SUNFLOWER PRODUCTIVITY IN RESPONSE TO HERBICIDE DIFLUFENICAN (PELICAN 50SC) AND FOLIAR FERTILIZING

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Abstract

Field experiment was conducted to evaluate the effect of herbicide Diflufenican with trade name Pelican 50 SC, biostimulant Amalgerol and foliar fertilizers KTS and Hi-Phos to the sunflower seed yield and quality. Pelican 50 SC in dose 0,250 L/ha was applied before sowing and before weeds germinating after sowing. Amalgerol in doses 3, 4 and 5 L/ha was jointly applied with KTS in doses 2,25, 4,5 and 6,75 L/ha, or with Hi-Phos in dose 5 L/ha. The highest seed yields of sunflower were obtained when Pelican50SC was applied before weeds germinating after sowing combined with Amalgerol in dose 5 L/ha and KTS in dose 6,75 L/ha or Hi-Phos in dose 5 L/ha. The obtained additional production of sunflower grain was in the range from 360 kg.ha^{-1} to 840 kg.ha^{-1}. Application of Pelican50SC before sowing and jointly foliar dressing with Amalgerol 4 L/ha and Hi-Phos demonstrated high total fat concentration and fat content. The use of Pelican 50SC, Amalgerol and foliar fertilizers increased productivity of fertilizer nutrients by 24.1 % to 55.2 %.

Key words: *sunflower, herbicide, foliar fertilizing, yield, fat*

INTRODUCTION

Sunflower is an important crop in Bulgaria with yields largely dependent on the variable climatic conditions (Chapman et al., 1993). Weiss (2000) considers that weather conditions can strongly influence sunflower responses to fertilizers. Nutrient uptake by sunflower is likely to be increased if there is adequate available soil water. In recent years many farmers are looking at ways to cut back on expenses and still produce satisfactory sunflower seed yields (Baligar, 2001). Availability of nitrogen, and consequent response to fertilizer nitrogen rates is closely linked to water availability (Blamey et al., 1997; Connor and Hall, 1997).

Modern technologies for sunflower production require a soil fertilization to be combined with application of foliar fertilizers (Bruulsema et al., 2008; Chien et al., 2009). Soil fertilization, and particularly the nitrogen fertilization, may be reduced by means of additional application of foliar biologically active fertilizers (Fageria et al., 2008). Foliar fertilization is a widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots (Shaaban, 2001). Intensive agriculture and use of high productivity cultivars led to a continuous decrease in soil micronutrient content. In addition, unfavorable soil and climate conditions cause the less availability of these nutrients to plant roots and addition of micronutrients to soil proved to be less beneficial (Hirschi, 2009). Sunflower is a sensitive crop to micronutrient deficiency, especially boron and zinc. High nitrogen rates generally increases crop susceptibility to pests and diseases (Reuveni and Reuveni, 1998). Applying foliar fertilizers, independently or together with pesticides, allow increasing the economic effect of mineral fertilization, to reduce the environment risk of pollution by reducing the rates of nutrients (Tejada and Gonzalez, 2003).

Recently a great amount of attention has been paid to enhanced efficiency of soil fertilizers. In this connections the modern production technologies in Bulgaria and worldwide a greater emphasis is placed on using mineral and complex foliar fertilizers (Delchev and Panayotova, 2010; Panayotova, 2007). The reduction of the negative effect of chemical fertilizers on the soil properties or eliminating their consequences is an issue of pressing interest for the modern agriculture; it is related to protecting the environment by obtaining ecologically clean plant products (Fageria et al., 2008; Foulkes and Hawkesfo, 2009). Foliar fertilization ensures better efficiency of the applied products as the nutrient and the biologically active substances are completely absorbed by the plants without the soil medium

where secondary processes of immobilization of the nutrient element may occur or it may be washed outside the root- system soil layer (Hirschi, 2009). The use of foliar fertilizers, independently or together with pesticides, creates an opportunity to increase the economic effect of mineral fertilization, to reduce the environment pollution by reducing the fertilizer rates and their use to the best advantage (Baligar et al., 2001).

The aim of this study was to investigate the effect of the action of diflufenican herbicide (trade name - Pelican 50 SC) and some foliar fertilizers on productivity and efficiency of nitrogen, phosphorus and potassium in sunflower.

