



## Efficacy of different herbicide combinations for weed control in irrigated maize silage

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(Manuscript received 1 October 2019; accepted for publication 13 January 2020)

**Abstract:** The aim of this study was to establish the efficacy of herbicide combinations between Tender EC and Titus + Magneto SL, and Wing P and Mistral Opti applied in a field of maize under the conditions of mixed irrigation. The study has been carried out with maize cultivated on meadow-cinnamon soil at the experimental field of the Agricultural Institute - Stara Zagora for the period 2014-2016. The research was conducted with a mid-grade hybrid corn LG35.62 with the same background of fertilization and irrigation with the following variants: 1) Control (without herbicides); 2) Wing P - 4000 ml/ha and Mistral Opti - 210 ml/ha, and 3) Tender EC - 1500 ml/ha and a mixture of Titus - 40 g/ha + Magnet SL - 1200 ml/ha. Increase of maize yield by 41.6% (on average) in comparison with the control variant and by 28.9% compared to the variant Wing P and Mistral Opti was found.

**Keywords:** maize, weeds, herbicides, yield, efficacy of herbicides

### Introduction

The limitation of weeds is one of the important factors that affects the development and yield of maize. Maize is highly susceptible to weeds, and yield is significantly reduced when the weeds are irregularly eliminated, especially in the early stages of its development (Spasov and Zhelyazkov, 2002). Secondary weeds should not be ignored, especially under irrigation conditions, which also reduces yields, but to a much lesser extent (Bazitov and Pavlov, 2005; Georgieva, 2008). A number of herbicides and herbicidal sessions with different active substances, doses and spectrum of activity have been tested for different maize hybrids in recent years (Molnar et al., 2001; Panfilov, 2002; Milivojevic et al., 2003; Mikova and Stoimenova, 2006; Hristova, 2007, 2008; Kopmanis and Gailé, 2008, 2010; Delchev, 2013, 2016). In the case of maize, large quantities of herbicides and herbicidal mixtures have been tested, and for technological, health, environmental and other reasons, have been periodically dropped and replaced with new ones. Studies show that the effectiveness of herbicides and herbicide mixtures depends mainly on the nature and degree of weeding of the crops, as well as on the growing conditions of the maize. The purpose of the present study was to determine the effect of the herbicide combinations Tender EC and Titus+Magneto SL, and Wing P and Mistral Opti in agrocenosis of irrigated maize silage under mixed weeded type.

### Material and methods

The study has been carried out with maize on meadow-cinnamon soil at the experimental field of the Agricultural Institute - Stara Zagora for the period 2014-2016. The soil in the test area was

characterized by a medium humus horizon. It is poor in nitrogen (31.3-38.1 mg/kg soil), poorly stored with absorbed phosphorus (3.1-4.3 mg/kg soil) and well stocked with digestible potassium (42.3-48.1 mg/100g soil). We experimented with the method of long plots in four repetitions with the size of the harvest plot.

The study was conducted with a mid-grade hybrid corn LG35.62 with the same background of fertilization and irrigation with the following variants:

- 1) Control (without herbicides);
- 2) Wing P (250 g/l Pendimethalin, 212.5 g/l Dimethenamide-P) - 4000 ml/ha (applied after sowing, before germination of maize) and Mistral Opti (240 g/l nicosulfuron) - 210 ml/ha (applied in stage 3-5 leaves of maize), and
- 3) Tender EC (960/l, S- Metolachol) - 1500 ml/ha (applied after sowing, before maize emergence) and a mixture of Titus - (Rimsulfuron) - 40 g/ha + Magnet SL (2.4D+Dicamba) -1200 ml/ha (applied in stage 3-5 leaves).

