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EFFICACY AND AFTER-EFFECT OF HERBICIDE PREPARATIONS IN THE MAIZE-WHEAT CROP-ROTATION UNIT

Maya DIMITROVA, Shteliyana KALINOVA, Tonya GEORGIEVA, Plamen ZOROVSKI

Agricultural University - Plovdiv, 12 Mendeleev Str., 4000, Plovdiv, Bulgaria, Phone: +35932654398, Emails: mayadimitrova30@yahoo.com; shtkalinova@au-plovdiv.bg; tonia@au-plovdiv.bg; plivz@abv.bg

Corresponding author: plivz@abv.bg

Abstract

The purpose of the study was to trace the after-effect of soil and leaf herbicides applied in maize on the next crop in rotation – wheat. In a 4-year period were carried out field experiments. The efficacy and selectivity of herbicides in maize were traced. Visual observations of plants of wheat were conducted during various phenological phases of the crop: germination, first leaf displayed (BBCH-11), two leaves displayed (BBCH-12), tillering (BBCH-20), lactic maturity (BBCH-77). Manifestations of phytotoxicity on the wheat plants were not established. After-effect of the herbicides was traced and the formation of major quantitative traits: plant height, length of classes, number of classes, number of grains in the class and weight of grain in the class. By variance analysis of pooled data were analyzed signs and evidenced the differences compared to the untreated control. The differences between the variatns with treatment and the control are essential. This confirms the visual assessments about the lack of negative after-effect of Laudis OD, Lumax 538 SC, Elumis, Gardoprim plus Gold 500 SC, Wing P, Stellar, Casper 55 VG and Merlin flex, applied in maize, on the next crop in rotation.

Key words**:** *development, efficacy, elements of crop yield, maize, herbicides, wheat*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important food and feed crops in the world. Over the last few years, there has been a steady tendency to an increase of the planted areas in Bulgaria, from 328,000 ha to 473,200 ha (*Report 2010-2020, Ministry of Agriculture and Food in the Republic of Bulgaria).* According to Popescu A. *et al*. the main agricultural crops cultivated in Romania are cereals. Agricultural production is mainly represented by cereals which achieved 30.41 million tons, of which maize grains 17.43 million tons (57.31%) [16]. Maize is highly susceptible to weeding. Weed species and its population density adversely affect the biomass accumulation of maize (fresh and dry); the plant height, leaf area, grain length, their mass, the number of grains per ear, and overall on maize yield reduction [3, 9, 13]. According to studies by various authors, at heavy weeding, the maize yields can be reduced by 77 to 91%. Research is also available on the indirect damage of the weeds on maize [5], as well as on manifestations of resistance of economically important weeds in maize production to certain active substances [2]. Research at home and abroad show that in order to reduce the harmful effects of weeds on maize, it is necessary to apply a complex of protective and agro-technical measures, in combination with chemical control agents [7, 11, 12, 18, 21]. A number of authors have reported data on the biological effect of soil and leaf herbicides on weeding in maize, as well as on their impact on grain yields, [3, 8, 20,]. In recent years, a number of studies have been conducted in Bulgaria on the efficacy of a significant number of herbicides for weed control in maize. For example [8] report that, under a three-year experiment, the studied soil and leaf herbicides have a very good effect on the available weeds by the 40th day after treatment. The dynamics in the development and production of the crop depend to a large extent on the soil and the climatic conditions, as well as on the agro-technology [4]. Herbicides are a major means of reducing the losses caused by weeds, and are an integral part of modern crop technologies. However, their intensive application leads to environmental pollution, including accumulation in soil and subsoil, [1, 14, 15]. Currently, over 260 herbicidally active compounds are known, on the basis of which hundreds of commercially available products are formulated. Recent generation herbicides are significantly more effective, used in low concentrations and are relatively rapidly degraded by soil microorganisms.

Researchers around the world are developing, enhancing and optimizing methods for the detection of herbicide residues in soil, however, studies related to identifying the after-effects of herbicides on the growth and yield of subsequent crops in crop rotation are still insufficient [19]. This type of research is therefore particularly relevant, and the data obtained provide more complete information on herbicide preparations in order to achieve a higher environmental and economic result in the use and optimization of the production of safe foods.

