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EFFECT OF SPOTLIGHT PLUS ON DESICCATION IN SOYBEAN

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Abstract

The present study aims to evaluate the effect of different doses of the selective herbicide Spotlight Plus on desiccation in soybean. The field experiment was set up in 2022 in the region of Knezha, Northern Bulgaria. Seven treatments, including untreated control, four experimental doses of the selective product Spotlight Plus, and two dose rates of the non-selective product Beloukha with a broad spectrum action, were analyzed. The products were applied with an experimental sprayer Pulvexper at BBCH stage 87. The results showed that using the selective product Spotlight Plus containing 60 g/l carfentrazone-ethyl as a desiccator does not negatively affect the crop's yield quantity or oil content. The application with both of the tested products increased the desiccation rate on pods, stems, and leaves in comparison to the untreated plots and enhanced the crop yield.

Key words*: carfentrazone-ethyl, desiccation, herbicide, soybean, yield.*

INTRODUCTION

Legumes provide more than 69% of the protein as well as 30% of the oils needed for the human diet (Ge et al., 2016). Soybean is one of the most cultivated legume crop worldwide. The leading country in soybean production for 2020 was Brazil with 138 million tons followed by the USA with about 120.7 million tons. After that in the list are Argentina, China, and India with 46.5, 16.4, and 11.5 million tons. Although soybean is grown also in Europe, Bulgaria is not a typical soybean producer. Soybean in Bulgaria is not a fundamental crop. It is grown mainly for human consumption and for seed production for planting, or as a rotation crop. It has a favourable nitrogen balance and contributes to the long-term sustainability and higher profit (Iantcheva et al., 2021). The European Union is providing subsidies for protein crops, which could be a motivation for the farmers (Oilseeds and Products Annual Report 2021). According to Dima (2015), Romania, Bulgaria, and the Republic of Moldova could supply 5% of the European Union annual consumption of soybean (30% of non-GM soybeans annually used in the EU), equal to more than 2 million tons. Soybean has a high nutritional value. It is rich in essential amino acids as lysine, tryptophan and methionine, and for that reason soy proteins play an important role in human in animal nutrition (Iantcheva et al., 2021). Soybean meal is rich in minerals, mainly calcium, iron and potassium and contains vitamin B complex and beta-carotene. In the last years, soybean has been used as an important source of phytoestrogens (genistein) and isoflavones (Sakthivelu et al., 2008). Usually, before maturity, the soybean is treated with desiccant products. It is important for the products that are used for desiccation, to leave no residues above the accepted levels in the seed or to cause no negative effects on the yield quality or quantity, as they are used mainly for human or animal consumption. (McNaughton, 2015). Due to the fact that the crop is indeterminate and because of variations within the field, not all beans mature simultaneously (Soltani et al., 2015). To ensure uniform weed and crop desiccation and reduce these variations, as a pre-harvest aid, farmers often apply herbicides (Cole & Cerdeira 1982; Wilson & Smith, 2002). Albrecht et al. (2022) reported about plenty of benefits of pre-harvest desiccation of soybeans (*Glycine max* L.). According to the authors, this agricultural practice could control weeds, stabilize plants with green stem/leaf retention problems, accelerate and/or optimize harvest, and reduce damage from pests and fungi that may attack the crop at the end of the crop cycle (Griffin et al., 2010; Toledo et al., 2014; Bezerra et al., 2016; Bellaloui et al., 2020).

The active ingredient and the application time of the desiccation product are of great importance, as they could result in yield loss and leave herbicide residues in the grain (Azlin & McWhorter 1981; Cerkauskas et al., 1982; Smith, 1996; Wilson & Smith, 2002).

In recent years, products based on glyphosate, glufosinate, diquat, carfentrazone-ethyl and others have been widely used for the desiccation of leguminous crops. Those based on carfentrazone-ethyl gave the lowest results (Soltani et al., 2013). For this reason, desiccation was mainly carried out with diquat, glyphosate and glufosinate.

