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Eco-friendly methods of protecting flax against weeds

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Abstract: In cultivation of fibre flax the main yield is the fibre yield. This raw material, owing to its „processing-using" properties, belongs to so called eco-fibres or green fibres. Thus, development of eco-friendly (also "plant-friendly") technologies of using pesticides (including herbicides) seems necessary.
Protection of flax plantations against weeds should combine efficiency and eco-friendly system of applying herbicides. Research done at the Institute of Natural Fibres in Poznań was focused on these issues. The green technologies of protecting flax against weed infestation comprise:

- Reducing the doses of chemical herbicides by using adjuvants, especially based on natural plant oils (e.g. Lenmix 800 EC contain flaxseed oil);
- Reducing herbicide doses by precise time of the treatment;
- Applying repeated treatments with lower doses of herbicides (split application);
- Precise application based on the analysis of weed infestation on field – the map of weed distribution;
- Rotation of herbicides.

Such a system allows for maintaining soil fertility, lowers environmental pollution and keeping pro-healthy properties of flax fibre.

Keywords: fibre flax, weeds, pro-ecological weed control

INTRODUCTION

Flax, due to the variety and importance of raw materials derived from it, is a significant plant in terms of sustainable development of agriculture and industry [1, 2]. Flax fiber serves as a valuable material for textile industry. Linen fabrics and knitwear are characterized by good healthy, hygienic and esthetic value. Linen products can inhibit bacterial growth and provides optimal microclimate in the

"skin-clothing" area. Pro-healthy properties of linen include also maintaining proper thermoregulation and preventing accumulation of electrostatic charges on clothing surface [3-5]. Due to all these properties flax fiber is considered as one of "eco-fibers". Moreover, non-textile uses of flax is gaining on importance. As a renewable resource it finds application in, for example, pulp and paper, automotive and building industries.

The above-mentioned ecological features of flax derived materials oblige to use green technologies of cultivation and processing.

Usable value of flax yield is very much influenced by weed infestation of plantations. Too high weed density and mass result in lowering straw and seed yields, reducing fibre content in stems and worsening the fibre quality (lower fineness, lower tenacity, and worse divisibility).

Eco-friendly methods of weeds control on flax plantations should be based on relatively smallest herbicide doses while maintaining their proper efficiency [6, 7].

MATERIALS AND METHODS

The studies were based on field experiments, where lower rates of herbicides were applied in order to develop ecological methods of plant protection in flax cultivation. The possibility of reducing the herbicide doses by earlier than recommended application – i.e. to younger and more susceptible weeds (field experiments conducted in 1997-1999) or with the use of adjuvants which enhance the effectiveness of herbicides (years 2003-2005). The experiments were set in a complete randomized block system with four replicaties on Experimental Stations (ES) of the Institute of Natural Fibres (Białobrzezie, Bukówka and Stary Sielec). Area of plots was 12 m^2. Flax was sawn in a second half of April. Sowing rate was 120 kg/ha. Plant spacing – 10 cm. In performed trials, plot sprayer was used. Spray pressure was 0.2 bar and spray volume was 200 l/ha.

The weed control was evaluated visually comparing weed biomass on each plot treated by the herbicide with suitable check plot.

Visual assessment of fiber flax susceptibility to applied herbicides was performed. All possible symptoms of crop damage were included: growth modifications (plant height, tillering, time of following growth stages), plant thinning, color modifications, necroses, deformations. The intensity of damage symptoms were presented in 1-9 grade scale, where 1 – no symptoms of phytotoxicity, 9 – total plants damage).

RESULTS AND DISCUSSION

The herbicides recommended for flax belong to the class IV of toxicity to humans and bees; i.e. they are little harmful for humans and practically harmless for bees. Unfortunately they are usually harmful for algae (toxicity class I or II) and little less harmful for fish (toxicity class II-IV).

The research carried out at the Institute of Natural Fibres is based on environmentally-friendly technologies of herbicides application in fibre flax on the following principles:

- optimal time of application – low herbicide doses,
- adjuvant application,
- herbicides mixtures,
- rotation of herbicides,
- application of herbicides according to the map of weed distribution in the field (precise treatments).