MATERIALS AND METHODS

Field experience with hybrid corn Kolomba (450 FAO) is based on the experimental base of the Agricultural University - Plovdiv, Bulgaria, in the period 2011 - 2014. The block method was used, with the size of the experimental plot 21 m^2, in four replications.

Table 1. Variants of the experiment

Soil herbicides		
Lumax 538 SK	375 g/l *S-metolachlor* +125 g/l *Terbuthylazine* +37,5 g/l *Mesotrione*	4 l/ ha
Gardoprim Plus Gold 500 SK	312,5 g/l *S-metolachlor* +187,5 g/l *Terbuthylazine*	4,5 l/ha
Wing P	212,5 g/l *Dimethanamid-p* +250 g/l *Pendimethalin*	4 l/ha
Merlin flex	240 g/l *Isoxaflutole*	420 ml/ha
Leaf herbicides		
Laudis OD	44 g/l *Tembotrione*	2 l/ha
Elumis	30 g/l *Nicosulfuron* +75 g/l *Mesotrione*	2 l/ha
Stelar	50 g/l *Topramezone* + 160 g/l *Dicamba*	1 l/ha
Caspar 55WG	50 g/kg *Prosulfuron* +500 g/kg *Dicamba*	300 g/ha
Controls		
Untreated cultivar		
Untreated cultivar with cultivation		

Source: Own experiment.

As variants for chemical weed control, the herbicides presented in Table 1 were tested: Variants Untreated cultivar and Untreated cuiltvar with cultivation were used for control. The soil in the examined region is classified as alluvium. Based on the international classification of FAO, it is defined as Mollic Fluvisols. It is characterized by average sandy-clay mechanical composition, not high humus content of 1.01-1.32%, a weak alkaline reaction of the soil (pH 7.6 to 7.9), carbonate content of up to 1.65% and lack of salts (0.06-0.07%) [17].

Maize is grown by established technology for tillage, fertilization, sowing, rolling. The herbicides are applied with a hand sprayer at a solution consumption of 30-40 l/da. To study the effectiveness of herbicides, two reports were made in each plot of the experiment - on the 28th and 40th day after treatment with soil herbicides; and on the 20th and 40th day after leaf herbicides.

2011 and 2012 are characterized by different agrometeorological conditions during the maize vegetation. In 2011 the spring is moderately warm and dry. The precipitation in January is only 24.6 l/m^2, while in the following 2012 the precipitation is 120.2 l/m^2. The summer of 2011 is very hot, but the rainfall is close to normal.

The pre-sowing preparation of the areas for sowing in 2012 was made in the conditions of extreme drought. In March and April of the same year the precipitation was only 27.1 m^2, which hindered the growth of certain groups of weeds, typical for this period. Heavy later rains (in May - 160.8 l/ m^2), however, created conditions for secondary weeding and reporting good effectiveness of soil herbicides.

RESULTS AND DISCUSSIONS

During the vegetation periods of maize in 2011 - 2013 there are agrometeorological conditions for strong weeding of the experimental plots mainly with late spring species. Mainly ten species of weeds were identified, with predominant annual dicotyledon species: red-root amaranth (*Amaranthus retroflexus* L.), blackberry nightshade (*Solanum nigrum* L.), goosefoots (*Chenopodium album* L.), common purslane

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(*Portulaca oleraceae* L.), common cocklebur (*Xanthium strumarium* L.) and caltrop/ goat's - head (*Tribulus terrestris* L.). Annual cereals are represented by green bush (*Setaria viridis* L.) and green foxtail (*Setaria glauca* L.). Of the perennial species, the main representatives during the experimental period were the Johnsongrass (*Sorghum halepense* L.), and bindweed (*Convolvulus arvensis* L.). The results obtained regarding the efficacy of the tested herbicides for the three trial years are demonstrated in Tables 2 - 5. In 2011 and 2012, the soil herbicides fully controlled the available weeds - from 92.6% for Merlin flex (2012) to 99.2% for Lumax 538 SK (2011). The leaf herbicides showed similar efficacy for this period. For Laudis, Elumis, and Stellar, weed control was above 95% during both reporting periods. Casper showed lower results by 4-5%, due to its spectrum of action, as this preparation is not effective enough against wheat weeds.