MATERIALS AND METHODS

A field experiment with sunflower PR 64E83 hybrid was conducted during the period 2010-2011 on the location of Pazardjik, southern Bulgaria. Winter wheat was the precursor crop of sunflower. We studied the effect of herbicide Diflufenican Pelican 50SC, biostimulant Amalgerol and foliar fertilizers KTS and Hi-Phos to the sunflower grain yield and quality.

Table 1. Main agrochemical characteristics of soil.

Soil reaction, pH water	Nitrogen, mg Nmin.kg^{-1}	Available phosphorus, mg P_2O_5.100g^{-1}	Available potassium, mg K_2O.100g^{-1}
5.92	31.3	10.8	21.0

Diflufenican is selective, systemic, pre-emergence or post-emergence pyridine carbaxamide herbicide. Herbicide Diflufenican – preparation Pelican 50SC (3 L.ha^{-1}) was applied in two different times - before sowing (P1), and before weeds germinating after sowing (P2). Biostimulant Amalgerol containing extract of algae, herbs and plant oils. Potassium thiosulfate (KTS) 0-0-25-17 (S) is a chlorine-free, clear liquid solution. Foliar fertilizer Hi-Phos contents (% w/w): P_2O_5 - 30.5%, K_2O - 5.1%, MgO – 5.5%.

Biostimulant Amalgerol in doses 3 (A3), 4 (A4) and 5 (A5) L.ha^{-1} was jointly applied with foliar fertilizers KTS in doses 2.25 (KTS2), 4.5 (KTS4), and 6.75 (KTS6) L.ha^{-1}, or with foliar fertilizer Hi-Phos (5 L.ha^{-1}). The experimental design consisted of a fully randomized block design in three replications. The studied treatments were: 1. Control (no-herbicide and no-fertilizing); 2. P1+A3+KTS2; 3. P1+A4+KTS4; 4. P1+A5+KTS6; 5. P1+A3+Hi-Phos; 6. P1+A4+Hi-Phos; 7. P1+A5+Hi-Phos; 8. P2+A3+KTS2; 9. P2+A4+KTS4; 10. P2+A5+KTS6; 11. P2+A3+Hi-Phos; 12. P2+A4+Hi-Phos; 13. P2+A5+Hi-Phos.

The soil type was Chromic luvisols (FAO, 2002). The agrochemical characteristics of soil in the arable layer before sowing of sunflower are listed in Table 1. The soil reaction (in water) and contents of available nutrients nitrogen, phosphorus and potassium were analyzed according methods described by Tomiv et al., 2009. The soil fertilization before sowing of the sunflower was done by applying of nutrients in rates $N_{120}P_{80}K_{60}$. The nitrogen was applied as NH_4NO_3 and phosphorus - as triple superphosphate. As source of potassium was used potassium chloride. The studied parameters of sunflower were seed yields, and concentration and yield of fats. The nutrient use efficiency of main nutrients nitrogen, phosphorus and potassium was estimated by the index partial factor productivity of applied nutrient (PFP). This parameter show kilogram harvested product per kg nutrient applied and it was calculated as PFP=Y/F, where Y was seed yield of sunflower and F – rates of fertilizers.

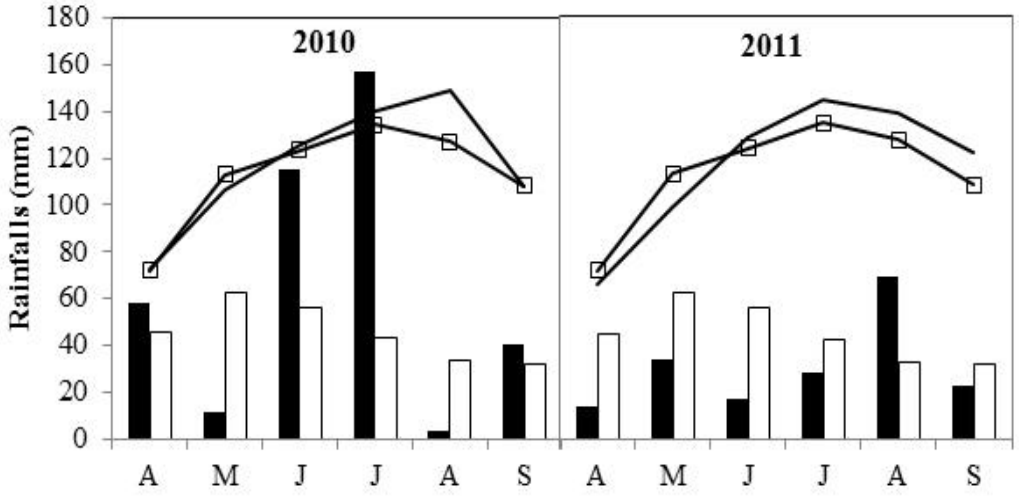


Figure 1. Air temperature and rainfalls: white bars and lines with bars denote mean values of previous period of 70 years