The use of glyphosate increased significantly after the cultivation of gene modified glyphosate resistant crops as rapeseed, corn, soybean, cotton and sugar beet (Cerdeira et al., 2007; Duke, 2018). As a result, glyphosate residues have been frequently detected in food (Zoller et al., 2018). According to the Food and Agriculture Organisation (FAO), both glyphosate and its primary degradation product, AMPA, lead to their accumulation in the food chain and increasing the potential risk for human health (Bai & Ogbourne, 2016).

In the last few years, however, the negative effects of the application of these active ingredients have been proven beyond doubt, and most of them have already been banned or are about to be banned for use in the next few years.

Carfentrazone-ethyl is classified as toxicity categories III and IV (USEPA, 1998) and is considered to be practically non-toxic to birds, but it is moderately toxic to aquatic animals (Han et al., 2007).

Therefore, the aim of the present study is to determine the effect of the application of carfentrazone-ethyl in soybeans, which has not been monitored in Bulgaria yet.

MATERIALS AND METHODS

Plant material

The field experiment was performed with soybean (*Glycine max* L.), cv. Srebrina - a modern Bulgarian cultivar, invented in the Experimental Station on Soybean in Pavlikeni, Bulgaria. The variety is mid-early, with growing season of 118-125 days. It has a compact habit and a resistant stem with a height of 80-98 cm, covered with short gray hairs. The mass of 1,000 seeds varies between 125-158 g. The variety is resistant to the diseases stem and bean canker, bean blight and resistant to ascochitosis, blight and bacteriosis.

Experimental design

The field experiment was set up in 2022 in the region of Knezha, Northern Bulgaria. Soybean cv. Srebrina was sown on 6 April 2022 with a sowing rate of 300,000 plants/ha. A randomized block design with four replicates was used. The young plants emerged on 20 April 2022. The treatment was performed on 19 August 2022. The air temperature during the application was 23.2°C and the relative humidity - 61%. As a test product a micro-emulsion (ME) selective herbicide Spotlight Plus (FMC Agro), containing 60 g/l carfentrazone-ethyl was chosen. As a reference product, the herbicide Beloukha (Belchim Crop Protection) was selected. It is a non-selective, broad spectrum, foliar-applied herbicide, containing 680 g/l pelargonic acid, made from sunflowers. The test variants included 1 - untreated control, 2 - Spotlight Plus (0.5 l/ha), 3 - Spotlight Plus (0.75 l/ha), 4 - Spotlight Plus (1 l/ha), 5 - Spotlight Plus (2 l/ha), 6 - Beloukha 16 l/ha, and 7 - Beloukha (32 l/ha). The products were applied with an experimental sprayer Pulvexper at BBCH stage 87 and the plant height during the application was 70 cm. The desiccation rate of leaves, stems, and beans was measured three times. The first measurement was done 3 days after the application, the second 1-9 days after the application, and the third 1-15 days after the application (on 2 August 2022, 28 August 2022, and 2 September 2022, respectively).

Statistical data analyses

The data are presented as mean of four replications. The experimental results were statistically processed with the SPSS program using a one-way ANOVA dispersion analysis, as well as Duncan's comparative method with a validity of differences determined at a 95% significance level.

RESULTS AND DISCUSSIONS

The rate of desiccation of leaves, stems, and pods is measured three times. The first observation was made 3 days after the treatment on 22 August 2022, the second 1-9 days after the treatment (28 August 2022), and the third 1-15 days after the treatment (2 September 2022 respectively). The data of the desiccation rate of leaves of soybean are presented in Figure 1.

