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STUDY OF VARIOUS SYSTEMS FOR CHEMICAL WEED CONTROL IN GRAPEVINES

Vyara Doycheva*, Iliyan Zheliazkov, Maya Dimitrova, Stefan Schilev

Agricultural University – Plovdiv

***E-mail: viarag1981@abv.bg**

Abstract

A precise field experiment for studying the efficacy and selectivity of various systems for chemical weed control in a vineyard of Sauvignon Blanc cultivar was carried out in the region of Brezovo (Plovdiv District, Bulgaria) in the period 2017-2019. The established weed species composition in the plantation was different in the two years of the study, which was due to the difference in weather conditions over the period. Weed associations included the species *Chenopodium album (L.), Solanum nigrum (L.), Portulaca oleracea (L.), Setaria viridis (L.), Xanthium strumarium (L.)* etc. The following winter-spring species also showed high density – *Capsella bursa-pastoris (L.) Medic, Erodium cicutarium (L.), Viola spp. (L)*. The following polycarpic species were found: *Convolvulus arvensis (L.), Trifolium spp. (L.), Cynodon dactylon (L.) Pers.,* etc.

The systems for chemical weed control included the following variants: 1. Smerch 24 EC (*oxyfluorfen*) – 3000 ml/ha+ Dual Gold 960 EC (*s-metolachlor*) – 1500 ml/ha – applied early in spring; 2. Stomp Aqua (*pendimethalin*) applied twice – early in spring (7000 ml/ha) and post-harvest (3000 ml/ha) in the first and the second years, and in the third once in spring early in a dose 7000 ml/ha; 3. Pledge 50 WP (*flumioxazine*) – applied once before vine vegetation, at a rate of 400 g/ha in the first year, 300 g/ha in the second and in the third year - 200 g/ha; 4. Pledge 50 WP (*flumioxazine*) applied twice – in spring, before vine vegetation and post-harvest at a rate of 400+400 g/ha in the first year, 300+300 g/ha in the second, and the third once – in the spring at dose 200 g/ha.

It was established that the herbicides based on *flumioxazine* and *oxyfluorfen* in combination with *s-metolachlor* showed high efficacy within 56 days after treatment.

At the Agricultural University-Plovdiv, Department of Microbiology and Environmental Biotechnology, in vitro biotest studies were conducted to obtain preliminary specific data regarding the effect of the introduction of various herbicides on soil microorganisms. Studies of each of the soil suspensions containing a representative sample of the respective microbial communities revealed a relatively small effect of the tested herbicides on them.

Keywords*:* vines, weeds, efficacy, herbicides, soil microorganisms

INTRODUCTION

One of the important factors for the production of high quality vines and wine is the control of weeding in the vineyards. Weeds are the main competitor of the vine in terms of water and nutrients, which leads to difficult growth and development of the vines, as well as reducing the quantity and quality of wine (Nikolov et al., 1988; Moullis, 1992; Tonev, 2019). *Sinapis arvensis (L.), Convolvulus arvensis (L.), Amaranthus retroflexus (L.) and Cynodon dactylon (L.)* species have been found to extract large amounts of water and nutrients from the soil and also have high transpiration (Boychev, 1980). Weed vegetation influences the microclimate of the vine, and favorable conditions for the development of diseases and pests on it are created.

The most widespread weeds in the vine plantations are perennial species from the group of rhizomes - *Cynodon dactylon (L.)* and *Sorghum halepense (L.),* as well as from the group of root-weed - *Cardaria draba (L.), Convolvulus arvensis (L.)* and *Cirsium arvense (L.).* Of the annuals, the late-spring species are represented - *Xanthium strumarium (L.), Amaranthus spp., Chenopodium album (L.), Setaria spp., Echinochloa crus-galli (L.), Portulaca oleracea (L.), Digitaria sanguinalis (L.), Solanum nigrum (L.)*, etc. (Nikolov, et al., 1988). They form typical trench type associations and are widespread not only in vineyards but also in own-rooted vines (Prodanova- Marinova, 2015).

In the past, weeds in vineyards were eliminated mainly by manual operations, which are labor-intensive and with high production costs, so the use of herbicides is required in their control. Chemical weed control including accumulation in the soil and subsoil (Bakalivanov, 1982; Monako, et al., 2002; Subhani, et al., 2000). The herbicides used have a direct effect on the activity and population dynamics of the soil microflora. The degradation of herbicides with the active substance *pendimetalin* has been found to depend on soil and climatic conditions and lasts up to 100 days (Kartalska, et al., 2009).