Meteorological conditions during sunflower vegetation are given in Figure 1. The data of temperatures showed that the summer of 2011 was hot with high temperature in August. Experimental years were very different with respect to the amount and distribution of rainfall throughout the sunflower vegetation. There was registered 113 mm more rains than usual for vegetation period in 2010, but the sums of precipitation over the maize growth in 2011 were below than average norm of the region. The lowest rainfalls sum during the period of April – September was observed in 2011.

All data were analyzed statistically according to the analysis of variance (ANOVA) procedure and significant differences ($p<0.05$) among treatment means were identified using Duncan's multiple range test.

RESULTS AND DISCUSSION

Studied combinations of herbicide Diflufenican Pelican 50SC with biostimulant Amalgerol and foliar fertilizers KTS and Hi-Phos showed proven increasing of grain yield of sunflower in average for both experimental years (Table 2).

The quantity of additional production of sunflower grain as a result of herbicide and foliar treatments was increased from 360 kg.ha^{-1} (at variant 2. P1+A3+KTS2) to 840 kg.ha^{-1} (at variant 10. P2+A5+KTS6). The highest average sunflower grain yield (2350 kg.ha^{-1}) was obtained in variant ten when herbicide Diflufenican Pelican 50SC) was applied before weeds germinating after sowing combined with biostimulant Amalgerol in dose 5 L.ha^{-1} and foliar fertilizer KTS in dose 6.75 L.ha^{-1}. The data showed high effect on the sunflower grain productivity when herbicide was applied before weeds germinating after sowing combined with biostimulant Amalgerol in dose 5 L.ha^{-1} and foliar fertilizer Hi-Phos (treatment P2+A5+Hi-Phos), as well. In these two variants sunflower grain yield was increased relative to the control by 55.6% and 52.3%, respectively. The positive effect on the productivity of sunflower was the least manifested in variants with a low dose of biostimulant Amalgerol (3 L.ha^{-1}) combined together with a low dose of 2.25 L.ha^{-1} of foliar fertilizer KTS or 5 L.ha^{-1} of foliar fertilizer Hi-Phos. In these treatments, the grain yields were increased by 23.8% and 27.8%, respectively, compared with the control variant. The time of applying of the herbicide did not affect significantly the grain yield of sunflower.

Table 2. Sunflower grain yields in response of herbicide application and foliar fertilizing, kg/ha

Treatment	Kg.ha^{-1}	± over the Control	%
1. Control	1510 f	0	100
2. P1+A3+KTS2	1870 e	360	123.8
3. P1+A4+KTS4	1950 cde	440	129.1
4. P1+A5+KTS6	2180 abcd	670	144.4
5. P1+A3+Hi-Phos	1900 de	390	125.8
6. P1+A4+Hi-Phos	2070 abcd	560	137.1
7. P1+A5+Hi-Phos	2240 abc	730	148.3
8. P2+A3+KTS2	1930 de	420	127.8
9. P2+A4+KTS4	2050 bcd	540	135.8
10. P2+A5+KTS6	2350 a	840	155.6
11. P2+A3+Hi-Phos	2030 bcd	520	134.4
12. P2+A4+Hi-Phos	2150 abcd	640	142.4
13. P2+A5+Hi-Phos	2300 ab	790	152.3

* Values followed by the same letter(s) within the same column and treatment group are not significantly different at the 5% probability level according to the Duncan's multiple range test

Fat concentration of grain and fat content and yield are of the most important quality characteristics of the seeds of sunflower (Table 3). Average fat content was changed ranging from 39.5% (treatment P2 + A5 + Hi-Phos) to 52.5% in variant 6. P1 + A4 + Hi-Phos. The result showed increased fat concentration of sunflower grain in variants 4. P1 + A5 + KTS6, 6. P1 + A4 + Hi-Phos and 8. P2 + A3 + KTS2 and the values exceeded the control variant of 19.5% to 29.9%. A trend indicated that variants in which the herbicide Diflufenican Pelican 50SC was applied before weeds germinating after sowing (P2) demonstrated a higher average fat content of sunflower grain (46.8%), compared to the treatments where the herbicide was used before sowing (P1), where the fat concentration was 42.8% on average.