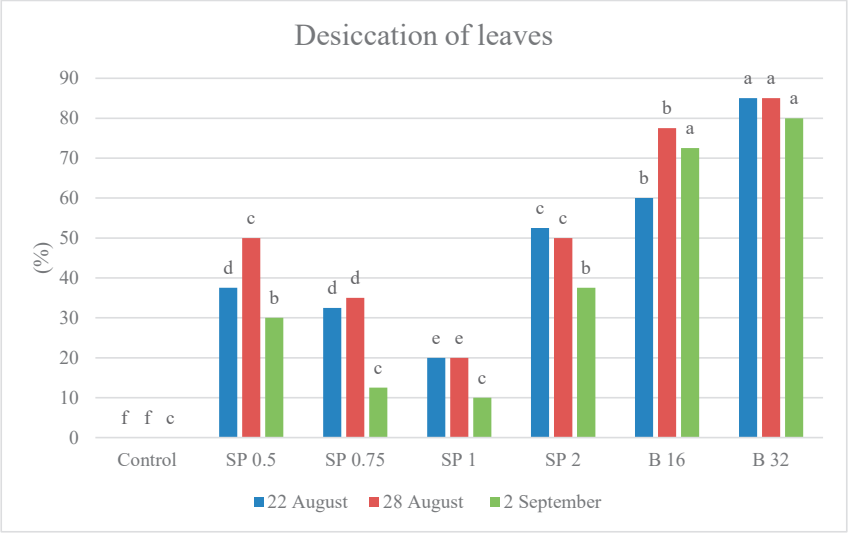

Figure 1. Desiccation rate of leaves of soybean (*Glycine max* L.) three, seven, and 14 days after herbicide application. SP - Spotlight Plus, B - Beloukha

The results show that the application of all the test products lead to an enhancement of the desiccation rate of leaves. The first observation was done three days after the herbicide treatment. A desiccation rate of about 37% higher than the control was observed when Spotlight Plus was applied in a dose of 0.5 l/ha. The increase in variant SP 0.75 and variant SP 1 was by 32% and 20%, respectively. The desiccation rate was about 52% higher when the selective product was applied in a dose of 2 l/ha. The desiccation was higher when the broad spectrum product Beloukha was applied. The percent of leaf desiccation in variants B16 and B32 was by 60% and by 85% higher than the control, respectively. The second estimation of the desiccation rate was performed three days after the first one (28 August 2022). On that date, the rate of the desiccation in variant SP 0.5 was 50% higher than the control. The dose of 0.75 l/ha lead to a 35% increase compared to the control. The rates of 1l/ha, and 2 l/ha increased the desiccation rate by 20% and 50% respectively. The desiccation on the leaves 15 days after the application enhanced by 30, 13, 10, and 38% for variants SP 0.5, SP 0.75, SP 1 and SP 2, respectively. The increase in variant B 16 and B 32 compared to the control was by 73% and 80%, respectively. The rate of desiccation of soybean stems is presented in Figure 2. At the first observation, it is seen that the application of carfentrazone-ethyl in a dose of 0.5 l/ha increased the desiccation rate by 11% compared to the control. The rate of 0.75 l/ha and 1 l/ha of the selective herbicide led to a 9% enhancement of the desiccation rate. After the application of 2 l/ha of the selective product the desiccation was 20% higher than the control.

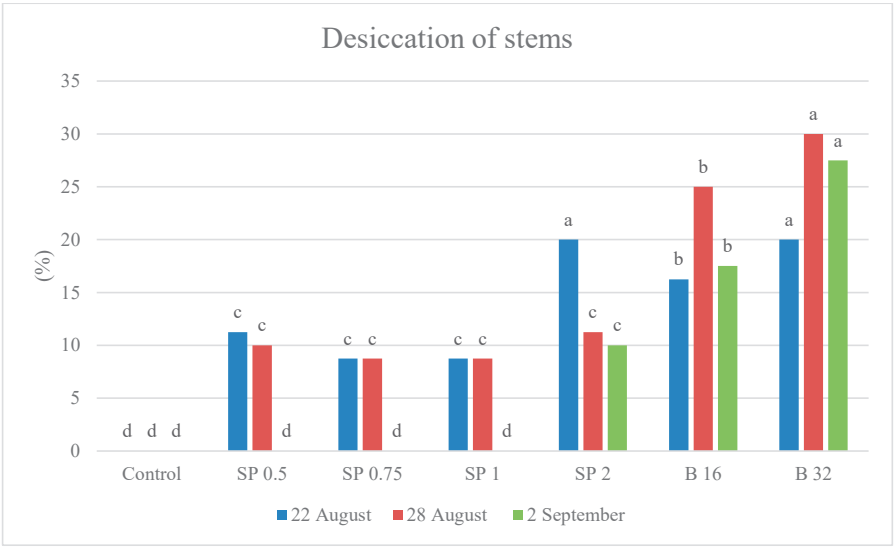

Figure 2. Desiccation rate of stems of soybean (*Glycine max* L.) three, nine, and 15 days after herbicide application. SP - Spotlight Plus, B - Beloukha

