on plants of *Raphanus raphanistrum*, *Thlaspi arvense*, *Capsella bursa-pastoris*, rapeseed drops, etc., polluting flax crops, i.e. it played a positive role (an agent of a kind of biometode limiting the flax clogging).

## 5 Conclusion

The biopreparation we are developing (a mixture of smut inoculum /urocystosis/couch-grass and rust /puccinia / yellow thistle - reduces the contamination of sowings with these weeds. When sowing flax in regions new to this crop, phytophages unusual for this crop (for example, cabbage stem flea beetle) can significantly damage not flax, but cruciferous weeds.

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