The results of the first trials with herbicides in Bulgaria in vineyards were published in 1960 (Nikov, 1960; Raykov et al., 1960; Fetvadzhieva, 1962). Later on the problems of the efficacy and selectivity of herbicides, their influence on the vine and soil microflora were reported by Boychev, (1975) and Chelebiev (1982). According to Rankova and Popov (2011) *flumioxazine* shows a very good effect against weed species in the intra-row plum plantation. In the apricot padding plant, the same author investigates the effect of the active substances *s-metolachlor, oxyfluorfen* and *flumioxazine*. These soil herbicides provide complete control of the weeds, with herbicidal efficacy lasting 3.5 - 4 months (Rankova, Tityanov, 2013). However, there is no new research in Bulgaria on the effect of new active substances on both weeding and soil microflora.

The purpose of this study is to determine the efficacy and selectivity of the soil herbicides *s-metolachlor, oxyfluorfen, flumioxazine* and *pendimethalin* administered by different regimens: alone and in combination, once and twice each year in vine planting, taking into account and summarizing their effect after a 3 year period against the available weeds in the vine plantations.

MATERIALS AND METHODS

In the period 2017-2019 in the village of Varben, Brezovo municipality, district Plovdiv field experiments in vine planting were carried out with Sauvignon Blanc wine variety. The vine pad is Berlandieri x Riparia, Kober 5 BB selection. Plants in 1 hectare are 5450 pieces, and the formation of vines - medium stem. The efficacy of soil herbicides and combinations for weed control in the vine plantation was investigated by monitoring the presence of phytotoxicity on the plants and their effect on the soil microflora. The filed experiment included 6 variants, located in a block diagram in three repetitions (tabl. 1). In each variant, mechanized excavation was performed in the rows.

Table 1 Variants

Variants		Year of application	Dose g/ml/ha	Active substance
1.	Control - untreated, not dug in the row	2017-2019	-	-
2.	Economic control - untreated, hand-dug in the row	2017 - 2019	-	-
3.	Smerch 24 EC + Dual Gold 960 EC	2017 - 2019	3000 + 1500	*240 g/l oxyfluorfen + 960 g/l s-metolachlor*
4.	Stomp Aqua + Stomp Aqua Stomp Aqua + Stomp Aqua Stomp Aqua	2017 2018 2019	7000 + 3000 7000 + 3000 7000	*455 g/l pendimethalin + 455 g/l pendimethalin*
5.	Pledge 50 WP Pledge 50 WP Pledge 50 WP	2017 2018 2019	400 300 200	*500 g/kg flumioxazine*
6.	Pledge 50 WP + Pledge 50 WP Pledge 50 WP + Pledge 50 WP Pledge 50 WP + Pledge 50 WP	2017 2018 2019	400 + 400 300+ 300 200	*500 g/kg flumioxazine + 500 g/kg flumioxazine*

The application of herbicides was done with a back sprayer with a working solution of 400 l/ha. The species and the quantitative composition of the weeds were recorded on the 28^{th} and 56^{th} day after the application of herbicides in the protection zone according to the methodology on the quantitative method (Zheliazkov et al., 2017). The second dose of herbicides was administered in the fall, about 1 month after harvest.

The second part of this study involves in vitro studies to obtain data on the effects of various herbicides on soil microorganisms. They were conducted in the laboratory of the Department of Microbiology and Environmental Biotechnology at the Agricultural University, Plovdiv (pic. 1, 2). For this purpose, the method of diffusion in agar medium was applied (Sapundzhieva et al., 2010).

The following variants are included for the in vitro studies: 1. Zero control; 2. Smerch 24 EC (3000 ml/ha) + Dual Gold 960 EC (1500 ml/ha); 3. Stomp Aqua (7000 ml/ha); 4. Stomp Aqua (3000 ml/ha); 5. Pledge 50 VP (400 g/ha).

