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CONTROL OF HIGHLY BLENDED WEEDING AT MAIZE (ZEA MAYS L.)

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Abstract

The experimental work was carried out during 2013-2015 in the training and experimental base for implementation of the Agricultural University of Plovdiv. In the trail the maize (*Zea mays L.*) hybrid “Florence” (FAO group 480) was used. The plant density was 6500 plants da^{-1}. In the experiment three herbicide tank mixtures during the vegetation were applied. In each of the herbicide combinations, the product Nishin 4 OD (40 g/l nicosulfuron) at dose of 130 ml da^{-1} was used. Against the broad leaf weeds, the herbicides Flurostar 200 EC (200 g/l fluroxypyr) at dose of 70 ml da^{-1}, Mustang 306.25 SC (florasulam + 2.4 D) at dose of 60 ml da^{-1} and Kalisto 480 SC (480 g/l мezotrione) at dose of 20 ml da^{-1} were applied. All products were studied together with one and two mechanized intercrop soil tillages. On one third of the treated experimental plots the soil tillages were not applied. The three herbicide mixtures were highly effective against the weeds and selective for maize. They effectively protect the crop free of weeds for more than 60 days. The highest efficacy against weeds and maximum yield was obtained after the combined usage of the herbicides Flurostar 200 EC + Nishin 4 OD. In the conditions of highly blended weeding, the mechanized soil tillage complemented the herbicide efficacy in the weed management very well.

Key Words: *maize, herbicides, soil tillages, weeds*

Introduction

Maize (*Zea mays L.*) is main grain-forage crop with adaptive ability to different geographical and climatic conditions. That is the reason for the successful growing of this culture in many regions around the globe. In Bulgaria it is strategical field crop. Maize has the highest energy value in comparison to the others forage crops (Tomov and Yordanov, 1984). The quality of maize grain is the main factor for the wealthy nutrition of the farm animals (Ivanov, 2007). One of the main negative factors for agricultural production is the weeds. They decrease the yields and the quality of maize grain (Spasov, 1995; Masqood *et al.,* 1999; Tonev, 2000; Werner *et al*., 2004; Changsaluk *et al.*, 2007). Weeds are annually emerging all over the fields and are causing great damage of the maize production (Tonev *et al.*, 2007). There are a lot of publications that indisputably prove the harmful effects of the weeds in the crops. There is large number of possibilities to control the weeds by mechanical tilth and chemical applications (Fetvadzieva, 1982; Spasov, 1995; Fetvadzieva *et al.*, 1991). Mezotrione for example is a member of the benzoylcyclohexane-1,3-dione herbicides, which are chemically derived from a natural phytotoxin of *Callistemon citrinus* (Curtis) plants. Mezotrione has been shown to be effective for both pre- and postemergence control of weeds in maize (Sutton *et al.,* 1999; Armel *et al.,* 2003). Nicosulfuron is a postemergence sulfonylurea herbicide that even in low rates can control many difficult to manage monocotyledonous weeds at maize (Green and Hale, 2005). Integrating the intercrop tillage with contemporary herbicides at maize is a perspective way for obtaining high efficacy of weed control and decreasing the harmful after-effect of the products for plant protection (Ljubenov, 1988; Tonev, 2006).

The objective of the study is to determine the alone and combine effect of systemic leaf herbicides applied together with three different intercrop tillages and their influence on maize grain yields.

Material and Methods

The experimental work was carried out during the period from 2013 to 2015 in the training and experimental base for implementation of the Agricultural University of Plovdiv. The trail was conducted by the split plot method with 12 variants in 4 replications. The size of the experimental plots was 60 m^2.

Table 1. Variants of the trail

X_1 Flurostar 200 EC - 70 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}	250 g/l fluroxypyr + 40 g/l nicosulfuron
X_2 Mustang 306.25 SC - 60 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}	6.25 g/l florasulam + 300 g/l 2.4 D ester + 40 g/l nicosulfuron
X_3 Kalisto 480 SC - ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}	480 g/l мezotrione + 40 g/l nicosulfuron
T_1 (a)	Without mechanized tillage
T_2 (b)	With one mechanized tillage
T_3 (c)	With two mechanized tillages

The herbicide efficacy was compared with the untreated controls. Each of the treated 60 m^2 plots was divided into three different 20 m^2 plots. On one of these plots two mechanized tilleges were done - first tillage in phenophase 3rd – 4th leaf and second tillage in 7th – 8th leaf of maize. On the second of these plots only one tillage in phenofase 3rd – 4th leaf of the crop was accomplished. On the third plot the weeds were controlled only with the evaluated herbicides and no tillage was performed. The herbicides were sprayed just before the tillage was done. The expense of spray solution was 25 l da^{-1}.

In the trail the maize (*Zea mays L.*) hybrid “Florence” (FAO group 480) was used. Plants were grown under irrigated conditions and the plant density was 6500 plants da^{-1}. Herbicides were applied with back sack sprayer for plot trails (brand “Solo”).