The treatment with the total herbicide increased the desiccation by 16% and by 20%, for dose rates of 16 and 32 l/ha, respectively. The second observation was performed tree days after the first one. It is seen that the rate of desiccation is the lowest in the untreated control. The enhancement in variants 2, 3, 4, and 5, where the selective product was used, was by about 10% compared to the control. A higher desiccation rate was observed when the non-selective product was applied. The increase in comparison to the untreated control was by 25 and 30%, respectively.

Fifteen days after the foliar treatment, there was no statistically proven differences between the desiccation rate of the stems of the control plants and the plants, treated with the selective product in all the rates that were lower than 1 l/ha. The spray with the highest dose (2 l/ha) increased the desiccation rate by 10% compared to the control. The application of the total herbicide increased

the desiccation by 18 and 28% for the application doses of 16 and 32 l/ha, respectively.

The desiccation rate of pods is presented in Figure 3. The first observation was performed on 22 August, three days after the application of the products. The use of 0.5 and 0.75 l/ha of the selective product led to a 6% higher desiccation rate than the control. The rate of 1 l increased the desiccation by 5%, and the rate of 2 l/ha - by 16% compared to the untreated plots, respectively. The application of the non-selective herbicide in a dose of 16 l/ha increased the desiccation rate by 6%, and the dose of 32 l/ha - by 18% compared to the untreated plots, respectively.

The second observation was done six days after the first one, on 28 August 2022. The rate of desiccation was the lowest on the untreated plots. The rate increased on the plots, treated with the selective product by 14, 13, 11, and 20% for the dose rates of 0.5, 0.75, 1, and 2 l/ha, respectively. The rate of desiccation was higher when the total herbicide was used. Both of the rates applied led to a 30% higher desiccation rate in comparison to the untreated control.

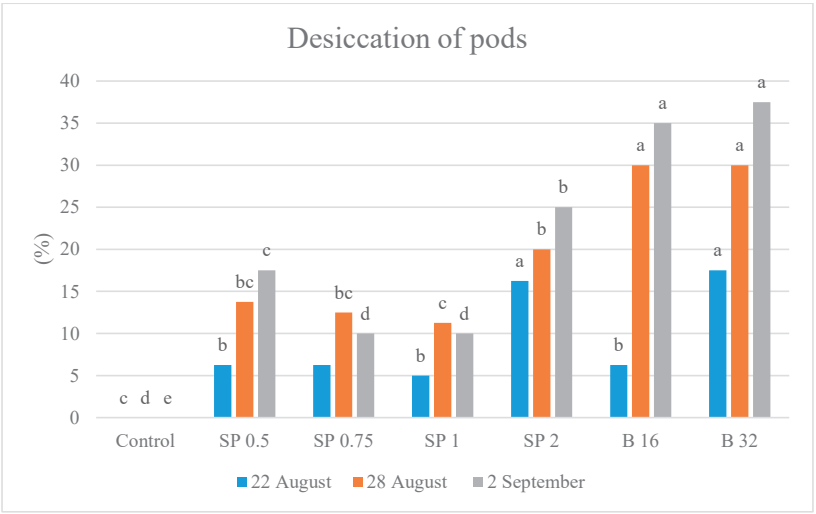

Figure 3. Desiccation rate of pods of soybean (*Glycine max* L.) three, nine, and 15 days after herbicide application. SP - Spotlight Plus, B - Beloukha

The last observation of pods desiccation was on 2 September (15 days after the application). The lowest rate of desiccation was measured on the untreated plots. In variant SP 0.5 the rate was 18%, and in variants SP 0.75 and SP 1, it was 10%, compared to the control. The highest dose of Spotlight Plus led to a 25% increase, and the application of Beloukha - 35% and 38% enhancement, compared to the untreated plots, respectively.

