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Biological performances of alfalfa treated with mineral oil Akarzin and reduced doses of insecticide

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Abstract. An important tendency over the past years in the conventional cultivation of crops is the reduced use of synthetic products. The experiment was carried out in the period 2014–2015 at the Institute of forage crops (Pleven) and aimed to study the biological performances of alfalfa after application of mineral oil Akarzin, either alone and in combination with reduced doses of synthetic insecticide (Eforia 045 ZC). The alone and combined use of Akarzin had no phytotoxic effect on the crop and influenced positively on the relative water content and dry mass productivity (an increase by 5.2 to 8.7 % and by 10.1 to 29.2 %, respectively). The treatment with the synthetic products also had a favorable effect on the phytosanitary status of the crop and restricted the attack by *Pseudopeziza medicaginis*. The combined application of Akarzin along with Eforia 045 ZC allowed reducing the applied dose of the insecticide up to 0.03 and 0.01 %, as the same time the achieved effect in regard to the productivity exceeded the one of self–application of Eforia 045 ZC in the highest dose (0.05 %). With a view to reducing the negative impact on environment a reduction of the application dose of the insecticide after combining it with the mineral oil is recommended as an environmentally friendly approach in conditions of conventional cultivation of alfalfa.

Keyword: mineral oil, alfalfa, reduced doses, yield.

Introduction

Alfalfa is determined as the "queen of forages" owing to its combination of high productivity and forage quality, nitrogen fixing ability, large adaptability, stand persistance, and soil profits.

It is one of the highest protein, energy and palatable forages.

Alfalfa may be successfully included into dairy cattle, sheep, goat and horses norms as its participation is strongly recommended by nutritionists.

Alfalfa is also used for human consumption as "alfalfa sprouts" or healthy supplements obtained from the leaves.

The technical application of this culture for enzyme production and for fractionation aiming use of the stems as bioenergy source is currently being investigated.

Main elements in the technology of cultivation are aimed at increasing productivity and forage quality, and pest control [PUTNAM *et al.*, 2008; IVANOVA and MARINOVA, 2016].

An important tendency over the past years in the conventional cultivation of crops is the reduced use of synthetic products. Reducing use of products for plant protection and their joint application with different products in order to reduce their negative impact on the environment is an environmentally friendly approach in conditions of conventional production.

This provides both a good plant protection and realization of considerably higher productivity [EL–GUINDY *et al.*, 1983; TSIBULKO *et al.*, 2000; DEMKIN, 2007].

The research aimed to study biological manifestations of alfalfa after application of mineral oil Akarzin, either alone and in combination with reduced doses of synthetic insecticide (Eforia045 ZC).

Material and methods

The field experiment was carried out in the period 2014–2015 at the Institute of Forage Crops (Pleven) under non–irrigated conditions with alfalfa (cultivar Dara).

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Randomized block design was used, with triple repeated variants and size of plots of 5 m^2. The action of a mineral oil (Akarzin) was studied, alone applied and in combination with reduced doses of the synthetic insecticide Eforia 045 ZC) (Table 1).

Table 1.

Characteristics of the used products and doses of application

Products	Active substances	Doses
Akarzin	85 % mineral oil (paraffin wax) +15 % emulsifier	4000 ml/ha*
Eforia 045 ZC	15 g/L lambda–cyhalothrin + 30 g/L thiamethoxam	0.05 %*
Eforia 045 ZC + Akarzin	15 gL lambda–cyhalothrin + 30 g/L thiamethoxam with combination of mineral oil	0.03 %+4000 mL/ha
Eforia 045 ZC + Akarzin	15 g/L lambda–cyhalothrin + 30 g/L thiamethoxam with combination of mineral oil	0.01 %+4000 mL/ha

*Doses of commercial products are according to the registration of the product by the manufacturer

The treatment was performed at the budding stage of second regrowth of alfalfa.

Aboveground mass was harvested at the stage of full flowering–early pod formation.

To determine the relative water content (RWC) of the plants from different variants was used the method of Barr and Weatherley [BARR and WEATHERLEY, 1962].

