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Herbological and agrotechnological approaches to weeding plants in modern flax growing

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ABSTRACT

The article presents the main trends of weed floristic composition change in flax crops, associated with the development of agrotechnical methods of this crop cultivation. It is shown that the development of scientific and technical support for the flax industry contributes to a more complete satisfaction of culture with all factors of life and enhances its competitive ability. So, the phytocenotic role of many segetal weeds present in crops decreases, up to their complete loss from agrophytocenosis. They considered the actual weediness of flax crops and the biological effectiveness of various preparations and their compositions to prevent weeds.

Keywords: Herbicide, Growth regulator, Fungicide, Flax, Yield increase, Efficiency.
Article type: Research Article.

INTRODUCTION

Contamination of cultivated plant crops with unwanted flora is one of the ancient problems in the history of human civilization. Weeds ("thorns and thistles"), their spontaneous growth, which complicates the work of farmers, is "the punishment to Adam and Eve for the Fall" according to the Old Testament story (bibliya-online.ru). So far, the degree of overgrowth of many agricultural lands and industrial territories of Russia with herbaceous and tree-shrub unwanted vegetation increases from year to year. It is appropriate to recall the prophetic biblical warning to idle, careless people - "thorns and thistles will grow on the earth and on the ruins of the cities that are now enjoying themselves" (bibliya-online.ru).

The pattern of segetal plant development is closely associated with the development of agricultural technologies (Tilman 2001; Baessler & Klotz 2006; Heller *et al.* 2008; Mankowsk *et al.* 2013; Gaba *et al.* 2014). The need to limit the spread of unwanted vegetation in agricultural crops is evident and is primarily related to the increased phytocenotic role of weeds (Liebman & Dyck 1993; Cardina *et al.* 2002). There are several reports about plant diversity around the world (Ameri Siahouei *et al.* 2020; Abolhasani *et al.* 2021; Omidipour *et al.* 2021) It is especially important to do this in flax growing, which is almost impossible without protection from weeds. In some cases, weeds are not only dangerous, but also aggressive, being a symbol of destruction and death. Observations of weed life allow us to be convinced of the deep meaning of the biblical "spread of thorns is the retribution for the sins of men." There is more than enough unwanted vegetation on our agricultural lands and industrial territories, and the anthropogenic factor continues to contribute to their growth (Savoskina *et al.* 2020). For example, pollution of nature and habitat is detrimental to many plants (this is noted in the growth deterioration of junipers and mosses, for example), and for some types of weeds, it seems to create favorable conditions. The destructive manifestation of the giant hogweed for the whole nature of Russia is especially metaphorical - "like a fiery hell." The extraordinary vitality (speed of growth and aggressive spread) of some types of unwanted vegetation is striking, reaching colossal parameters in the case of the hogweed. The seeds of many weeds can remain viable for many years. Therefore, the purpose of our research was to study the nature of weed species changing course in agrophytocenoses during the intensification of flax growing.

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MATERIALS AND METHODS

The studies of weeds in fiber flax crops were carried out in the experimental fields of FSFRI 'Federal Scientific Center for Bast Crops' in the Torzhok region and in production conditions on the basis of peasant farms located in the Tver and Smolensk regions. Weed plants were counted by the quantitative-specific method, by imposing a frame with the area of 0.25 m2. The number of stations was determined by the area of the surveyed territory.

