

Original Article

Application of soil herbicides in gardening to improve fruit production

Aplicação de herbicidas de solo na jardinagem para melhorar a produção de frutas

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Abstract

The study considered the use of soil herbicides: Begin Turbo, KS; Dual Gold, KE; Euro-Lighting, VRK; Command, KE; Pivot, VK; Proponite, KE; Zenkor Ultra, KS and partially soil action: Demetra, KE, and Dialen Super, KS. We conducted a comparative assessment of the biological effectiveness of the studied herbicides against the main species of weeds present in the experimental plots, annual and perennial dicotyledonous, annual cereal weeds. The effect of soil herbicide treatments on the physiological state of plants of apple, pear, walnut, and black currant was studied. The effect of the use of the studied drugs on the yield of protected crops for three years was evaluated. The tests proved the applicability of soil herbicides in nursery, production gardens, as well as on seedlings with a closed root system. The tested products, despite the principle of their action - penetration into weeds through the soil, did not harm the protected crops, no negative effect on the growth of trees and shrubs was recorded. The study revealed no evidence that drugs had a negative impact on fruit and berry crop productivity. There are suggestions for improving the efficacy of using soil herbicides when planting fruit and berry crops.

Keywords: herbicides, soil herbicides, apple, pear, walnut.

Resumo

O estudo considerou o uso dos herbicidas de solo: Begin Turbo, KS; Dual Gold, KE; Euro-Lighting, VRK; Command, KE; Pivot, VK; Proponite, KE; Zenkor Ultra, KS e ação parcial do solo: Demetra, KE e Dialen Super, KS. Realizou-se uma avaliação comparativa da eficácia biológica dos herbicidas estudados contra as principais espécies de plantas daninhas presentes nas parcelas experimentais, dicotiledôneas anuais e perenes, plantas daninhas de cereais anuais. Estudou-se o efeito de tratamentos com herbicidas de solo sobre o estado fisiológico de plantas de macieira, pera, noqueira e groselha preta. Foi avaliado o efeito do uso das drogas estudadas na produtividade de cultivos protegidos por três anos. Os testes comprovaram a aplicabilidade de herbicidas de solo em viveiros, hortas de produção, bem como em mudas com sistema radicular fechado. Os produtos testados, apesar de seus princípios de ação - penetração em ervas daninhas através do solo, não prejudicou as culturas protegidas, não foi registrado nenhum efeito negativo no crescimento de árvores e arbustos. O estudo não revelou evidências de que as drogas tenham um impacto negativo na produtividade das frutas e bagas. Existem sugestões para melhorar a eficácia do uso de herbicidas de solo ao plantar frutas e bagas.

Palavras-chave: herbicidas, herbicidas de solo, maçã, pera, noz.

1. Introduction

Weeds in orchards, in addition to a direct negative impact on fruit trees (competition for water, nutrients) are also a source of the spread of diseases and pests (Rico et al., 2007; Popov and Rankova, 2009; Egorov et al., 2017; Sedov et al., 2017; Brühl and Zaller, 2021), therefore, the fight against weeds in horticultural farms is an urgent problem, as the most common method of control are mechanized now, and in some cases, manual processing of plantings. A separate complex issue is posed by weed

control in nurseries and schools of seedlings of fruit and berry crops. Manual removal of weeds requires a significant amount of time and several repetitions during the season, is not economically justified, and ineffective in the case of control of perennial rhizome weeds. Mechanized weed control is associated with a high risk of damage to the root system of trees and shrubs and does not have high efficiency as it prevents the cultivation of the entire soil area (Awan et al., 2018). For these reasons, in recent years,

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Received: May 21, 2022 – Accepted: July 29, 2022