Table 3. Fats concentration of sunflower seeds in response of herbicide application and foliar fertilization, %

Treatment	%	± over the Control	% to the Control
1. Control	40.4	0	100
2. P1+A3+KTS2	46.9	6.5	116.1
3. P1+A4+KTS4	40.8	0.4	101.1
4. P1+A5+KTS6	48.3	7.9	119.5
5. P1+A3+Hi-Phos	44.6	4.2	110.4
6. P1+A4+Hi-Phos	52.5	12.1	129.9
7. P1+A5+Hi-Phos	47.6	7.2	117.8
8. P2+A3+KTS2	49.8	9.4	123.3
9. P2+A4+KTS4	41.6	1.2	103.0

10. P2+A5+KTS6	42.1	1.7	104.2
11. P2+A3+Hi-Phos	43.3	2.9	107.2
12. P2+A4+Hi-Phos	40.8	0.4	101.0
13. P2+A5+Hi-Phos	39.5	-0.9	97.6

Fat yield of sunflower was increased as a result of the application of herbicide Diflufenican Pelican 50SC, biostimulant Amalgerol and foliar fertilizers KTS and Hi-Phos (Table 4). All studied combination of the applied herbicide must foliar products in sunflower demonstrated proven higher fat grain yield in comparison to the control variant. The lowest fat yield was obtained from the untreated with the herbicide and leaf products control plants - 610 kg.ha^{-1}. The data indicated a trend that the using of the herbicide before sowing (P1) let to increasing the fat grain yields of sunflower. The resulting average fat content of the studied variants with included biostimulant Amalgerol and foliar fertilizers was 954 kg.ha^{-1}, which was 43 kg.ha^{-1} more than the average fat grain yield from the treatments where the herbicide was applied before weeds germinating after sowing (P2). The highest fats content of sunflower grain (1086 - 1066 kg.ha^{-1}) were obtained in variants foliar treated with biostimulant Amalgerol in doses 4 L.ha^{-1} and 5 L.ha^{-1} and foliar fertilizer Hi-Phos (5 L.ha^{-1}) – treatments 6. P1+A4+Hi-Phos and 7. P1+A5+Hi-Phos.

The results showed a rise of fat contents of sunflower grain by 45.5 – 47.6 kg.ha^{-1} over the control treatment. A high positive effect on the fat grain yield of sunflower was established from the application of foliar fertilizer potassium thiosulfate in dose 6.75 L.ha^{-1} in combination with a biostimulant Amalgerol in dose 5 L.ha^{-1} regardless of the time of applying of the herbicide Diflufenican - preperetion Pelican 50SC. In these two variants the yield of fat in the grain of the sunflower was increased by 62.2% to 72.5%, compared to the control treatment.

Table 4. Fats content of sunflower grain in response of herbicide application and foliar fertilization, kg/ha

Treatment	Kg.ha^{-1}	± over the Control	%
1. Control	610 e	0	100
2. P1+A3+KTS2	877 bcd	26.7	143.8
3. P1+A4+KTS4	796 d	18.6	130.5
4. P1+A5+KTS6	1053 a	44.3	172.5
5. P1+A3+Hi-Phos	847 cd	23.7	138.9
6. P1+A4+Hi-Phos	1086 a	47.6	178.1
7. P1+A5+Hi-Phos	1066 a	45.6	174.7
8. P2+A3+KTS2	961 abc	35.1	157.6
9. P2+A4+KTS4	853 cd	24.3	139.9
10. P2+A5+KTS6	989 ab	37.9	162.2
11. P2+A3+Hi-Phos	879 bcd	26.9	144.1
12. P2+A4+Hi-Phos	877 bcd	26.7	143.8
13. P2+A5+Hi-Phos	907 bcd	29.7	148.7

* Values followed by the same letter(s) within the same column and treatment group are not significantly different at the 5% probability level according to the Duncan's multiple range test