The tillage during the vegetation was done with cultivator for intercrop dredging. The second tillage was combined with earthing up of the maize.

Predecessor of maize in the crop rotation was winter wheat. After the wheat harvest deep plowing at 30-32 cm depth was done. Before this tillage fertilization with 16 kg P_2O_5 and 12 kg K_2O da^{-1} was applied (the fertilizer rates are in active substance). Before maize sowing, fertilization with nitrogen at rate of 22 kg da^{-1} was applied.

The herbicide efficacy was reported on the 14th, 28th and 56th day after treatment. The weed species were observed by the visual scale of EWRS (European Weed Research Society), and the degree of weeding was evaluated by the quantitative method (number of weeds per 1 m^2).

The maize grain yield was recorded on the base of experimental plot for the four replications. The standard grain humidity was 14 %. For disperse statistical analyses of the collected data, the software package of Biostat 5.1 was used (Penchev, 1998).

Results and Discussion

According to Tonev *et al*. (2008) maize is highly sensitive to weeding especially in the early development stages. That is observed especially in the cases when the germination is delayed because of unfavorable conditions. It is proved by a lot of experimental work that at high weed infestation the maize grain yield could be decreased from 77 to 91 % (Tonev *et al.*, 2008). For the current study natural background of weeding of the maize field of the experimental base of the Agricultural University of Plovdiv was used. The weed associations that prevailed on the field during the experimental period were 12 annual species: Common amaranth (*Amaranthus retroflexus L.*), Thorn apple (*Datura stramonium L.*), Rough cocklebur (*Xanthium strumarium L.*), Black nightshade (*Solanum nigrum L.*), Fat-hen (*Chenopodium album L.*), Velvetleaf (*Abutilon theophrasti L.*), Purslane (*Portulaca oleraceae L.*), Wild raddish (*Raphanus raphanistrum L.*), Charlock (*Sinapis arvensis L.*), Barnyard grass (*Echinochloa crus gali L.*), Yellow bristle-grass (*Setaria glauca L.*) and Red finger-grass (*Digitaria sanguinalis L.*). From the perennial weed species, with highest density were Johnson grass *(Sorghum halepense L.*), followed by Field bindweed (*Convolvulus arvensis L.*), Bermuda gras (*Cinodon dactilon L.*) and Creeping thistle (*Cirsium arvense L.*). The examined herbicide mixtures were with closer spectrum of action. The studied herbicide combinations controlled mostly the annual broad leaf and grass weeds, as well as the Johnson grass *(Sorghum halepense L.*) developed from seeds and rhizomes and also the root-sprouted species. As leaf herbicides, their efficacy against the weeds was not highly influenced by the soil moisture at the time of the treatment, as well as the net precipitation and its distribution. On table 2 is shown the efficacy against weeds after the alone and combined effect of herbicide application and intercrop tillage at maize 56 days after treatments.

Table 2. Efficacy against weeds after the alone and combined effect of herbicides application and intercrop tillage average for the period of the study (2013-2015)

Var.	Herbicide / tillage	Average weed number per 1 m^2 – 56 days after treatment				Total weed number
		Monocotyledonous	Di-cotyledonous	Annual	Perennial	
X_1 Flurostar 200 EC - 70 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}						
1.	Without mechanized tillage	5.6	5.2	10.8	11.8	22.6
2.	With one mechanized tillage	3.4	2.6	6.0	8.8	14.8
3.	With two mechanized tillage	1.4	1.4	2.8	5.6	8.4
X_2 Mustang 306.25 SC - 60 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}						
4.	Without mechanized tillage	4.8	5.0	9.8	16.2	26.0
5.	With one mechanized tillage	1.8	3.2	5.0	10.6	15.6
6.	With two mechanized tillage	1.0	1.8	2.8	6.4	9.2
X_3 Kalisto 480 SC - 20 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}						
7.	Without mechanized tillage	3.8	7.6	11.4	18.6	30.0
8.	With one mechanized tillage	2.0	4.4	6.4	13.2	19.6
9.	With two mechanized tillage	1.4	3.2	4.6	8.6	13.2
Without herbicide application						
10.	Without mechanized tillage	42.6	65.6	108.2	25.6	133.8
11.	With one mechanized tillage	19.4	38.8	58.2	19.4	77.6
12.	With two mechanized tillage	11.6	21.8	33.4	8.8	42.2

The highest total weed number on the 14^{th} day after the treatments was 141.2 specimens per 1 m^2 at the untreated control (without herbicide application and without tillage). On the same date, after the application of the studied herbicides, at the variants without applied tillage, the total weed number was as follows: At variant X_1 (Flurostar 200 EC - 70 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}) – 29.5, at variant X_2 (Mustang 306.25 SC - 60 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}) – 32.8 and at variant X_3 (Kalisto 480 SC - 20 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}) – 37.0 specimens per 1 m^2. At the second report of the herbicides efficacy (on 28th day after treatments) the total number of unaffected weeds was again for the untreated control - 138.4 specimens per 1 m^2. The number of unaffected weeds at the treated plots was as follows: At variant X_1 – 25.4, at variant X_2 – 29.6 and at variant X_3– 33.2 specimens per 1 m^2.