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specialists in horticultural farms have been asking about the use of herbicides in fruit and berry plantations, nurseries (Audus, 1964; Kopytowski et al., 1999; Wocior et al., 1999; Gercheva et al., 2002; Rankova and Koumanov, 2004; Rankova et al., 2006, 2009; Rico et al., 2007; Hanson and Schneider, 2008; Popov and Rankova, 2009; Rankova, 2011; Nacheva et al., 2012; Rankova and Zhivondov, 2013; Egorov et al., 2017; Sedov et al., 2017). At the moment, in the Russian Federation, glyphosate products are allowed for use in orchards, for example, Roundup Max, BP (450 g/l glyphosate (in the form of isopropylamine salt)), Argument Star, BP (540 g/l glyphosate (potassium salt)), Glibel, BP (360 g/l glyphosate (as isopropylamine salt)). Preparations based on glyphosate are systemic herbicides of continuous action (Steinmann et al., 2021). Being highly effective, these herbicides, at the same time, pose a danger to fruit and berry crops; when settling on the leaf surface, their phytotoxic effect can persist for two years (Rico et al., 2007; Greer, 2022). The disadvantage of glyphosate products is that they penetrate weeds only upon direct contact of their working solution with the vegetative part of the weeds (Fisseha et al., 2021). For this reason, the study of the possibility of using herbicides of various mechanisms and periods of action is a very important issue in improving protective measures in orchards. It is promising, in particular, to study the possibility of using soil herbicides with a long-term protective effect in fruit and berry plantations.

2. Material and Methods

The studies were conducted at the educational and experimental farm of the Federal State Budgetary Educational Institution of Higher Education "K.A. Timiryazev RSAU-MAA", Moscow, in 2017–2020. The soil in the surveyed area is sod-podzolic, medium loamy on podzolic loam, with a plow horizon thickness of 25–27 cm, pH = 6.2, humus - 2.6%. The plantations of mature trees and pome fruit seedlings were examined: *Malus domestica* Borkh., *Pyrus domestica* Medik; berries: *Ribes nigrum* L., *Ribes rubrum* L., and nut crops: *J. regia* L.

To determine weed infestation in different experimental variants, we used 5 registration plots with an area of 1 m². The original experimental plots were selected with a uniform type of contamination and a similar amount of weeds. The effectiveness of the use of herbicides was assessed by reducing the number of weeds in% to the initial weed infestation adjusted for control (option without treatment with drugs) (Ortiz-R et al., 2014; Cerit et al., 2017; Shutko et al., 2021).

We studied the use of the following herbicides: Begin Turbo, KS (250 g/l C-metolachlor + 250 g/l terbutylazine) at an application rate of 2.0 l/ha; Demeter, EK (350 g/l fluroxypyr) at an application rate of 0.57 l/ha; Dialen Super, KS (344 g/l 2,4-D acid in the form of dimethylamine salt + 120 g/l dicamba acid in the form of dimethylamine salt) at an application rate of 1.5 l/ha; Dual Gold, EK (960 g/l of C-metolachlor) at an application rate of 1.3 l/ha; Euro-Lighting, VRK (33 g/l imazamox + 15 g/l imazapir) at an application rate of 1.0 l/ha; Command, EK (480 g/l

of clomazone) at an application rate of 1.0 l/ha; Pivot, VK (100 g/l imazethapyr) at an application rate of 1.0 l/ha; Proponite, EK (720 g/l of propisochlor) at an application rate of 3.0 l/ha; Zenkor Ultra, KS (600 g/l metribuzin) at an application rate of 1.0 l/ha (Shorokhov et al., 2021). All products were applied with the application rate of the spray material - 200 l/ha. Dialen Super, KS and Demetra, EK were used in the second decade of May after the massive growth of weeds, the treatment with the rest of the herbicides in the production garden was carried out in the first decade of May, after inter-row cultivation before the emergence of weeds. Herbicidal treatments in nurseries were also conducted in the first ten days of May when the first weed appeared. All operations with the products were conducted in windless weather conditions to exclude the drift of the spray material. For the introduction of herbicides, the following technique was used: a mounted herbicidal sprayer OG-600 and Stihl SG 71 knapsack sprayer with a herbicide nozzle.