The efficiency of fertilization was characterized by the main indicator of the crop practice - partial factor productivity of nitrogen, phosphorus and potassium (Delogua et al., 1998; Snyder, 2009; Bruulsema at al., 2008). Partial factor productivity is the most important for farmers because it integrates the use efficiency of both indigenous and applied nutrients. High indigenous soil nutrient supply and high agronomic efficiency are equally important for this index. Partial factor productivity represents the kilogram of grain harvested per kilogram of N, P_2O_5 or K_2O of fertilizer applied. It can be used as an index of total economic outputs relative to the use of all NPK sources – nutrients from soil and applied fertilizer (Weih et al., 2011). The calculated values of partial factor productivity of nitrogen, phosphorus and potassium in sunflower were low in the untreated control (Table 5). The use of herbicide, biostimulant Amalgerol and foliar fertilizers demonstrated a positive influence on the productivity of nitrogen, phosphorus and potassium from soil applied fertilizers. Partial factor productivity of NPK was increased by 24.1 % to 55.2 %, compared to the control. Applying of herbicide Diflufenican Pelican 50SC before weeds germinating after sowing (P2) combined with biostimulant Amalgerol (5 $L.ha^{-1}$) and foliar fertilizer KTS (6.75 $L.ha^{-1}$) or foliar fertilizing with Hi-Phos was showed the highest average productivity of nitrogen, phosphorus and potassium – increased by 51.7 – 55.2 % in comparison to the control.

Table 5. Partial factor productivity of nitrogen, phosphorus and potassium in sunflower

Treatment	PFP-N	PFP-P	PFP-K	PFP-NPK	%
1. Control	12.6	18.9	25.2	5.8	100
2. P1+A3+KTS2	15.6	23.4	31.2	7.2	124.1
3. P1+A4+KTS4	16.3	24.4	32.5	7.5	129.3
4. P1+A5+KTS6	18.2	27.3	36.3	8.4	144.8
5. P1+A3+Hi-Phos	15.8	23.8	31.7	7.3	125.9
6. P1+A4+Hi-Phos	17.3	25.9	34.5	8.0	137.9
7. P1+A5+Hi-Phos	18.7	28.0	37.3	8.6	148.3
8. P2+A3+KTS2	16.1	24.1	32.2	7.4	127.6
9. P2+A4+KTS4	17.1	25.6	34.2	7.9	136.2
10. P2+A5+KTS6	19.6	29.4	39.2	9.0	155.2
11. P2+A3+Hi-Phos	16.9	25.4	33.8	7.8	134.5
12. P2+A4+Hi-Phos	17.9	26.9	35.8	8.3	143.1
13. P2+A5+Hi-Phos	19.2	28.8	38.3	8.8	151.7

CONCLUSIONS

Herbicide Diflufenican with trade name Pelican 50SC jointly used with biostimulant Amalgerol and foliar fertilizers KTS and Hi-Phos proven increased grain yield and fat grain yield of sunflower. The obtained additional production of sunflower grain was in the range from 360 $kg.ha^{-1}$ to 840 $kg.ha^{-1}$. The highest average grain yield of sunflower (2350 $kg.ha^{-1}$) was established when herbicide Diflufenican – preparation Pelican 50SC was applied before weeds germinating after sowing combined with biostimulant Amalgerol in dose 5 $L.ha^{-1}$ and foliar fertilizer KTS in dose 6.75 $L.ha^{-1}$.

It was showed a trend indicated that variants in which the herbicide Diflufenican – preparation Pelican 50SC was applied before weeds germinating after sowing was demonstrated a higher average fat content of sunflower grain (46.8%), compared to the treatments, where the herbicide was used before sowing.

The highest fats content of sunflower grain (1086 - 1066 kg.ha^{-1}) were obtained in variants foliar treated with biostimulant Amalgerol in doses 4 L.ha^{-1} and 5 L.ha^{-1} and a foliar fertilizer Hi-Phos in dose 5 L.ha^{-1} regardless of the time of applying of the herbicide Diflufenican – preparation Pelican 50SC.

The use of herbicide – preparation Pelican 50SC, biostimulant Amalgerol and foliar fertilizers increased productivity of fertilizer nutrients by 24.1 % to 55.2 %. The highest average partial factor productivity of nitrogen, phosphorus and potassium was established at applying of herbicide Diflufenican – preparation Pelican 50SC before weeds germinating after sowing combined with biostimulant Amalgerol (5 L.ha^{-1}) and foliar fertilizer KTS (6.75 L.ha^{-1}) or foliar fertilizing with Hi-Phos (5 L.ha^{-1}).

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