According to the manufacturer (Agriflor), Akarzin is an emulsifiable concentrate whose active substance contains mineral oil [BUTNARIU *et al.*, 2015; SAMFIRA *et al.*, 2015].

It improves the action of plant protection products by reducing the surface tension of the working solution and creates a uniform film on the leaves of treated plants and the body of pests {BUTNARIU and SAMFIRA, 2012].

This product acts suffocatingly on insects, eggs of mites and aphids.

Besides the characteristics of the product given by the manufacturer, in the scientific literature, there was data indicating a high efficiency of Akarzin in control of aphids [YANKOVA *et al.*, 2009].

Atanasov and collab. reported a use of Akarzin in combination with fungicide for controlling rust on plum (*Tranzschelia pruni–spinosae* (Pers) Diet.) [ATANASOV *et al.*, 2012; BUTNARIU and CORADINI, 2012; RODINO *et al.*, 2014].

In addition to the positive manifestations of mineral oils, there were studies which have established a synergistic effect when combining mineral oils with insecticides [AL–MRABEH *et al.*, 2010], protection of plants from different viruses by suppressing their transmission [POWELL *et al.*, 1998; SURANYI, 2010; MARGARITOPOULOS *et al.*, 2009] and lower toxicity of the oils in regard to the beneficial entomofauna compared with other pesticides [MCLAREN *et al.*, 2008].

Results and discussion

The results concerning the application of oils (plant and mineral) reported in the scientific literature were contradictory.

Some authors have established some delay at the phenological phases, manifestations of phytotoxicity and yield decreases [STANSLY *et al.*, 2002].

The phytotoxic manifestations were determined by various factors including dose of application, physical and chemical properties of the oil, plant species and environmental conditions, especially temperature [DAVIDSON *et al.*, 1991; ANGELLO, 2002].

In the terms of this study, delays at the phenological stages and phytotoxic manifestations after using mineral oil Akarzin were not observed.

It was possible the reason for that to be the fact that most formulations of different oils according to Al–Mrabeh and collab. in the last 2–3 decades have been improved to be more effective and less harmful products [AL–MRABEH *et al.*, 2010].

Also, manifestations of phytotoxicity were reported mainly in the 80s when the formulations have been quite different.

With regard to the sustainability of mineral oils, in the scientific literature were reported data for effective retention of mineral oil on the leaf surface in the laboratory for two months [BRADLEY, 1963].

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In field conditions, the oils retained themselves on the leaf surface for 10–14 days after application [SIMONS *et al.*, 1977], and smaller amounts of rainfall (<25 mm per day) did not remove the oily film from the treated leaves [SIMONS and ZITTER, 1980]. The oil stability was also defined by temperature [SIMONS *et al.*, 1977] and light [HODGKINSON *et al.*, 1999] as high values of these factors had a negative effect.

In 2015, after treatment with Akarzin (alone and in combination with Eforia 045 ZC) oily film on the leaves of alfalfa was observed for 15 days (Table 2).

Table 2.
Retention of mineral oil Akarzin on the alfalfa leaves depending on meteorological conditions

Years	Date of treatment with Akarzin	Retention of oil film to:	Duration of the period	Average daily Temperature °C	Rainfalls mm
2014	16 June	4 July	18 days	20.9	34.7
2015	23 June	8 July	15 days	22.1	38.3

In comparison with 2014, the duration of the retention period was smaller, which was determined by the higher values of average daily temperatures and quantity of rainfalls.

The plants treated with Akarzin, alone or in combination with Eforia 045 ZC, showed an increased RWC (relative water content) on average by 5.6 % in comparison with the untreated control (Figure 1).