The phytotoxicity of the products was assessed visually. In the experimental variants, the amount of plant growth and productivity were considered.

3. Result and Discussion

The herbicides studied have an effect on soil; after application, these drugs create a protective layer on the soil surface, which stays up to 60–70 days and affects germinating weeds. The active ingredients of these herbicides enter cereal weeds, mainly through colioptile, and into dicotyledons, mainly through cotyledons. These drugs act on already vegetating weeds as contact-systemic. It should be noted that the herbicide Dialen Super, KS has in its composition a component - dicamba acid in the form of dimethylamine salt, and the herbicide Demeter, EK contains fluroxypyr, these active substances (a.s.) have a partial soil effect. Euro-Lighting, VRK has a longer protective effect against weeds - up to 1 year.

Dicotyledonous weeds dominated in the training and experimental farm – *Convolvulus arvensis* L. – 4–5 ind./m², *Polygonum convolvulus* L. – 3–4 ind./m², *Amaranthus retroflexus* L. – 12–14 ind./m², *Chenopodium album* L. – 20 ind./m², *Galinsoga parviflora* Cav. – up to 7 ind./m², *Persicaria hydrophiper* (L.) Spach. – up to 5 ind./m², less represented species (3–4 ind./m²) – (*Artemisia vulgaris* L.), *Cirsium arvense* (L.) Scop., *Galium aparine* L., *Anthemis arvensis* L., *Sonchus oleraceus* L., *Stellaria media* (L.) Vill., *Rumex confertus* Willd., *Veronica chamaedrys* L., *Fumaria officinalis* L., *Malva parviflora* L., *Taraxacum officinale* (L.) Webb ex F.H.Wigg., *Lamium album* L. The number of annual cereal weeds – *Echinochloa crusgalli* (L.) Beauv. and *Setaria pumila* (Poir.) Schult was 3–4 ind./m².

Pivot, VK reduced the number of weeds by 73.3%, thus we can note its high efficiency against sow thistle, thistle, horse sorrel, starwort, and moderate action against field bindweed and frost blite. A comparative assessment of the biological effectiveness of the studied herbicides against the main species of weeds present in the experimental plots, annual and perennial dicotyledonous, annual cereal weeds is presented in Table 1.

Table 1. Biological efficiency of herbicides (average for 2018-2020).

Black currant infestation (nursery garden)							
Variant	Application rate, l/ha	Average amount of weed in variants and biological effectiveness (BE) of products, %					
		annuals		perennials		All types of weed	
		ind./m ²	BE, %	ind./m ²	BE, %	ind./m ²	BE, %
Begin Turbo, KS	2.0	7	83.7	5	70.6	13	80
Demetra, EK	0.57	5	88.4	6	64.7	11	81.7
Dialen Super, KS	1.5	6	86	5	70.6	11	81.7
Dual Gold, KE	1.3	8	81.4	7	58.8	15	75
Euro-Lighting, VRK	1.0	2	95.3	2	88.2	4	93.3
Command, KE	1.0	6	86	5	70.6	11	81.7
Pivot, VK	1.0	10	76.7	6	64.7	16	73.3
Proponit, KE	3.0	12	72.1	7	58.8	19	68.3
Zenkor Ultra, KS	1.0	5	88.4	4	76.5	9	85
Control (untreated)		43	-	17	-	60	-

Begin Turbo, KS, Dual Gold, KE, and Command, KE suppressed the development of weeds by 75-81.7%, showing high efficiency against cereal weed species present in the experiment, however, against the seedlings of perennial dicotyledonous plants, the efficiency was not 60-70% (Table 1).

Proponit, EK, demonstrated efficiency of 68.3%. This drug was also highly effective against the prevailing species of weeds, including cereals, however, it showed insufficient suppression (at the level of 58.8%) of pigweed and peppermint (Table 1).

