EFFECT OF SELECTIVE HERBICIDES IN THE PRODUCTION OF TURKEY OAK SEEDLINGS (*Quercus cerris* L.)

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Abstract. The effect of selective herbicides was studied in the production of Turkey oak (*Quercus cerris* L.) seedlings. The study was conducted in 2010 in a nursery at an altitude of 345 m. The climate is continental. The soil type is alluvial, Class (Fluvisols), type alluvial soil (Alluvial Fluvisols). The effect of different selective herbicides was studied on 2-year old Turkey oak seedlings grown in the open field. The seedlings were treated with 5 ml l^{-1} water solution of GOAL 2E (active ingredient oxyfluorfen - 240 g l^{-1}), Fuzilade Forte (active ingredient fluazifop-P-butyl - 150 g l^{-1}), Tornado (active ingredient quizalofop-P-ethyl - 50 g l^{-1}), and Furore super (active ingredient Fenoxaprop-p-ethyl 69 g l^{-1}). The results were compared with the control (untreated variant). To establish the effect of herbicides in different phenological phases of the seedlings, treatments were carried out in the beginning of growth (April 22), intensive growth (May 12), end of growth /formation of apical bud/ (June 30), and late wood production (August 2). The effect of herbicides on the seedlings was evaluated after the end of the growing season by their survival rate, length of the roots, number of stem and root branching, and dry weight of the seedlings. The results demonstrated that the selective herbicide Furore can be used for the production of Turkey oak seedlings during the whole growing season in all phenological phases.

Keywords: forest nursery, Furore super, Fuzilade Forte, Goal 2E, seedlings, Tornado.

Rezumat. Efectul ierbicidelor selective asupra producţiei de răsaduri de gorun (*Quercus cerris* L.). Efectul erbicidelor selective a fost studiat asupra producției de răsaduri de gorun (*Quercus cerris* L.). Studiul a fost realizat în 2010, într-o pepinieră, la o altitudine de 345 m. Clima este continentală. Tipul de sol este aluvial, clasa (Fluvisoluri), tipul de sol aluvial (Fluvisoluri aluviale). Efectul diferitelor erbicide selective a fost studiat pe răsaduri de gorun de 2 ani, cultivate în câmp deschis. Răsadurile au fost tratate cu 5 ml de l^{-1} soluție de apă de GOAL 2E (ingredient activ oxifluorfen - 240 g l^{-1}), Fuzilade Forte (ingredient activ Fluazifop-P-butil - 150 g l^{-1}), Tornado (ingredient activ quizalofop-P-etil - 150 g l^{-1}), și super-Furore (ingredient activ Fenoxaprop-p-etil 69 g l^{-1}). Rezultatele au fost comparate cu martorul (varianta netratată). Pentru a stabili influența erbicidelor în diferite faze fenologice, tratamentele au fost efectuate în mai multe perioade - începutul perioadei de creștere (22 aprilie), creșterea intensivă (12 mai), sfârșitul creșterii / formarea mugurilor apicali / (30 iunie) și producția de lemn (2 august). Efectul erbicidelor asupra răsadurilor fost evaluat după sfârșitul perioadei de vegetație prin rata lor de supraviețuire, lungimea rădăcinilor, numărul de ramificări ale tulpinilor și rădăcinilor și greutatea uscată a răsadurilor. Rezultatele au demonstrat că erbicidul selectiv Furore poate fi folosit pentru producerea de puieți de gorun pe toată perioada de vegetație, în toate fazele fenologice.

Cuvinte cheie: pepinieră, Furore super, Fuzilade Forte, Goal 2E, răsaduri, Tornado.

INTRODUCTION

The weed control is one of the most labour-consuming working operations in forest nurseries (BOCHEV 1988; ABRAHAMSON 1987; SOUTH 1994). Numerous researches showed the economic efficiency of the herbicides use, which is related not only to decrease in the prime-costs, but also to quality betterment of the produced seedlings (KEREMIDCHIEV et al., 1980; BOCHEV 1985, 1988; OWSTON & ABRAHAMSON 1984; SOUTH 1984, 1995; ABRAHAMSON 1987; NAMBIAR 1988). Unfortunately the potentialities of herbicides for the improvement of the production operations are still used mainly in the agriculture (GIANESSI & SANKULA, 2003).

Herbicides still have limited application in the Bulgarian forestry. Researches in this field were done already in 1956-1957 (KEREMIDCHIEV et al., 1980; VATOV & ZAHOV 1981).

Relatively more organized practical application of herbicides in Bulgaria started in 1978 when the Forestry Directorate at Ministry of Forests and Forest Industries had developed a Program for the use of herbicides in forestry (VATOV 1980).

BOGDANOV (1959), GARELKOV et al., (1962), JANAKIEV et al. (1967) published the results from their studies on herbicides application in forest nurseries and forest plantations. Later on, the potentialities of the use of herbicides in forestry was studied by SIMEONOV (1975), CHERNEV (1976), VATOV & ZAHOV (1980), BOCHEV (1981, 1982, 1985).