RESULTS AND DISCUSSION

The established weed species composition in the plantation was different in the three years of the study, which was due to the difference in weather conditions over the period. Weed associations included the species *Chenopodium album (L.), Solanum nigrum (L.), Portulaca oleracea (L.), Setaria viridis (L.), Xanthium strumarium (L.)* etc. The following winter-spring species also showed high density – *Capsella bursa- pastoris (L.) Medic, Erodium cicutarium (L.),Viola spp. (L)*. The following polycarpic species were found: *Convolvulus arvensis (L.), Trifolium spp. (L.), Cynodon dactylon (L.) Pers.,* etc. (tabl. 2).

The composition of annual species varies from 21 number (2017) to 29 number (2019), and of perennials 7- 9 number, i.e. the main weeding is of annual species, of the ephemeral group, winter-spring and late-spring (fig. 1).

Perennial weeds include mainly species from the group of weeds with spindle-shaped root, rhizomes and root-shoots. Two representatives of two-year-old weeds were also reported - *Conium maculatum (L.) u Malva sylvestris (Wallr.)* (tabl. 2).

The results of the observations during the three experimental years show close values in the ratio of annual and perennial weed species. In terms of species diversity, there is an annual upward trend compared to the first experimental year (2017), with annual species being 9,5% (2 species) in 2018 and 38,1% (8 species) in 2019, respectively per year. In perennial weeds, growth in species diversity was reported only in the last year by 28,6% (2 species) (fig. 1). The observed trends in the changes in the species composition of the weeds once again prove the potential they have for preserving the vitality of the seeds in the soil. The density of weeds in the zero control is very high and at first reading (on the 28th day after spraying) varies from 134 number/m^2 in 2018 to 280 number/m^2 in 2019. The ratio of annual to perennial weeds is 2: 1. The higher density in the last year of the study is mainly due to favorable weather conditions. This pattern is also observed on the 56th day after treatment.

Fig. 2 and Fig. 3 show data on weed density by year and the efficiency of weed control systems 28 days after their application. The highest weed density was reported in Option 1 - untreated and uncovered control, with their number varying over the three experimental years, 146,7; 134 and 280 number/m^2. The tendency that we observe in terms of increasing the species composition of weeds is also observed in terms of their density. The lowest density was reported in variant 6 - 14 number/m^2 (2017), 5,8 number/m^2 (2018) and 11,4 number/m^2 (2019).

The results obtained on the 28th day after the implementation of the control systems show that the efficiency of mechanical control approaches (var. 2) varies between 50% and 79%, and when applying chemical methods the efficiency is in the range of 66% (var. 3) up to 96% (var. 6).The highest effect on total weeding was obtained in var. 6 and varied over the years from 91% to 96%, followed by var. 5 (84%- 91%) and var. 4 (82%- 89%). The most pronounced decreasing degree of weed control (by an average of 27%) when applying the same herbicide products over three consecutive years was reported in var. 3 (from 90% to 66%), a similar trend was observed in var.5 , but the difference here is only 7% (91% to 84%). In contrast, options 4 and 6 reported increasing efficiencies in the third year - from 82% to 89% (var. 4) and from 91% to 96% (var. 6).

In (fig. 4) presents the results for weed density at 56 days after the application of the individual weed control systems over the three test years. The data show that the number of weeds in lime 1 (untreated and uncovered control) ranges from 335,1 number/m^2 (2017) to 236 number/m^2 (2019). This change can be explained by the natural extinction of part of the species (mainly from the ephemeral group) that has completed its life cycle between these two readings. In economic control (var. 2), as a result of the application of mechanical means of control, the density of weeding in the second and third year decreases - from 382 number/m^2 (2017) to 65 number/m^2 (2019). Smerch 24 EC (3000 ml/ha) + Dual Gold 960 EC (1500 ml/ha) (var. 3) and (var. 5) Pledge 50 WP 400, 300, 200 g/ha. The tendency to increase weed density continued, which was also reported on the 28th day after treatment, while for variants 4 and 6 the number of weeds decreased over the last year.

The efficiency of the applied weed control schemes within the row is shown in fig. 5. The data show that the systematic application of mechanical methods (var. 2) is a short-term measure, since even their complete removal for 28 days, after about 1 month, they reach their previous levels. The effect of implementing this control system can range from 60% (2018) to 73% (2019).

The efficiency conclusions drawn for herbicide variants repeat the findings of 28 days of treatment. For var. 3, the decreasing efficiency was most pronounced (from 95% to 64%), followed by var. 5 from 96% to 79%. When treated with Pledge 50 WP twice daily in spring and autumn (var. 6), the 56 day efficacy was highest from 94% to 96% and did not decrease over the study period.