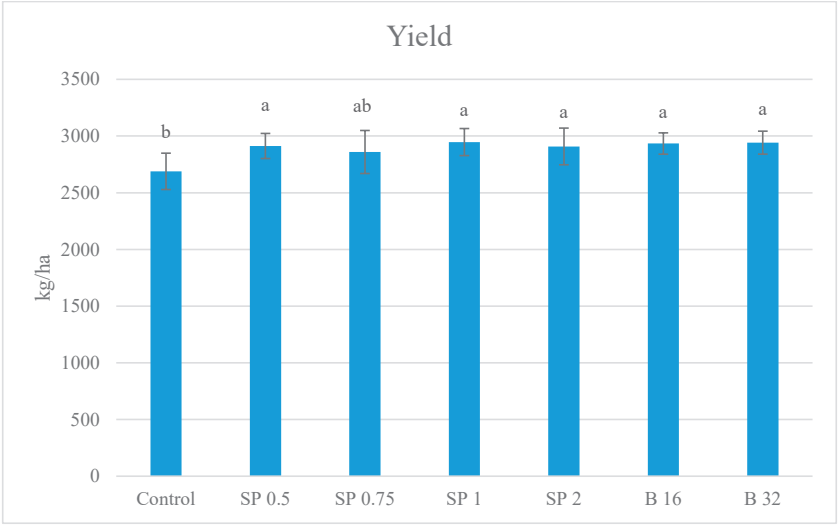

Figure 4. Yield of soybean (*Glycine max* L.) after the application of desiccation products. SP - Spotlight Plus, B - Beloukha

The yield is harvested and analyzed on 5 September 2022. The lowest yield was recorded on the untreated plots. The increase in variant SP 0.75 is by 8%. For all of the other variants the enhancement is by about 9%, compared to the untreated control.

Table 1. Parameters of the yield of soybean. SP - Spotlight Plus, B - Beloukha

Variants	TKW (g)	Moisture content (%)	Oil content (%)
Control	161.72	12.53a	36.45
SP 0.5	165.35	10.68c	36.33
SP 0.75	169.14	11.23bc	36.18
SP 1	156.77	11.93ab	37.2
SP 2	159.54	10.8bc	35.63
B 16	168.46	10.9bc	37.3
B 32	164.12	10.7c	36.73

The application of the different herbicides affected also the moisture content of the treated plants (Table 1). The moisture content was the highest in the untreated plots. There was a slight decrease in all of the other variants, varying between less than 5% in variant SP 1, and 15% in variant SP 0.5 respectively. The thousand kernel weight (TKW) as well as the oil content of soybean were not significantly affected by the treatments.

In the research of Havstad et al. (2022) a comparison between the action of Spotlight Plus, Beloukha and other herbicides was made. The effect of Beloukha was satisfactory, but as the price of that type of organic products is still high, this could be consider as a disadvantage. The treatment with Spotlight Plus had minimal or no effect in the experiment with clover, but in a research for its action in potato, the product was among the most perspective desiccants for that crop (Haesaert et al., 2004).

CONCLUSIONS

The experimental results showed that the selective herbicide Spotlight Plus, containing 60 g/l carfentrazone-ethyl, could be successfully used for pre-harvest desiccation on soybean in Bulgaria. The data demonstrated that the desiccation rate of leaves, stems and beans were higher on the sulfentrazone-ethyl-treated plots, compared to the untreated controls. According to the experimental doses, higher rates led to better desiccation, especially on pods, when applied at the rate of 2 l/ha. Two weeks after the application, some of the test plants demonstrated the tendency of recovering. The effect was satisfactory only when the highest doses were applied. Regarding the yield, the results show that both of the tested products were able to increase it and the differences were statistically proven. No statistically proven differences in oil content and thousand kernel weight were measured. After the analyses performed, as the tested product did not negatively affect the soybean yield quality or quantity, we could recommend the use of carfentrazone-ethyl in soybean in Bulgaria as a good alternative to the widely used active ingredients glufosinate and diquat.

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