The doses of herbicides were given in technical preparation per hectare. The variants were earthed between the rows once and all furrowed for irrigation. During the vegetation of maize, an optimal humidity of 80-85% of the field capacity (FC) was maintained through three irrigations. The degree of weeding has been of a mixed type during the years of the study. In the weeds of one-year, monocotyledon group, the predominant species were: *Setaria viridis* (L.) Beauv; *Echinochloa crus-galii* L. and *Digitaria sanguinalis* (L.) Scop. The one-year dicotyledon weeds were mostly represented by *Amaranthus retroflexus* L., *Chenopodium album* L., *Datura stramonium* L., *Portulaca oleracea* L., *Solanum nigrum* L. and other perennial rhizomes: *Cynodon dactylon* (L.) Pers., *Sorghum halepense* L., perennial root-shoots: *Cirsium arvense* (L.) Scop, *Convolvulus arvensis* L., etc. The application

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of herbicides and mixtures was done with a back sprayer at a rate of 400 L/ha. Weeds were recorded on permanent sites of 0.5m<sup>2</sup> for repetitions on day 14 in soil and on day 20 with foliar herbicides after their application. Mathematical processing of the data was performed by software product ANOVA- 1.

## Results and discussion

The results for the herbicides and herbicidal mixtures effects on the species composition and weed amount are presented in Table 1. The effect of the action of herbicides Wing P and Tender EC on the total number of annual weeds

was relatively the same, at the time of the first recording. Their number was decreased from 110 to 46 and 42, respectively. The differences were mainly due to the unequal phytotoxicity of herbicides on the different weed species. Wing P herbicide destroyed *Solanum nigrum* L. and Tender was resistant to Tender EC. With regard to perennial weeds, Tender EC which destroys *Sorghum halepense* L., showed a better effect. The number of this weed decreased from 16 to 10 pcs/m<sup>2</sup>. The effect shown by the two remedies on rumination and root and shoot types of *Convolvulus arvensis* (L.) Scop. and *Cirsium arvense* L. was unsatisfactory. The number of these weeds increased.

**Table 1.** Efficacy of herbicides and herbicidal mixtures on the species composition and weed amount, average for the period 2014-2017

Weed species	Variants					
	Untreated		Wing P and Mistral Opti		Tender EK and Titus + Magneto SL	
	Number of weeds - I and II reporting					
Reporting of weeds	I	II	I	II	I	II
I. Annual						
A. Monocotyledon						
1. <i>Setaria viridis</i> (L.) Beauv.	29	22	8	6	7	4
2. <i>Echinochloa crus-galii</i> L.	35	16	9	4	8	2
3. <i>Digitaria sanguinalis</i> (L.) Scop.	7	5	5	3	5	2
Total	71	43	22	13	20	8
B. Dicotyledon						
1. <i>Amaranthus retroflexus</i> L.	6	3	3	-	-	-
2. <i>Chenopodium album</i> L.	14	9	3	3	14	2
3. <i>Datura stramonium</i> L.	3	2	4	-	4	-
4. <i>Portulaca oleracea</i> L.	4	2	-	-	.	-
5. <i>Solanum nigrum</i> L.	12	10	13	3	4	3
Total	39	26	23	6	22	5
Total A + B	110	69	46	19	42	13
II. Perennial						
A. With root system Root - suckers						
1. <i>Cynodon dactylon</i> (L.) Pers.	4	6	4	6	5	6
2. <i>Sorghum halepense</i> L.	16	10	16	5	10	5
B. Root - suckers						
1. <i>Cirsium arvense</i> (L.) Scop.	9	8	7	9	10	6
2. <i>Convolvulus arvensis</i> L.	7	5	8	7	7	3
Total A + B	36	29	35	27	32	20
Total I + II	146	98	80	46	74	33

The results indicated that the Titus 25 DFE+Magneto SL mixture exhibited strong combinative phytotoxicity to annual weeds, at the time of second recording. In comparison with the control, the number of *Setaria viridis* (L.) Beauv. decreased from 22 to 6 pcs/m<sup>2</sup>, *Echinochloa crus-galii* L., from 16 to 4 pcs/m<sup>2</sup>, *Digitaria sanguinalis* (L.) Scop. from 5 to 3 pcs/m<sup>2</sup>. Against the annual birch weeds, the mixture had a very good effect on *Amaranthus retroflexus* L., *Datura stramonium* L. and *Portulaca oleracea* L., completely destroying them. Against *Chenopodium album* L. and *Solanum nigrum* L. the effect was also good. The number of *Chenopodium album* L. was reduced from 9 to 2 and *Solanum nigrum* L. from 10 to 3, according to the control.