Table 2. Efficacy of soil herbicides on maize on the 28th day after treatment, 2011-2013

Variants	**2011**		**2012**		**2013**		**Average for the period**	
	Weeds n./m^2	Efficacy,%	Weeds n./m^2	Efficacy, %	Weeds n./m^2	Efficacy, %	Weeds n./m^2	Efficacy, %
UTC	564.0	-	284.0	-	172.0	-	340.0	-
UTC with cultivation	45.8	91.9	13.5	95.2	47.0	85.5	28.1	91.7
Lumax 538 SK – 4l/ha	4.7	99.2	9.3	96.7	36.0	81.4	15.3	95.5
Gardoprim Plus Gold 500 SK– 4l/ha	6.3	98.9	6.5	97.7	44.0	79.6	15.9	95.3
Wing P – 4l/ha	11.8	97.9	16.5	94.2	36.0	82.0	19.8	94.2
Merlin flex - 420 ml/ha	17.6	96.9	21.0	92.6	62.0	79.1	24.9	92.7

Source: Own survey.

Table 3. Efficacy of soil herbicides in maize on the 45th day after treatment, 2011-2013

Variants	**2011**		**2012**		**2013**		**Average for the period**	
	Weeds n./m^2	Efficacy,%	Weeds n./m^2	Efficacy, %	Weeds n./m^2	Efficacy, %	Weeds n./m^2	Efficacy, %
UTC	602.0	-	597.0	-	220.0	-	473.0	-
UTC with cultivation	57.0	90.4	37.0	93.8	55.0	73.8	49.9	89.4
Lumax 538 SK– 4l/ha	9.5	98.4	19.3	96.8	65.0	69.0	31.3	93.4
Gardoprim Plus Gold 500 SK– 4 l/ha	11.4	98.1	18.6	96.9	60.0	71.4	30.0	93.7
Wing P – 4 l/ha	19.4	96.7	21.4	96.4	58.0	72.4	32.9	93.0
Merlin flex – 420 ml/ha	22.1	96.3	28.8	95.2	61.0	70.9	37.3	92.1

Source: Own survey.

Table 4. Efficacy of leaf herbicides on maize on the 20th day after treatment, 2011-2013

Variants	**2011**		**2012**		**2013**		**Average for the period**	
	Weeds n./m^2	Efficacy,%	Weeds n./m^2	Efficacy, %	Weeds n./m^2	Efficacy, %	Weeds n./m^2	Efficacy, %
UTC	706.0	-	724.0	-	316.0	-	582.0	-
UTC with cultivation	6.0	99.1	9.0	98.8	90.0	71.5	35.0	94.0
Laudis OD – 2 l/ha	12.0	98.3	7.0	99.0	24.0	92.4	14.3	97.5
Elumis – 2l/dka	28.0	96.0	24.0	96.7	18.0	94,3	23,3	96.0
Stelar - 1 l/ha	8.0	98.9	7.0	99.0	34.0	89.2	16.3	97.2
Caspar 55WG - 300 g/ha	43.0	93.9	37.0	94.9	42.0	86.7	40.7	93.0

Source: Own survey.

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In 2013, which was characterized by less favorable climatic conditions during the growing of maize, a lower efficiency of the applied herbicides was observed.

For the soil ones, it was ranging from 69% to 82% for both periods of monitoring, due to the severe drought after the second ten days of April and the whole of May, when the rainfall was only 3.4 mm/m^2, i. e. during the active period of action of the herbicides. For the leaf herbicides, the efficacy was higher and ranges from 77.8% to 96.8%.

For the soil ones, it was ranging from 69% to 82% for both periods of monitoring, due to the severe drought after the second ten days of April and the whole of May, when the rainfall was only 3.4 mm/m^2, i. e. during the active period of action of the herbicides. For the leaf herbicides, the efficacy was higher and ranges from 77.8% to 96.8%.

On average, during the test period, the efficacy of the soil herbicides is high - from 92.7% to 95.5% and is maintained until the 45th day after treatment. Leaf herbicide control is also high and ranges from 90.7% (Casper - 30 g/da) to 97.5% (Laudis OD – 200 ml/da). In the zero control, weed density reaches 564 n./m^2.