RESULTS AND DISCUSSION

When the acreage of fiber flax (back in the USSR) was annually more than a million hectares and weed control measures were not very effective, specialized weeds ("weed satellites") were associated with this crop: a parasitic flowering plant - flax dodder (*Cuscuta epilinum* Weiche.); annual cereal - hardy ryegrass (*Lolium linicola* A. et Br. = *L. remotum* Schrank.); dicotyledonous annual weeds: knotweed linseed "bun" (*Polygonum linicola* Sutulow. = *Persicaria linicola* [Sutul.] Nenjuk.), flax pea spurry (*Spergula linicola* Boreau.), flax camelina (*Camelina linicola* Sch. et Sp. / = *C . alyssum* [Mill.] Thell.) and its variety (*C. sub-linicola* N. et Zing.), linseed mustard (*Sinapis dissecta* Lag.), linseed bedstraw (*Galium spurium* L.), and linseed corncockle (*Agrostemma linicola* Terech). Specialized fiber flax weeds demonstrate an adaptive evenness of populations within a development similar to this crop. In the past, the unintentional selection of specialized forms of flax-infesting plants took place in connection with sheaf harvesting. For example, the populations of flaxseed knotweed (*Polygonum linicola*) species were characterized then by a loss of self-fertilization, with adherent fruits, while in dock-leaved persicaria (*P. scabrum* Moench.), a related species, the fruitlets were segmented and could easily crumble. This gave the knotweed linseed the opportunity to be removed from the field and threshed together with flax in sheaves, i.e., to litter the seeds of this culture systematically. In the 70 decade of the last century, with the transition to a combine technology for flax harvesting with stripping of its seed pods on the vine, this advantage of *P. linicola* became less important and its distribution in flax crops decreased. Besides, the progress of seed cleaning contributed to seed infestation decrease. It is known that sowing of flax seeds without thorough cleaning promotes the spread of infesting plant species. During the cleaning of seeds practiced in previous years according to the coefficient of their sailing capacity, we noted the inappropriate selection of weed forms most adapted to this event. During this selection, for example, flax chaff (*Lolium linicola*) was selected unintentionally, which was one of the most widespread specialized flax weeds. Using the properties of a greater roughness of chaff seeds in comparison with (SCM) that separates (more precisely, “sweeps out”) chaff from flax seeds with soft, fleecy, rotating brushes (Erugin *et al.* 2001). Note that the word "chaff" is borrowed from the Church Slavonic language. The Russian word "polovel" corresponds to it. It is associated with the verb "to weed", that is, "to destroy the chaff." We see a certain correspondence of the agro-technological process (weeding) to Biblical parables. For example, the Gospel of Matthew tells about weeds, "tares": weeds ("tares") sprout in the field together with wheat, to the surprise of the workers, because the seed was good. However, the seeds of flax chaff were sown mainly together with flax seeds. Similarly, flax seeds (*Cuscuta epilinum*) with a coarsely pitted rough surface are sown in the field together with flax seeds (if they are not cleaned) (Shutova 1980). They also can be swept out of flaxseeds with the soft, fleecy, rotating brushes of SCM. This cleaning of seeds is progressive and preferable in a sanitary and hygienic respect, because previously, dodder seeds were separated from flax seeds using electromagnetic machines (for example, EMC-1) and magnetic powder, which is hazardous to human health (Erugin *et al.* 2001). Probably due to the success of modern seed cleaning and biological characteristics of some specialized flax weeds (for example, poor preservation of Lolium linicola and Cuscuta epilinum seed viability) their premature germination and death, which got into the soil much earlier than flax seeds, is much less frequently than in the last century. They began to be found in the crops of flax culture. This was facilitated by the tendency to increase the effectiveness of the applied herbicides (if the old herbicides based on MCPA / 2M-4X / reduced the weight of weeds in flax crops by 40-50%, then modern sulfonylureas are at the level of 90% and a significant decrease of fiber flax cultivation areas (Kudryavtsev *et al.* 2017; Kudryavtsev & Zaitseva 2018). Now Russian fields sown with fiber flax are more often littered with “cosmopolitan” plants, which are not specialized for this crop, but typical for the existing crop rotations (or their absence). Perennial weeds are common in the fields with a low level of agricultural technology. Creeping wheatgrass (*Elytrigia repens* Nevski.) reduces the yield and quality of products considerably, the harmfulness of which is manifested not only in the suppression of cultivated plant crops, but also in spoiled fibrous products (since wheatgrass stems are difficult to separate from flax stems during the processing of retted stalks). Bottle brush (*Eguisetum arvense* L.), rarely meadow horsetail (*E. pratense*