Reducing the herbicide doses by earlier treatment

The optimal time for applications of post emergent herbicides is BBCH 12-14 stage of flax, i.e. when flax is 6-12 cm tall. In this stage of growth leaves of flax are set at sharp angle to the stem and covered with a thick layer of wax. This prevents the spray to stick on the crop.

Rather important in flax cultivation are the sulfonylurea herbicides mainly Glean 75 WG and Chisel 75 WG. These are applied mainly due to physiological and metabolic resistance of the crop because flax can detoxify the herbicides. This type of selectivity offers application of herbicides to a wide range of time limits, when plants are 5-20 cm tall. This is important since the time of application of a herbicide may be earlier, when weeds are more susceptible to herbicides and this enables the reduction of herbicide doses (Table 1).

Table 1. The effect of time application on herbicide efficacy (ES Bukówka, ES Sielec Stary 1997-1999 average from 2 field trials)

No.	Herbicides [g ha^{-1}]	Time of herbicide application – height of flax plants [cm]	Broad-leaved* biomass control [%]	Flax susceptibility to herbicides**
1	Glean 75 WG [10]	5	86	1
2	Glean 75 WG [15]	12	88	1
3	Chisel 75 WG [30]	5	83	1
4	Chisel 75 WG [40]	12	84	1

* broad-leaved weed species dominating in the field trials: *Chenopodium album* L., *Falllopia convolvulus* (L.) Love, *Viola arvensis* Murr., *Lamium amplexicaule* L. *Thlaspi arvense* L.,

** according to 1-9 grade scale, where: 1 – no injury, 9 – total damage

Lowering herbicide doses by using Lenmix 800 EC adjuvant

Composition of Lenmix 800 EC

Lenmix 800 EC is a new adjuvant formulated at the Institute of Natural Fibers. The Lenmix 800 EC contains: 80% raw linseed oil, 10% non-ion surfactant, 6% cation surfactant – A, 4% cation surfactant – B (Table 2).

Table 2. Composition of Lenmix 800 EC

Lp.	Component	% share in the formulation
1	Flaxseed oil, raw	80
2	Tegitol 15-S-9 (non-ion surfactant)	10
3	Hydroxy-alkilo-dimethylo polyoxyethylene (cationic surfactant - A)	6
4	Ethomeen T/25 (cationic surfactant - B)	4

Physico-chemical properties of Lenmix 800 EC

The highest decrease of surface tension was observed when Lenmix 800 EC was applied with Glean 75 WG. The addition of Lenmix 800 EC to the spraying liquid containing the Glean 75 WG herbicide reduced the surface tension from 69.08 mN/m to 30.4 mN/m. Some physicochemical properties of Lenmix 800 EC adjuvant are presented in Table 3.

Table 3. Surface tension of spraying liquids containing herbicides alone or mixed with adjuvants

Objects	Rate/ha	Mean amount of drops	Surface tension [mN/m]
H_2O	-	30	72.53
Linen oil	-	82	31.84
Glean 75 WG	15 g	31.5	69.08
Glean 75 WG + Lenmix 800 EC	12 g + 1 l	67.5	32.24
Glean 75 WG + Lenmix 800 EC	12 g + 1.5 l	71.5	30.43
Perenal 104 EC	1.25 l	91	23.91
Perenal 104 EC + Lenmix 800 EC	1.0 l + 1.0 l	98	22.20
Perenal 104 EC + Lenmix 800 EC	1.0 l + 1.5 l	105	20.72
Targa Super 05 EC	2.0 l	139	15.65
Targa Super 05 EC + Lenmix 800 EC	1.5 l + 1.0 l	151.5	14.36
Targa Super 05 EC + Lenmix 800 EC	1.5 l + 1.5 l	170	12.80

The efficiency of Lenmix 800 EC applied along with herbicides in flax cultivation

The Lenmix 800 EC generally improved the performance of herbicides. Glean 75 WG applied in mixture with Lenmix 800 EC controlled effectively the majority of broadleaf weeds except *Viola arvensis* and *Lamium spp.* The graminicides Targa Super 05 EC and Perenal 104 EC applied in mixture with Lenmix 800 EC controlled the grass species *Elymus repens* and *Echinochloa cruss-galli*. The addition of the Lenmix 800 EC allowed for reduction of doses of Glean 75 WG, Perenal 104 EC and Targa Super 05 EC by 20-25% with no loss of efficacy. Application of the herbicides in mixture with Lenmix 800 EC did not cause any crop injury.