According to FETFADJIEVA et al. (1994), against annual graminaceous and dicotyledonous weeds, in forest nurseries there can be used selective herbicides containing the active ingredients simazin, difenamid and oxiphluorofen; or containing the active ingredients gliphozat, dikvat, hexazinot. Also, according to the National standard for plant protection (2009) GOAL 2E, Fuzilad Super, Lontrel 300 EK, Targa Super 5 EK, Tornado etc. are recommended.

The effect of most selective herbicides was evaluated for coniferous species (BOCHEV 1985; ILIEV 2009; ILIEV & ILIEV 2010; SOUTH 1995).

SOUTH (1995) recommended the application of some selective herbicides in the production of broadleaved species. However, OWSTON & ABRAHAMSON (1984) pointed out that due to numerous reasons the use of selective herbicides is not universal and the best weed control can be done by the application of several herbicides during the growing season.

The aim of the present study is to investigate the effect of several selective herbicides applied in the production of Turkey oak seedlings at various phenological phases.

MATERIAL AND METHODS

The present study was done at "Vetren" forest nursery of the State forestry "Maglizh" (village Vetren), at an altitude of 345 m. The nursery is situated in the European continental climate zone, temperate-continental zone, East transitional continental inner climatic zone. It includes the lands situated between the Balkan Range and Sredna Gora Mountain along the Tundja river valley. The type of soils is Fluvisols (*Fluvisols*), alluvial soils (*Alluvial Fluvisols*).

The effect of different selective herbicides was studied on 2-year old Turkey oak seedlings in the open field, which were treated with 5 ml l^{-1} water solution of GOAL 2E (active ingredient oxyfluorfen - 240 g l^{-1}), Fuzilade Forte (active ingredient fluazifop P-butyl - 150 g l^{-1}), Tornado (active ingredient quizalofop-P-ethyl - 50 g l^{-1}), and Furore super (active ingredient fenoxaprop-P-ethyl 69 g l^{-1}). The results were compared with the control (untreated variant) (Fig. 1).

Figure 1. Two-year old Turkey oak seedlings, treated with different selective herbicides (original).

For the evaluation of effect of the herbicides the treatments were implemented during the various phenological phases of seedlings growth i.e. beginning of growth (April 22, 2010), intensive growth (May 12, 2010), end of growth /formation of apical bud/ (June 30, 2010), and late wood production (August 2, 2010).

Three replications, each containing 100 seedlings, were used per treatment.

The effect of herbicides on the seedlings was evaluated after the end of the growing season by their survival rate, length of the roots, number of stem and root branching, and dry weight of the seedlings.

For the determination of dry weight, the seedlings were dried in drying machine at 105ºC.

The results were analysed by ANOVA (post hoc LSD test) using SPSS 10.0 (SPSS for Windows 1999).

RESULTS

The seedlings survival is the leading criterion in the analysis of each production process at forest nurseries. It gives the best idea whether the applied technologies were adequate production intervention in comparison to the existing soil and climatic conditions. After application of the tested selective herbicides the seedlings survival varies from 82.0% (Goal E2) to 90.7% (Tornado). Our results demonstrated that the higher survival rate (95.7%) was obtained when no herbicide was applied. However, this value does not differ statistically from the results obtained after the application of Fuzilade Forte (87.3%), Tornado (90.7%) and Furore (88.0%). After the treatment with Goal 2E, the seedlings survival rate (82.0%) was statistically lower in comparison to the control. The lack of statistically significant differences between the results showed that the herbicides used did not affect the survival of the seedlings (Table 1).

Table 1. Effect of selective herbicides on seedlings survival (%).

Herbicides	Survival M ± SE
Control	95.7 ± 1.2 b
Goal 2E	82.0 ± 3.5 a
Fuzilade Forte	87.3 ± 2.3 ab
Tornado	90.7 ± 2.4 ab
Furore	88.0 ± 3.8 ab

Legend: Values are mean (M) ± standard error (SE). Means in the column followed by the same letter are not significantly different estimated by One-Way ANOVA followed by a post hoc LSD test at $p < 0.05$

It is known that the herbicide Goal 2E, applied as a leaf herbicide, acts systematically and kills dicotyledonous grass species. However, its use at Turkey oak seedlings demonstrated another effect i.e. mostly contact one, inducing defoliation of all seedlings.

The Turkey oak seedlings, grown at favourable conditions, are characterized by a second and even a third increment in one growing season. This biological characteristic was observed during the implemented experiments. After the treatment with Goal 2E in the phenological phase of intensive growth (since June 21, 2010), the treated seedlings started to form new sprouts and foliage. The use of the herbicide led to 18.0% seedlings mortality (Table 2).

While the survival of seedlings is mainly a quantitative criterion in the nursery production, the length of stem and root system are the main qualitative criterions. The most negative effect on the length of the seedlings was induced by the herbicide Goal 2E, and the seedlings reached a length of 13.6 cm. Identical, or even better results from the statistical point of view, were observed at seedlings treated by Fuzilade Forte (17.9 cm) and the control (17.0 cm). Furore and Tornado herbicides did not have negative effect on the growth of the seedling. Their length reached identical values from the statistical point of view, respectively 18.1 and 19.0 cm (Table 2).While the seedlings stem length is a prerequisite for quicker initial results from the afforestation works, the quality of the produced timber is dependent on stem branching. From physiological point of view, the presence of numerous branching and dead orthotropic shoot shows the toxic effect of some of the herbicides on the buds and young shoots (specific impact of the herbicide), leading to the renewal of growing from dormant buds.