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Ehrh.) or forest horsetail (*E. silvaticum* L.), which also belong to perennial rhizome weeds, are more common on poorly cultivated acidic soils. Perennial root-sprouting dicotyledonous weeds: yellow thistle (*Cirsium setosum* Willd. Bess.), field milk thistle (*Sonchus arvensis* L.), field sorrel (*Rumex acetosella* L.), bitter winter cress (*Barbarea vulgaris* R. Br.), wild purslane virgate (*Euphorbia virgata* W. et K.), willow-tea, rosebay willowherb (*Epilobium angustifolium* L.), lesser bindweed (*Convolvulus arvensis* L.), bastard toadflax (*Linaria vulgaris* Mill.) litter most of all the flax sown after insufficiently intensive development of a layland. Infestation by annual spring dicotyledons is characteristic for the developed typical fields of fiber flax in Russia: corn spurrey (*Spergula arvensis* L.) and large spurrey (*S. maxima* L.); dawny hemp nettle (*Galeopsis tetrahit* L.), common hemp nettle (*G. speciosa* Mill.); Henbit Dead-nettle (*Lamium amplexicaule* L.), white dead nettle / white deadly / (*L. album* L.), spotted dead nettle (L. *maculatum* L.); climbing buckwheat (*Poligonum convolvulus* L.), dock-leaved persicaria (*P. scabrum* Moench.); lambsquarter goosefoot (*Chenopodium album* L.), oak-leaf goosefoot (*Ch. glaucum* L.), allseed (*Ch. polyspermum* L.), maple-leaved goosefoot (*Ch. hybridum* L.); winterweed / starweed / (*Stellaria media* Cyr.), easter-bell (*S. holostea* L.). There are other plant species in such fields, where the development cycle lasts one growing season. Wintering plants growing on flax fields appear as spring weeds: the species of chamomile - common (*Matricaria chamomilla* L. and odorless (*M. inodora* L.); the species of button - field (*Antemis arvensis* L.) and stinky (*A. cotula* L.); field pennycress (*Thlaspi arvense* L.); common shepherd's purse (*Capsella bursa-pastoris* [L.] Medik.); A kind of tricolor violet "pansies" (*Viola tricolor* L.) can be represented in two forms - *V. t. Vulgaris* Koch. and *V. t. Arvensis* Koch.; Blue cornflower (*Centaurea cyanus* L.); several species of vetch - tufted vetch (*Vicia cracca* L.), wild vetch (*V. angustifolia* Reichard.), tare milk vetch (*V. hirsuta* [L.] S. et F.), - downy vetch (*V. villosa* Roth.). A variant of the weed species composition and their specific abundance in flax crops of one of the experiments of the FSBSI FNTs LK OP Torzhok (2018-2020) without the use of herbicides is illustrated in Table 1. They identified grain and mainly dicotyledonous plants, typical for the fields of the Tver region and many other regions of Russia. In 2018-2020 their total density on the plots of the control variant at the beginning and at the end of the growing seasons made 70 and 120 stems m^{-2} respectively. In addition to them, bottle brush appeared - 3 and 8 stems m^{-2}. These and some other types of plants that infest agricultural land, in particular, flax crops, were studied by us together with the colleagues from other scientific institutions. Taking into account our experience with the use of herbicides on fiber flax against most of the above species of dicotyledonous weeds, we used the herbicides based on the active ingredient - thifensulfuron-methyl, WDG - 750 g kg^{-1} (25 g ha^{-1}). For enhanced herbicidal action against root-sprouting perennial dicotyledonous weeds we used a mixture of thifensulfuron-methyl, WDG - 750 g kg^{-1} (20 g ha^{-1}) + clopyralid, WS - 300 g L^{-1} (0.3 L ha^{-1}). Since there were also cereal weeds and bottle brush in the crops, a triple composition of herbicides was used in an additional version (which turned out to be the most effective) - thifensulfuron-methyl, WDG - 750 g kg^{-1} (20 g ha^{-1}) + clopyralid, WS - 300 g L^{-1} (0.3 L ha^{-1}) + haloxyfop-P-methyl, EC - 104 g L^{-1} (0.7 L ha^{-1}). The herbicidal effect of various applications of the studied preparations is illustrated in Table 2. They established the effect of various agents and their mixtures on the most common types of undesirable vegetation in the experimental sowing of flax. The preparations based on thifensulfuron-methyl produced in the USA and the Russian Federation (25 g ha^{-1}) 30 days after application (when spraying during the flax herringbone phase) showed the biological effectiveness of flax protection from weeds at the level of 93%. A mixture of a domestic drug with this application rate at a reduced consumption rate (20 g ha^{-1}) with a drug based on clopyralid (0.3 L ha^{-1}) - 96.3%. The addition to the above-mentioned anti-Dicotyledon herbicides - graminicide based on haloxyfop-P-methyl, EC - 104 g L^{-1} (0.7 L ha^{-1}) - increased the efficiency of weed weight reduction to 97.7%. In the Tver region, the contamination of fiber flax crops by Sosnovsky hogweed (*Heracleum sosnowskyi* [L.] Manden) often began to appear, sometimes significant even after the treatment of the crop field with herbicides containing glyphosate, as it was in the crops of one of our experiments within a production environment (Fig. 1).