The Glean 75 WG applied in mixture with Lenmix 800 EC resulted in a significant increase in flax straw and seed yield. Application of the graminicides in mixture with Lenmix 800 EC had no significant effect on straw and seed yield (Table 4).

Table 4. Herbicide efficacy in fiber flax (average of 2 trials) - EF Białobrzezie, EF Sielec Stary (2003-2004)

Treatment (g or l ha^{-1})	Broad-leaved weed biomass control [%]	Grass weed biomass control [%]	Yield of flax [dt ha^{-1}]		Fiber flax susceptibility to herbicides[1]
			straw	seed	
Check (weed biomass g m^{-2})	113.5	28.4	62.1	9.5	1
Glean 75 WG (15 g)	94.7	23.5	63.6	9.9	1
Glean 75 WG (12 g) + Olbras Super(1.5 l)	90.6	33.4	62.3	9.4	1
Glean 75 WG (12 g) + Lenmix 800 EC (1.5 l)	93.0	10.2	64.9	10.0	1
Glean 75 WG (15g) after 5 days Perenal 104 EC (1.0 l)	86.4	90.8	63.3	9.6	1
Glean 75 WG (15g) after 5 days Perenal 104 EC (1.0 l) + Olbras Super (1.5)	86.4	79.5	60.4	9.1	1
Glean 75 WG (15g) after 5 days Perenal 104 EC (1.0 l) + Lenmix 800 EC (1.5)	93.3	97.8	61.2	9.2	1
Glean 75 WG (15g) after 5 days Targa Super 05 EC (2.0 l)	95.3	94.7	63.0	9.4	1
Glean 75 WG (15g) after 5 days Targa Super 05 EC (2.0 l) + Olbras Super (1.5)	79.3	94.3	63.6	10.4	1
Glean 75 WG (15g) after 5 days Targa Super 05 EC (2.0 l) + Lenmix 800 EC (1.5)	92.4	91.4	61.1	9.1	1
LSD $_{(0.05)}$			2.1	0.5	

[1]According to a 1-9 grade scale, where: 1 – no injury, 9 – total damage

Eco-friendly technologies of protecting flax against weeds basically involve rational application of herbicides, according to the principles of sustainable agriculture [2]. They include rotation of herbicides, applying the treatments in repeated reduced doses, precise application and reduction of harmful effect of herbicides on the environment (reducing the doses) by using herbicides with adjuvants [8-10]. Herbicide rotation prevents occurrence of compensation and resistance of weeds. This leads to decrease in number of chemical treatments and the level of herbicide doses.

Another method involves applying preparations with different active substances and of different mode of action. Application of registered herbicide mixtures reduces the risk of occurrence of mixed and multiple resistances of weeds.

Using repeated reduced doses frequently improves herbicide efficiency and at the same time lowers their total usage. This process involves using small doses in 2-3 times of application (with a few or several-day intervals) instead of a single application at a full dose. Such a system results in lower accumulation herbicide residues in the plant and environment.

The adjuvant importance in limiting the negative impact of herbicides on the environment results from better evenness of spraying, minimizing the effect of weather conditions during treatments, improvement of herbicide efficiency, what enables to use lower doses and decrease their residues in soil and plants.

A significant issue in eco-friendly weed control in flax cultivation is also accuracy of herbicide application. This is based on using changing doses of plant protection preparations, depending on the degree of weed infestation both in terms of amount and species present. Initially, an electronic map of weeds must be prepared with the use of GPS system. Then, the data is entered into the computer of the tractor with sprayer. As a result herbicide application is made only in the places where weeds grow. The used dose is also controlled depending on the amount of weeds per specified area unit.

CONCLUSIONS

- Pro-ecological methods of flax protection from weeds rely on using eco-friendly methods of herbicides application.
- For these methods included: rotation of herbicides and using split application system, adjuvant application and precise treatments.
- Using of pro-ecological methods of plants protection from weeds enables protection of fertility of soil and limitation of environment pollution.

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