Table 2. Effect of selective herbicides on the seedling's growth.

Herbicide	Stem length (cm)	Root length (cm)	Stem branching (no.)	Root branching (no.)
Control	17.0 ± 0.3 b	35.5 ± 0.3 d	2.3 ± 0.1 a	3.0 ± 0.1 bc
Goal 2E	13.6 ± 0.4 a	26.7 ± 0.3 a	3.6 ± 0.1 c	2.4 ± 0.1 a
Fuzilade Forte	17.9 ± 0.4 bc	31.8 ± 0.3 b	2.5 ± 0.1 a	2.7 ± 0.1 b
Tornado	19.0 ± 0.4 d	32.5 ± 0.4 b	2.9 ± 0.1 b	2.2 ± 0.1 a
Furore	18.1 ± 0.4 cd	33.5 ± 0.4 c	2.4 ± 0.1 a	3.1 ± 0.1 c

Legend: Values are mean (M) ± standard error (SE). Means in the column followed by the same letter are not significantly different estimated by One-Way ANOVA followed by a post hoc LSD test at $p < 0.05$.

The statistical analysis showed that the control seedlings and those treated by Fuzilade Forte were with identically small number of lateral branching (2.3 and 2.5), hence with no toxic effect on the green parts of the seedlings. After the application of Tornado, the mean number of stem branches reached 2.9. Statistically significant the most negative effect was observed after the application of Goal 2E, where the number of stem branching was 3.6 on average (Table 2).

The root length is an indicator that has an impact on the successful adaptation and survival of seedlings in young plantations, and determines their draught resistance. The obtained results demonstrated that all used herbicides have a negative effect on the elongation of the central root. For the Turkey oak, in particular, this is not a main problem, because the deep central root without lateral branching does not favour the good adaptation and survival of seedlings in plantations. The study showed that seedlings from the control formed the longest root with an average length of 35.5 cm. The growth of the root system is in most suppressed by the application of Goal 2E and reached only 26.7 cm length. The application of Fuzilade Forte and Tornado herbicides resulted in statistically identical length of the root system (31.8 and 32.5 cm). The herbicide Furore had the slightest negative effect and the central root reached an average length of 33.5 cm (Table 2).

Having in mind the aforementioned problems with planting of Turkey oak seedlings caused by the type of the root system, the present study tried to answer the question to what extend different selective herbicides can influence the branching of the central root. The results showed that the application of Furore herbicide has no depressive effect on the branching of the root system in comparison with the control trial. Identical with the control, but with different effect in comparison to Furore is Fuzilade Forte that reduces the number of root branching to 2.7 on average. Goal 2E and Tornado had statistically identical suppressing impact on root branching as the mean number of lateral roots was 2.2 and 2.4 respectively (Table 2).

The seedlings dry weight measured in the end of the growing season is an indicator that gives additional information for seedlings physiological activity and summarizing the growing processes in all experiments.

Goal 2E has a negative effect on growing from the statistical point of view as the mean dry weight of the treated seedlings decreased to 4.6 g. The other herbicides did not show statistically significant difference from the control in regard to this indicator and the mean dry weight varied from 6.6 g (Fuzilade Forte and Tornado) to 7.4 g for the control (Table 3).

Table 3. Effect of selective herbicides on the dry weight of the seedlings (g).

Herbicide	Seedling dry weight (M ± SE)
Control	7.4 ± 0.4 b
Goal 2E	4.6 ± 0.3 a
Fuzilade Forte	6.6 ± 0.0 b
Tornado	6.6 ± 0.5 b
Furore	7.3 ± 0.1 b

Legend: Values are mean (M) ± standard error (SE). Means in the column followed by the same letter are not significantly different estimated by One-Way ANOVA followed by a post hoc LSD test at $p < 0.05$.

CONCLUSION

On the base of the obtained results, the following conclusions and recommendations can be made:

The studied selective herbicides as a whole do not lead to losses in the production process over the acceptable limit of 20%. The most suitable from this point of view are Fuzilade Forte, Tornado, and Furore. Furore and Tornado herbicides are appropriate for provision of intensive height growth and formation of quality stem of the seedlings.

All studied herbicides have a negative impact on the growth of the central root. The slightest depressive effect was observed during the application of Furore herbicide.

Fuzilade Forte and Furore can be used for the production of seedlings with quality and branched root system.

The assessment of growth processes by the accumulation of dry weight outlines the need for reduced application of Goal 2E herbicide. It could be used as defoliant in the production of Turkey oak seedlings for the interruption of the growing process in years with long, warm, and humid autumn in order to increase the seedlings sustainability to the minimum winter temperatures.

The general assessment of studied selective herbicides allows recommending the application of Furore in the production of Turkey oak seedlings throughout the whole growing season and all phenological phases of seedlings.

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