The studies of each of the soil suspensions containing a representative extract of the respective microbial associations showed a relatively low impact of the used herbicides on them. The microbial associations of the surface soil layer with a depth of 0-20 cm manifested tolerance to the studied soil herbicides in the variants Smerch 24 EC (3000 ml/ha) + Dual Gold 960 EC (1500 ml/ha). Regarding the herbicides Stomp Aqua (3000 ml/ha) and Pledge 50 WP (400 g/ha), there is a slight suppression which is more explicitly manifested with the second preparation. On the other hand, among the microbial associations found in the soil at a depth of 20-40 cm, more representatives of the bacteria and the years have been registered compared to those of the mould and the actinomycetes. There is some suppression among the herbicides Pledge 50 WP (400 g/ha). In the zero control sample, the effect is stimulating. The microorganisms are not affected by the combination of Smerch 24 EC (3000 ml/ha) + Dual Gold 960 EC (1500 ml/ha) and also by Stomp Aqua in a dose of 7000ml/ha.

Tabl. 2. Weed species composition, average for the period 2017**-**2019

Types of weeds in the experimental areas - 35 pieces			
Monocarp weeds – 27 number			**Polycarp weeds - 8 number**
Lamium amplexicaule (L.)	*Setaria viridis (L.)*	*Vicia spp. (L.)*	*Lotus corniculatus (L.)*
Chenopodium album (L.)	*Xantium strumarium (L.)*	*Stellaria Media (L.) Cyr.*	*Trifolium pratense (L.)*
Solanum nigrum L.	*Coniza canadensis (L.)*	*Bromus arvensis (L.)*	*Trifolium arvense (L.)*
Portulaca oleracea (L.)	*Bifora radians (L.)*	*Echinochloa crus-galli (L.)*	*Trifolium spp. (L.)*
Sonchus oleraceus (L.)	*Poligonum aviculare (L.)*	*Galium aparine (L.)*	*Rumex acetosella (L.)*
Myosotis stricta (Link)	*Lactuca serriola (L.)*	*Matricaria chamomilla (L.)*	*Cynodon dactylon (L.)*
Arabidopsis thaliana (L.) Heync	*Capsella bursa-pastoris (L.) Medic*	*Geranium molle (L.)*	*Convolvulus arvensis (L.)*
Veronica hederifolia (L.)	*Erodium cicutarium (L.)*	*Conium maculatum (L.)-biennial weed*	*Muscari spp. (L.)*
Poligonum convolvulus (L.)	*Viola spp. (L.)*	*Malva sylvestris (Wallr.)-biennial weed*	