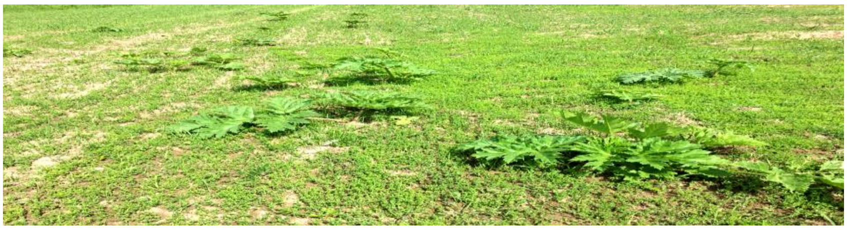

Fig. 1. Clogging of flax sowing by hogweed plants during the "herringbone" phase (after treatment of the crop field with a herbicide containing glyphosate).

Table 1. Species composition and number of weeds in flax crops on the plots of the control variant (on average during 2018-2020).

Plant species	Amount (pcs./m^2)	
	1 (flax herringbone phase)	**2 (prior to harvesting)**
Couch grass (*Agropirum repens* L. = *Elytrigia repens* Nevski.)	4	8
Prickly grass (*Echinochloa crus galli* P.B.)	2	5
Other types of cereal plants	3	6
Cereals total	**19**	**39**
Sandweed (*Spergula arvensis* L.)	22	24
Lambsquarter goosefoot (*Chenopodium album* L.)	6	11
Dawny hemp nettle (*Galeopsis tetrahit* L.)	4	5
Climbing buckwheat (*Poligonum convolvulus* L.)	3	9
Common camomile (*Matricaria chamomilla* L.)	3	6
Shepherd's-purse (*Capsella bursa-pastoris* [L.] Medik.)	2	2
Pin grass (*Erodium cicutarium* [L.] Herit.)	2	4
Corn pansy (*Viola tricolor* L. /*V. t. arvensis* Koch./)	2	4
Yellow thistle (*Cirsium setosum* /Willd./ Bess.)	2	7
Field milk thistle (*Sonchus arvensis* L.)	2	5
Other types of dicotyledonous plants	3	3
Dicotyledons total	**51**	**81**
Bottle brush (*Eguisetum arvense* L.)	3	8
Weeds total	**73**	**128**
HCP_{05}	1	2

Table 2. Herbicidal efficacy of various drugs and their compositions on average for 2018-2020 (dicotyledonous, cereal weeds and bottle brush weight decrease 30 days after the treatment of crops).

Item №	**Option name (crop treatment)**	**Weight (g m^{-2})**	**Efficiency (%)**
1	Control (without processing)	284,7	-
2	Standard - thifensulfuron-methyl, USA, WDG - 750 g kg^{-1} (25 g ha^{-1})	19,9	93,0
3	Thifensulfuron-methyl, RF, WDG - 750 g kg^{-1} (25 g ha^{-1})	19,9	93,0
4	Thifensulfuron-methyl, RF, WDG - 750 g kg^{-1} (20 g ha^{-1}) + clopyralid, RF, WS - 300 g L^{-1} (0.3 L ha^{-1})	10,4	96,3
5	Thifensulfuron-methyl, RF, WDG - 750 g kg^{-1} (20 g ha^{-1}) + clopyralid, RF, WS - 300 g l^{-1} (0.3 L ha^{-1}) + haloxyfop-R-methyl, RF, EC - 104 g L^{-1}(0.7 L ha^{-1})	6,6	97,7
	HCP_{05}	0,4	0,1

The herbicide based on MCPA (2M-4X) applied against hogweed and other weeds during the flax herringbone phase turned out to be insufficiently effective (Fig. 2 (A)).

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A Б

Fig. 2. A - Weediness of flax crops after application of the herbicide based on MCPA, Б - the effectiveness of the applied mixture of sulfonylurea herbicide and clopyralid based preparation.

The mixture of sulfonylurea herbicide and clopyralid based preparation was much more effective (in this variant, almost uncontaminated sowing of flax was observed (Fig. 2 (Б)).

SUMMARY

The presented review of the dominant species of weed change in flax crops depending on biotic and abiotic factors over several decades allows us to note the peculiarities of changes in the composition of flax agrophytocenoses, which makes it possible to systematize the data obtained and use them in practice.

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