For the research period, more favorable conditions for the development of wheat were recorded in the growing 2013/2014 season, compared to 2012/2013 one.

The visual observations of the crop for manifestations of phytotoxicity due to the soil and leaf herbicide products applied in the previous crop were carried out through five phenophases of wheat: germination, first leaf displayed (BBCH-11), two displayed leaves (BBCH-12), twinning (BBCH-20), milky maturity (BBCH-77).

Table 5. Efficacy of leaf herbicides in maize on the 40th day after treatment, 2011-2013

Variants	**2011**		**2012**		**2013**		**Average for the period**	
	Weeds n./m^2	Efficacy, %	Weeds n./m^2	Efficacy, %	Weeds n./m^2	Efficacy, %	Weeds n./m^2	Efficacy, %
UTC	767.0	-	797.0	-	424.0	-	662.7	-
UTC with cultivation	13.0	98.3	19.0	97.6	170.0	59.9	67.3	89.8
Laudis OD – 2 l/ha	19.0	97.5	12.0	98.5	52.0	87.7	27.7	95.8
Elumis – 2l/dka	34.0	95.6	34.0	95.7	48.0	88,7	38,7	94,2
Stelar - 1 l/ha	18.0	97.6	17.0	97.9	64.0	84.9	33.0	95.0
Caspar 55WG - 300 g/ha	48.0	93.7	42.0	94.7	94.0	77.8	61.3	90.7

Source: Own survey.

The data show that there were no visual negative effects on the wheat plants, Diamond variety (EWRS ball is 1). The effect of the applied herbicides on the height of the wheat plants, Diamond variety, and the formation of basic quantitative traits in the crop were also monitored (Table 6 and Table 7).

Table 6. Evidence of the differences by traits between the treatment variations and the untreated control, 2013-2014 (average) Height of wheat plants (cm)

Variants	$\bar{x}$	**D**	**Evidence**
5	81.34	1.19	ns
2	81.23	1.08	ns
3	81.11	1.12	ns
6	81.10	0.95	ns
8	80.65	0.50	ns
9	80.36	0.21	ns
UTC	**80.15**		
4	80.10	-0.05	ns
1	79.98	-0.12	ns
7	79.86	-0.24	ns
	$gD_{5\%} = 1.98$	$gD_{1\%} = 2.85$	$gD_{0.1\%} = 3.87$

Source: Own survey.

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Table 7. Elements of yield

Variant №	$\bar{x}$	D	Evidence	Variant №	$\bar{x}$	D	Evidence
Length of ear (cm)				Number of classes			
2	7.01	0.235	ns	9	46.95	0.97	ns
7	6.985	0.21	ns	8	46.58	0.6	ns
UTC	**6.775**			6	46.27	0.29	ns
5	6.735	-0.04	ns	5	46.07	0.09	ns
1	6.73	-0.045	ns	**UTC**	**45.98**		
8	6.71	-0.065	ns	1	45.79	-0.19	ns
6	6.675	-0.1	ns	4	44.90	-1.08	ns
4	6.575	-0.2	ns	2	44.56	-1.42	ns
3	6.49	-0.285	ns	3	44.16	-1.82	ns
9	6.485	-0.29	ns	7	44.11	-1.87	ns
LSD	5%	1%	0.1%	LSD	5%	1%	0.1%
	0.38	0.59	0.83		2.40	3.58	4.86
Number of grains per classes				Mass of the grain in the class (g)			
2	26.18	1.15	ns	9	1.04	0.095	ns
9	26.16	1.13	ns	2	1.005	0.06	ns
UTC	**25.03**			5	0.98	0.035	ns
5	24.87	-0.16	ns	**UTC**	**0.945**		
8	24.46	-0.57	ns	1	0.935	-0.01	ns
6	24.36	-0.67	ns	6	0.89	-0.05	ns
4	24.22	-0.81	ns	8	0.885	-0.06	ns
1	24.18	-0.85	ns	4	0.875	-0.07	ns
3	24.01	-1.02	ns	3	0.865	-0.08	ns
7	24.00	-1.03	ns	7	0.84	-0.10	ns
LSD	5%	1%	0.1%	LSD	5%	1%	0.1%
	2.16	3.75	5.32		0.11	0.21	0.35

Source: Own survey.