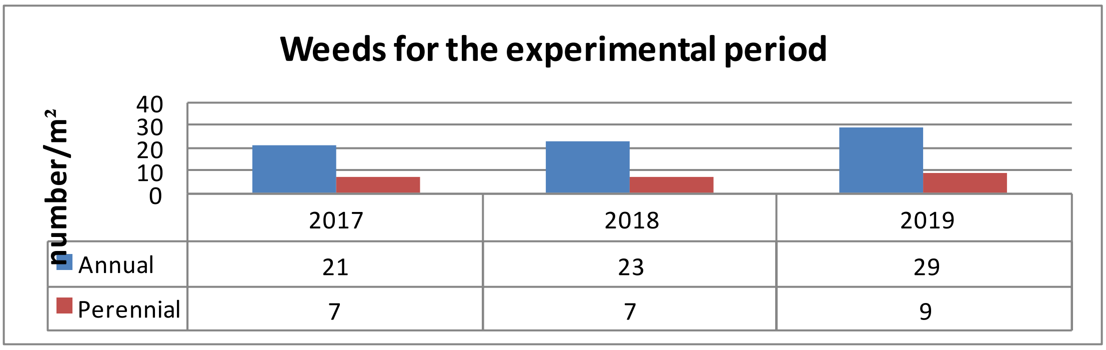

Fig. 1 Weeds for the experimental period

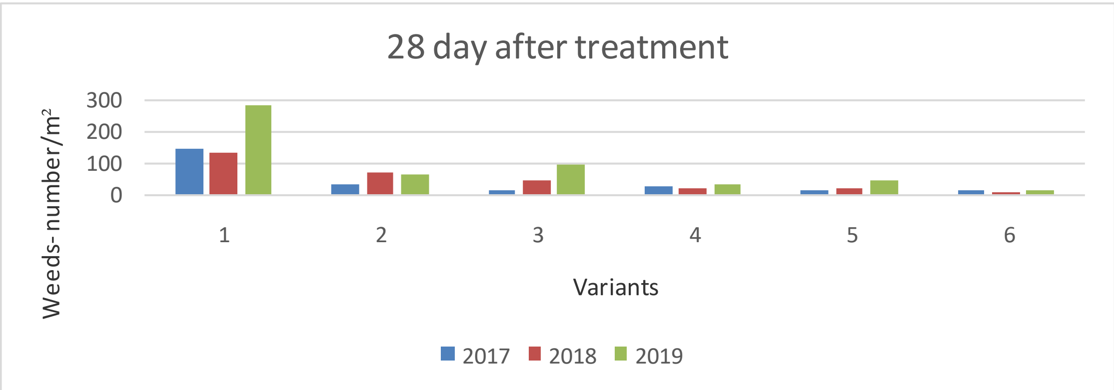

Fig. 2 Weeds 28 day after treatment

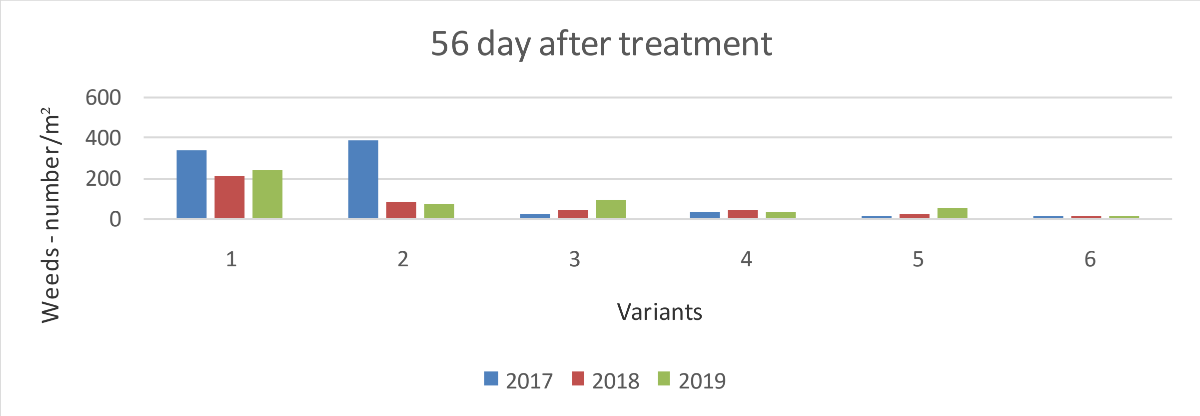

Fig. 3 Weeds 56 day after treatment

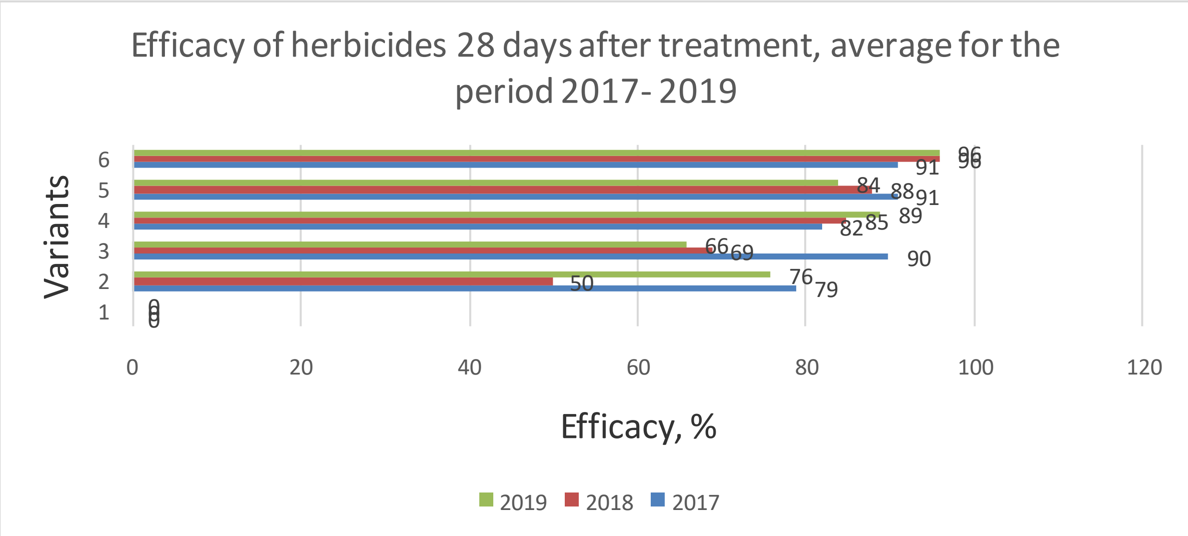

Fig. 4 Efficacy of herbicides 28 days after treatment

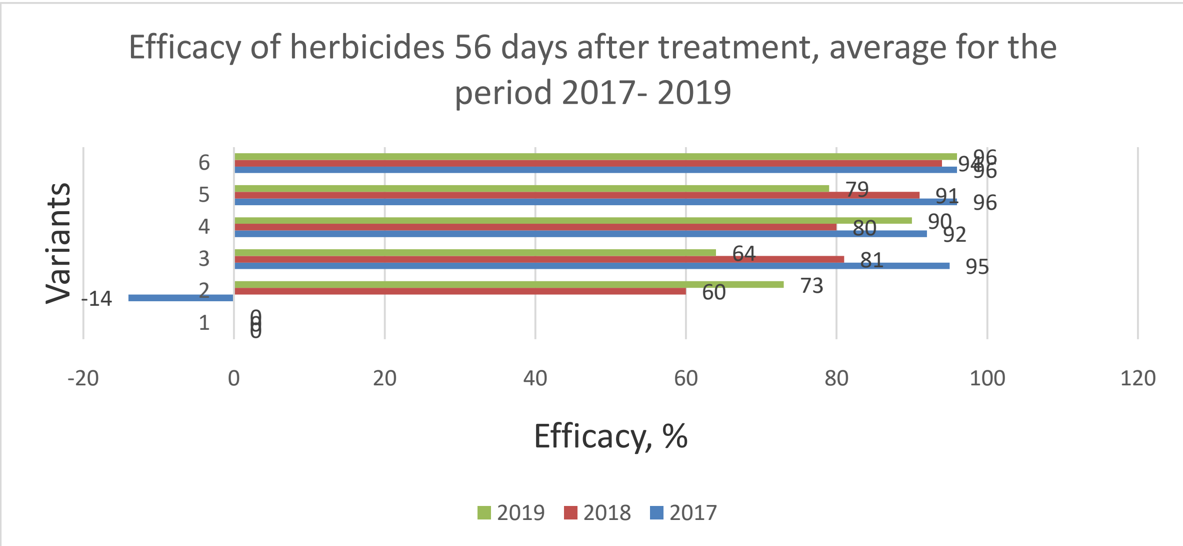

Fig. 5 Efficacy of herbicides 56 days after treatment

CONCLUSIONS

Average for the experimental period it was established that the herbicides based on *flumioxazine* (Pledge 50 WP) applied twice in spring, before vine vegetation and post-harvest at a rate of 400+ 400 g/ha in the first year, 300+ 300 g/ha in the second, and the third once in the spring at dose 200 g/ha showed highest efficacy from 91% to 96% at 28 and 56 days after treatment.

Pendimethalin (Stomp Aqua) applied twice early in spring 7000 ml/ha and post-harvest 3000 ml/ha in the first and the second years, and in the third once in spring early in a dose 7000 ml/ha showed the same high efficacy from 80% to 92%.

Comparing the applied weed control chemical systems, we can summarize that with twice a year's application of herbicides in the vineyards (in the autumn and in the spring), weed efficiency increases compared to the previous year.

Treatment with soil herbicides Smerch 24 EC 3000 ml/ha + Dual Gold 960 EC 1500 ml/ha and Pledge 50 WP 400, 300, 200 g/ha, applied once a spring, in the third year yield diminishing effect on weeding.

In vitro biotest studies were conducted to obtain preliminary specific data regarding the effect of the introduction of various herbicides on soil microorganisms. Studies of each of the soil suspensions containing a representative sample of the respective microbial communities revealed a relatively small effect of the tested herbicides on them.

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