With respect to perennial weeds, Titus 25 DFE+Magneto SL herbicide mixture showed good effect against Johnson grass, reducing the number of weeds from 10 to 5 pcs/m<sup>2</sup>. The two Magneto SL active substances (2.4D and Dicamba) helped to increase the phytotoxicity of the mixture on root weed shoots, *Convolvulus arvensis* L. and *Cirsium arvense* (L.) Scop. The stems of *Convolvulus arvensis* L. decreased from 5 to 3 pcs/m<sup>2</sup>, and of *Cirsium arvense* (L.) Scop. from 8 to 6 pcs/m<sup>2</sup>. Against *Cynodon dactylon* (L.) Pers. the herbicidal mixture had no effect. In terms of efficacy against annual weeds, the combination of Tender EC and Titus+Magneto SL showed about 14-15% better effect than the standard (Wing P and Mistral

Opti). Compared to perennial weeds, the effect was higher by 16-17%. The combination of herbicides showed a higher effect of 15-16% compared to the standard, but compared to the control, the effect was 56-57%.

Recordings were taken for phytotoxicity of the preparations on the maize plants on the 10<sup>th</sup> and 20<sup>th</sup> days after treatment with herbicides and the mixture. No damages on maize from the applied herbicides and the herbicide mixture were found.

The effects of herbicides on maize yield were summarized

**Table 2.** Yield of dry biomass from silage maize, kg/ha

Variants	2014		2015		2016		Average	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
1. Without herbicides	13324	100	10359	100	11473	100	11719	100
2. Wing P and Mistral Opti	16402	123.1	14171	136.8	14754	128.6	15109	129.9
3. Tender EK and Titus+Magneto SL	18000	135.1	15569	150.3	16234	141.5	16601	141.6
Great differences (GD), %								
	5.0%	149.31 kg/ha	160.10 kg/ha	142.61 kg/ha				
	1.0%	215.80 kg/ha	227.51kg/ha	211.52 kg/ha				
	0.1%	309.32 kg/ha	328.62kg/ha	296.11 kg/ha				

In the other options this trend was broken. The highest yield, both year by year and average over the period, was obtained in the Tender EC and Titus+Magneto SL variants, which exceeded the control by 41.6% and, compared to the standard, the excess was 28.9%. The resulting differences in yields between the two variants with different herbicide combinations and control variant (without herbicides) were highly statistically significant.

## Conclusion

Effective weed control of mixed-type weed irrigation with predominantly annual weeds (72-74%) could be successfully achieved by using the herbicidal combination: Tender EC - 1500 ml/ha applied after sowing before emergence of maize and Titus mixture - 40 g/ha + SL magneto - 1200 ml/ha applied in stage 3-5 leaf of maize. The combination effect Wing P and Mistral Opti against annual and perennial weeds outperformed the standard by 15-16% and the control by 56-57%. The herbicidal combination used to control weeds had no phytotoxic effect on irrigated maize. As a result of the good herbicide efficiency, Tender EC combination - 1500 ml/ha, Titus - 40 g/ha + SL magneto - 1200 ml/ha increased maize yield by 41.6% on average and 28.9% on the standard.

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in Table 2. It was found that the yields of maize obtained during the years of the study varied directly depending on the degree and nature of weeding, the herbicidal effect shown and the differences in the weather conditions of the years. The herbicide-untreated variant tended to decrease the yield of maize for silage from the first to the third year, regardless of the different rainfall over the years. This was most likely attributed to the increased weed density during the years of the study as a result of the non-proliferation of herbicides.

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