The characteristics were analyzed through variance analysis of the averaged data over the study period: height, length of ears, number of ear, number of grains in the ear, and mass of the grain in the ear [6, 10].

The reliability of the differences was evaluated against the untreated control. The values of the wheat plants height of the variants tested ranged from 79.86 to 81.34 cm (at untreated control - 80.15 cm); the length of the class was from 6.48 to 7.01 cm (at untreated control - 6.77); the number of classes from 44.11 to 46.95 (at untreated control - 45.95). The number of grains in one class was 24.0-26.18 (at untreated control - 25.03, and the mass of grains in one class was from 0.84 to 1.04 (at untreated control – 0.945).

It is noteworthy that for all traits, the differences between the treated variations and the control are insignificant, ie. they form values at the level of the untreated variant.

This confirms the visual assessment of the absence of adverse effects on the next crop – wheat, from the herbicides Laudis OD, Lumax 538 SC, Elumis, Gardoprim plus Gold 500 SC, Wing P, Stellar, Casper 55 VG and Merlin flex, applied to leaf and soil on maize.

CONCLUSIONS

Under experimental conditions, the soil herbicidal preparations exhibit very good to excellent efficacy against sensitive weeds, destroying from 92.6% to 99.2% of them.

The leaf herbicides Laudis OD, Elumis, Stellar, with the exception of Casper, destroy more than 95% of the annual weeds in the trial zone.

The visual observations, performed in five phenophases of wheat development, show that the herbicides Laudis OD, Lumax 538 SK, Elumis, Gardoprim plus Gold 500 SK, Wing P, Stellar, Casper 55 VG and Merlin flex, applied in soil and on leaves of the previous crop (maize), have no adverse effect on wheat as the next crop in the rotation.

The differences between the treated variants and the control, regarding the basic quantitative traits - the height of the wheat plants, the length of the class, the number of classes, the number of grains in one class and the weight of the grain in one class, are insignificant, ie. they form values at the level of the untreated control.

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REFERENCES

[1]Bakalivanov, D., 1982, Soil and microbiological aspects of pollution. Zemisdat, Sofia, pp.212.

[2]Burgos, N., R., Kuk, Y-I, Talber, R, E., 2001, Amaranthus palmeri resistance and differential tolerance of Amaranthus palmeri and Amaranthus hybridus to ALS-inhibitor herbicides. Pest Management Science, 57 (5), 449 – 457. https://onlinelibrary.wiley.com/doi/abs/10.1002/ps.308, Accessed on 10 February 2021.

[3]Goranovska, S., 2015, Study of new possibilities for control of the weed in maize, farmed in the conditions of typical black earth soil. Doctoral thesis.

[4]Delibaltova, V., Ivanova, R., 2009, Production capacity of maize hybrids grown by applying irrigation in the region of Plovdiv. Plant-growing, 46, 493-496. https://www.cabdirect.org/cabdirect/abstract/20113370657, Accessed on 9 Jan 2021.

[5]Dimitrov, Y., Palagacheva, N., Dimova, M., Vitanova, M., Rashev, S., 2012, Multiplication of cotton bollworm Helicoverpa armigera Hubner favors the development of fungal pathogen,s corn. Ecology and Future, 1, 24-28. https://www.cabdirect.org/cabdirect/FullTextPDF/2015/20153317789.pdf, Accessed on 10 February 2021.

[6]Dimova, D., Marinkov, E., 1999, Experimental work and biometrics. Academic Publisher of Agricultural University of Plovdiv, pp.263.

[7]Dimitrova, M., Zhalnov, I., Zhelyazkov, I., Stoychev, D., 2013, Efficiency and selectivity of new herbicides on fodder maize. Agrolife Scientific Journal, Vol.2(1),47-50. http://www.agrolifejournal.usamv.ro/pdf/vol.II/Art6.pdf , Accessed on 10 February 2021.

[8]Dimitrova, M., Dimova, D., Zhalnov, I., Zorovski, P., Zhelyazkov, I., Valcheva, E., Popova, R., 2013, The influence of new herbicides on the growth and the some structural elements of the yield of fodder maize. Scientific Papers Series, A. Agronomy, Vol. LVI, 226-230.http://www.agronomyjournal.usamv.ro/pdf/vol.LVI/Art41.pdf , Accessed 10 February 2021.