A decrease in the quantity of weed in the variant with the use of Zenkor Ultra, KS was 85% (Table 1). This drug suppressed well such mass species as redroot amaranth, pigweed, chickweed, garden sow thistle and did not effectively act on such species as field thistle, catchweed, and field bindweed (Figure 1).

Euro-Lighting, VRK showed high efficiency (on average - 93.3%) against all types of weeds available in the experiment, which persisted throughout the growing season (Figure 2).

Dialen Super, KS showed a higher efficiency against pigweed and mayweed, reducing the total infestation by 81.7% (Table 1). Demetra, EK was especially effective against such problematic weeds as bindweed and bedstraw, less effective against perennial weeds but reduced the total weed infestation by 81.7% (Table 1). The use of soil herbicides on seedlings with a closed root system (pear, apple, walnut), infested with amaranth, barn grass, pigweed, showed high efficiency and safety for the protected crop. The use of herbicides during three years of testing has shown their safety for plants of apple, pear, walnut, black currant and red currant. The use of drugs in the rows of young and adult fruit trees, with the exclusion of contact with the leaf surface, did not cause a phytotoxic effect, although all the drugs used have a soil effect. No negative impact on the growth of plants and their yield was recorded for three years.



Figure 1. The result of using Zenkor Ultra, KS at an application rate of 1.0 l/ha on black currants (left), control on the right (untreated), 30.06.2020.

We should note that the deliberate treatment of part of the leaves of the apple and pear trees with such products as Euro-Lighting, VRK, Begin Turbo, KS, Dual Gold, KE, Command, KE and Zenkor Ultra, KS, caused discoloration of the treated leaf surface, which lasted for 30-45 days; the phytotoxic effect after ingestion of other test drugs was less pronounced. Thus, we can state that when using soil herbicides in gardens, avoid the ingress of the spray material of the drug on the leaf surface of the protected plants; the application on the stem of trees is allowed.

It is important to note that the use of soil herbicides for the maximum protective effect must be carried out on well-prepared soil (after cultivation, with a fine-lumpy



Figure 2. Application of Euro-Lighting, VRK at a consumption rate of 1.0 l/ha (upper left part of the row) and Roundup Max at an application rate of 3.0 l/ha (lower right part of the row) in a pear production garden one year after treatment, 10.05.2020.

structure), with an undried upper soil layer and the emergence of weed seedlings, in compliance with the general requirements for pesticide treatments.

4. Conclusion

- 1) The following soil herbicides showed their efficiency in the schools of seedlings, the first and second fields of the nursery, as well as in the process of producing large-sized planting material of fruit crops after tillage, when weed plants emerge: Begin Turbo, KS at an application rate of 2.0 l/ha; Demeter, KE at an application rate of 0.57 l/ha; Dialen Super, KS at an application rate of 1.5 l/ha; Dual Gold, KE at an application rate of 1.3 l/ha; Euro-Lighting, VRK; Command, KE at an application rate of 1.0 l/ha; Pivot, VK at an application rate of 1.0 l/ha; Proponite, KE at an application rate of 3.0 l/ha; Zenkor Ultra, KS at an application rate of 1.0 l/ha.
- 2) After the emergence of weed plants in seedling schools, nursery fields, and production gardens, the use of Dialen Super, KS at an application rate of 1.5 l/ha and Demeter, KE at an application rate of 0.57 l/ha is feasible.
- 3) When treating with herbicides, exclude contact of the herbicide solution with the leaves of the protected fruit trees and berry crops.
- 4) The use of the studied herbicides in seedling schools, nursery fields, and production gardens is safe regardless of the varietal characteristics and age of the trees and significantly reduces the use of manual and mechanized labor.

Acknowledgements

The article was made with support of the Ministry of Science and Higher Education of the Russian Federation in accordance with agreement N° 075-15-2020-905 date November 16, 2020 on providing a grant in the form of

subsidies from the Federal budget of Russian Federation. The grant was provided for state support for the creation and development of a World-class Scientific Center “Agrotechnologies for the Future”.

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