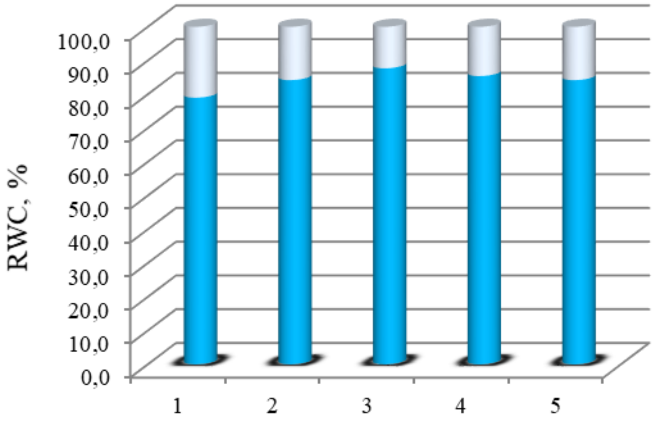

Figure 1. Relative water content (RWC) in alfalfa treated with synthetic products
Legend: 1. Control, 2. Akarzin, 3. Eforia, 4. Akarzin + Eforia 0.03 %, 5. Akarzin + Eforia 0.01 %

Self–application of Eforia 045 ZC also resulted in an improved water status of alfalfa and difference from 8.7 % compared to the control variant.

The data in the literature on the impact of pesticides on the water potential of plants were contradictory.

Han and collab. found an increase in RWC of plants treated with imidacloprid [HAN et al. 2010] while Nasrabadi and Dhumal observed a decrease under the influence of the increasing doses of organophosphorus insecticides (chloropyrifos and malathion) [NASRABADI and DHUMAL, 2014].

In the particular conditions of this study, the higher values of RWC can be explained by the protective effect of the used synthetic products defining the lower density of insects in the treated variants.

In support of this were the results from study of Riedell, who established a highly reduced RWC, reduced conductivity of stomata and water potential in barley after a 7–day period of infection with aphids (*Diuraphis noxia* Mordvilko) compared to the same parameters of uninfected plants [RIEDELl 1989; BUTNARIU, 2014; PETRACHE *et al.*, 2014].

The application of Akarzin at budding stage had significantly positive effect on the alfalfa development and increased the amount of dry aboveground mass with 8.8 % compared to the control (Table 3).

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Table 3.
Dry mass productivity in alfalfa treated with mineral oil Akarzin and insecticide Eforia 045 ZC (2014–2015)

Products	Doses	Dry mass, kg ha^{-1}		% to control
Control (untreated)	–	3011.89	a	
Mineral oil Akarzin	400 mL/da	3276.00	b	8.8
Eforia 045 ZK	0.05 %	3747.89	c	24.4
Akarzin + Eforia 045 ZK	400 mL/da+0.03 %	3998.30	d	32.8
Akarzin + Eforia 045 ZK	400 mL/da+0.01 %	3946.81	cd	31.0
		LSD $_{0.05\ \%}$	208.80	

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The application of Akarzin at budding stage had significantly positive effect on the alfalfa development and increased the amount of dry aboveground mass with 8.8 % compared to the control (Table 3). Increasing yield after alone use of mineral oil (Stylet oil) was reported by Stansly and Cawley [STANSLY and CAWLEY 1992].

According to Hilton and collab. of particular importance was also the cultivar: after treatment with the same oils in some cultivars was observed a reduction in yield, while in others–an increase [HILTON *et al.*, 2002; BUTNARIU, 2012; BUTU *et al.*, 2014].

Significantly more essential was the increment of the yield (with 24.4 %) after treatment with Eforia due to a good preventive effect against pest insects.

Highest productivity exceeding that of the control (with 31.0 and 32.8 %) was found after the combined use of Akarzin with reduced doses of Eforia (of respectively 0.01 and 0.03 %), with nonsignificant differences between the two variants.

The synergistic effect of the combination did not exceed the total productivity of the alone use of Akarzin and Eforia, which is known as subadditive synergism.

The meteorological conditions during the period of formation of second alfalfa regrowth (May–July) favored the development of phytopathogens–daily average temperature of 22.0 °C and 145 mm rainfalls.