[9]Ford, G. T., Peeasant, M., 1994, Competitive abilities of six corn (Zea mays) hybrids with four weed control practices. Weed technology, Vol. 8, p. 124-128. https://www.jstor.org/stable/3988277?seq=1, Accessed on 10 February 2021.

[10]Fowler, J., Cohem, L., 1992, Practical statistics for field biology. England, 179-207. https://trove.nla.gov.au/work/7476198/version/12385074, Accessed on 10 February 2021.

[11]Hellwig, K. B., Johnson, W. G., Scharf, P. C., 2002, Grass weed interference and nitrogen accumulation in no-tillage corn. Weed Science, 50, 757 – 762. https://www.researchgate.net/profile/William-Johnson2/publication/232687098_Grass_weed_interference_and_nitrogen_accumulation_in_notillage_corn/links/57e3e07008ae62ccfdd63f91/Grass-weed-interference-and-nitrogen-accumulation-in-no-tillage-corn.pdf , Accessed on 10 February 2021.

[12]Maric, D., 2007, Testing of efficacy of some herbicides combination in maize. Herbologia, vol. 8, № 1, 177 – 179.

[13]Maqsood, M., Akbar, M., Yousaf, N., Mahmood, M. T., Ahmed, S., 1999, Studies on weed-crop competition in maize. International Journal of Agriculture & Biology, 4, 270-272. https://scholar.google.com/scholar?hl=bg&as_sdt=0%2C5&q=+Maqsood%2C+M.%2C+Akbar%2C+M.%2C+Yousaf%2C+N.%2C+Mahmood%2C+M.+T.%2C+%26+Ahmed%2C+S.+%281999%29.+Studies+on+weed-crop+competition+in+maize&btnG=, Accessed 10 February 2021.

[14]Milanova, S., Streibig, J., 1999, Persistence and residual effects of imazamethabenz-methyl in the field. Proceeding of 11th EWRS Symposium, Basel, 143.

[15]Monako, T., Weller, St., Ashton, F., 2002, Weed Science. Principles and Practices, IV ed. John Wiley & sons, Inc. https://books.google.bg/books?hl=bg&lr=&id=cjn_DwAAQBAJ&oi=fnd&pg=PR9&dq=Monako,+T.,+Weller,+St.,+Ashton,+F.+(2002)+Weed+Science&ots=VAMITiJQJr&sig=OjQ6zdrV-mmE8i3vsGOJD3I98vE&redir_esc=y#v=onepage&q=Monako%2C%20T.%2C%20Weller%2C%20St.%2C%20Ashton%2C%20F.%20(2002)%20Weed%20Science&f=false, Accessed on 10 February 2021.

[16] Popescu, A., Dinu, T., Stoian, E., Serban, V, 2020, Variation of the main Agricultural crops yield due to drought in Romania and Dobrogea Region in the period 2000-2019. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 20(4), 397-416.

[17]Popova, R., Zhalnov, I., Valcheva, E., Zorovski, P., Dimitrova, M., 2012, Estimates of environmental conditions of soils in Plovdiv Region in applying the new herbicides for weed control in major field crops. JCEA (Journal of Central European Agricultural), 13(3),595-600. https://hrcak.srce.hr/ojs/index.php/jcea/article/view/1549, Accessed on 10 February 2021.

[18]Shnajder, A., Dunaeva, C., 2009, Kallisto v sovremennoj zashtite kukuruza ot sornyacov. № 4, c. 51-53.
[19]Weber, R., Kieloch, R., 2013, Influence of herbicides on yield stability of winter wheat cultivars under different sowing rates. International J. of Plant Production, vol. 7(1), 55-65. https://www.sid.ir/en/Journal/ViewPaper.aspx?ID=272860, Accessed 10 February 2021.
[20]Yamakova, Ts., Dimitrova, M., 2002, Study on the efficacy of certain soil herbicides and their impact on the yield of maize – hybrid Kneza 614. Jubilee Scientific Conference, Plovdiv, Vol. XLVII, 1, 185-190.
[21]Zhelyazkov, I., 2007, Integration of new and classical methods against intensive weeding among some field crops. Doctoral thesis.