The highest total weed number on the 56th day after treatments was for the untreated control – 133.8 per 1 m^2 (Table 2). After the usage of the herbicides without application of tillage there were a number of weeds that remained in the field. The number of the existing specimens after the treatments were: At variant X_1 – 22.6 specimens per 1 m^2, at variant X_2 – 26.0 specimens per 1 m^2 and at variant X_3 – 30.0 specimens per 1 m^2. The main part of not influenced or recovered weeds after the treatments were mostly from the perennial species.

The highest efficacy of the examined herbicide tank mixtures was recorded at the combination of Flurostar 200 EC - 70 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1} (Table 2). The supremacy of the herbicide compilation with Mustang 306.25 S + Nishin 4 OD - 130 ml da^{-1} was observed at the high density of the weed Fat-hen (*Chenopodium album L.*) in 2014. The superiority of Flurostar 200 EC was strongly revealed at the fields infested with Field bindweed (*Convolvulus arvensis L.*). That could be explained with the fact that the active substance of this herbicide (fluroxypyr) have very high efficacy against this weed.

By the one or especially two intercrop tillages more than the half of the unaffected from the herbicides weed plants, were temporarily cut. That was inhibiting their growth and development. At the conditions of highly blended weeding with different species, the intercrop tillage successfully supplemented the herbicide effect of the used products. The tillage complemented maize to use fully the resources like water, light, soil nutrients and air. The tillages contributed for the statistically proved increase of the maize grain yields when compared with any of the variants with applied herbicides without any performed tillage.

Table 3. Maize grain yields (kg da^{-1})

Variants		Yields			Average
		2013	2014	2015	
X_1 Flurostar 200 EC - 70 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}					
1.	1 a	900	802	728	912
2.	1 b	944	888	904	988
3.	1 c	1000	922	1042	1036
X_2 Mustang 306.25 SC - 60 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}					
4.	2 a	880	894	962	810
5.	2 b	1002	932	1030	912
6.	2 c	1034	962	1112	988
X_3 Kalisto 480 SC - 20 ml da^{-1} + Nishin 4 OD - 130 ml da^{-1}					
7.	3 a	800	776	788	788
8.	3 b	956	846	766	856
9.	3 c	1002	922	908	944
Without herbicide application					
10.	4 a	296	274	234	268
11.	4 b	486	456	390	444
12.	4 c	730	636	512	626
GD 5% =		22.26	24.58	28.64	
GD 1% =		30.44	36.48	36.40	
GD 0,1% =		44.42	40.22	44.68	

Pandej (1989) conduct field trials in Bihar and recoreded that the earthing up at the 25th or 25th and 45th days after sowing as well as the application of metribuzin at dose of 0.5 kg ha^{-1} and pendimethalin at 1.0 kg ha^{-1} (at pre-emergence), and spraying with 2.4-D at 0.8 kg ha^{-1} after emergence led to increasing of maize yield and suppressed the Wild hemp (*Canabis sativa L.*) growth. The best results in the study were recorded after usage of metribuzin and pendimethalin + two times earthing up. The highest yield average for the period in our study was achieved after the combined application of Flurostar 200 EC - 70 ml da^{-1} + Nishin 4 OD - 130 ml/da + two intercrop tillages – 1036 kg da^{-1} (Table 3). At the variants treated with herbicides plus one intercrop tillage the maize grain yield was increased from 68 to 102 kg da^{-1}. The two intercrop tillages together with herbicide spraying contributed for even higher yield increase – from 124 to 178 kg da^{-1}.

The selectivity of the studied herbicides to maize on the 10th and on the 20th day after the treatment was reported. There were not visually observed symptoms of fitotoxicity on the crop in any of the three years of the trail.

Conclusions

The three examined tank mixtures of the products Nishin 4 OD with Flurostar 200 EC, Mustang 306.25 SC and Kalisto 480 SC were herbicide combinations with strong effect against the broadleaf and grass weeds. The products had also continuous influence on weeds that was observed on the 56th day after treatments.

The studied herbicide mixtures were highly selective for the maize crop.

The highest herbicide efficacy and the highest maize grain yields were obtained after the use of Flurostar 200 EC + Nishin 4 OD. The active substance of the product Flurostar 200 EC (fluroxypyr) had excellent control of the broadleaf weed - Field bindweed (*Convolvulus arvensis L.*).

At the conditions of highly blended weeding with different species the intercrop tillage successfully supplemented the herbicide effect of the used products that lead to increasing of the maize grain yields.

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