Particularly favorable were conditions in June: temperatures ranging from 17 to 25 °C and frequent precipitations with total amount of 95.7 mm (50 % of the days in the month were secured by rainfall). The conducted phytopathological examinations of the alfalfa stand showed an infestation of black leaf spots caused by *Pseudopeziza medicaginis* (Lib.) Sacc. The degree of the attack was determined on 6–grade scale (0–5) of Harvey and Martin:

- 0–healthy plants;
- 1–plants with an affected area to 1 %;
- 2–from 1 to 5% affected leaf area;
- 3–from 6 to 20 % affected leaf area;
- 4–by 21–50 % affected area; and
- 5–heavily infested plants with over 50 % affected leaf area [HARVEY and MARTIN 1980].

The degree of infestation in the alfalfa stands ranged from 20.00 to 28.33

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% with established differences between the individual variants (Figure 2).

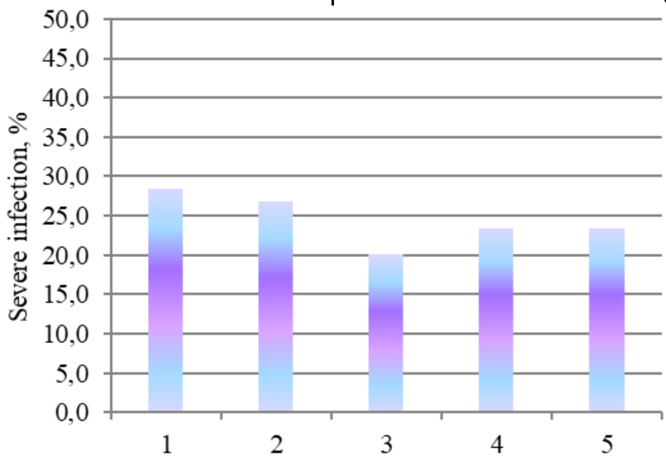

Figure 2. Degree of infestation by *Pseudopeziza medicaginis* (Lib.) Sacc. in alfalfa
Legend: 1. Control, 2. Akarzin, 3. Eforia, 4. Akarzin + Eforia 0.03 %, 5. Akarzin + Eforia 0.01 %

The treatment with Eforia and mineral oil Akarzin influenced on the susceptibility of plants to *Pseudopeziza medicaginis*.

The plants from the treated variants were distinguished with more favorable physiological status, formed greater aboveground biomass and were protected from pest insects.

Better developed plants were less attacked by the phytopathogen. Here the percentage of affected plants was lower and ranged from 20.00 (treatment with Eforia) to 26.67 % (treatment with Akarzin).

The low percentage damaged plants in which was used synthetic insecticide Eforia was determined not only by the good protective effect against pests but also by the fungicidal action, found by some authors [AL–MRABEH *et al.*, 2010; BUTNARIU *et al.*, 2016], of one of the active substances (lambda–cyhalothrin) of the product.

This active substance belonged to the group of pyrethroids–the only class of insecticides having a fungicidal action.

On the other hand, in the variants with application of Akarzin the presence of an oil film on the plant surface probably contributed to suppress the spread of *P. medicaginis*.

A similar protective effect of mineral oils in suppressing the transmission of different viruses was reported by a number of researchers [POWELL *et al.*, 1998; MARGARITOPOULOS *et al.*, 2009; SURANYI, 2010].

Conclusions

The application of mineral oil Akarzin, either alone or in combination with insecticide product Eforia 045 ZC, had a positive effect on the relative water content (an increase by 5.2 to 8.7 % units) and dry mass productivity in alfalfa (an increase by 10.1–29.2 %).

The treatment with the synthetic products also had a favorable effect on the phytosanitary status of the crop and restricted the attack by *Pseudopeziza medicaginis*.

The combined application of Akarzin along with Eforia 045 ZC allowed reducing the applied dose of the insecticide up to 0.03 and 0.01 %, as the same time the achieved effect in regard to the productivity exceeded the one of self–application of Eforia 045 ZC in the highest dose (0.05 %).

With a view to reducing the negative impact on environment a reduction of the application dose of the insecticide after combining it with the mineral oil is recommended as an environmentally friendly approach in conditions of conventional cultivation of alfalfa.

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