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Influence of foliar herbicides treatment on malting barley (*Hordeum vulgare* L.) productivity of Emon, Vanessa and Vicky varieties

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Abstract. *During the period 2012 – 2014 in the Institute of Agriculture, Karnobat a field experiment was conducted with winter malting barley varieties Emon, Vanessa and Vicky. The influence of broadleaf (dicotyledonous) herbicides alone and in their combination with wild oat (monocotyledonous) in tillering stage of the crop was studied in optimal and double doses. The herbicide selectiveness was assessed according to the EWRS scale. Yields were reported after harvest. In variety Vanessa during the treatment with Derby Super, Granstar Super, Sekator OD and combination of Puma Super 7.5 EW + Sekator OD in optimal doses, the yield does not differ from the weed control. Variety Vicky endures well the treatment with optimal doses in all of the tested herbicides, except Husar Max. In treatment with double doses, only Granstar Super does not affect negatively the yield of grain. Comparing the data from ANOVA about the role of herbicides and year conditions on the malting barley varieties it can be concluded that the yield of variety Emon is the most stable in regard to herbicides applied in optimal doses (5%), followed by Vanessa (17%) and Vicky (18%). At application of the herbicides in double doses, their influence is increased – in variety Emon up to 15%, and in varieties Vanessa and Vicky – up to 23%.*

Keywords: malting barley, susceptibility, herbicides, weeds

Introduction

The productivity of winter crops can be reduced as a result of the phytotoxic activities of certain herbicides (Heering and Peeper, 1989; Gospodinov, 1990; Dadari et al., 1990; Tonev et al., 2001; Delchev, 2003; Georgiev, 2015; Petrova, 2015). The comparison of crops showed that barley is significantly more susceptible to herbicides than wheat (Jung Sup Choi et al., 1999; Elliot et al., 1975). Varietal differences were proven in yield as well as the response to some of the herbicides used on barley (Dimitrova et al., 2003; Ilyin, 2007; Atanasova and Maneva, 2014; Atanasova, 2014). Research on different varieties of barley also reported negative effect from grass herbicides, especially if the doses were increased (McMullan, 1993) or the preparations were used in combination with broadleaf herbicides (Michael and Mickelson, 2001). Certain susceptible varieties were established where the herbicides cause damage of various extent and significantly decrease yield (Korres et al., 1999).

The aim of this study was to establish the influence of treatment with several broadleaf herbicides applied individually and in combination with grass ones on the productivity of certain malting barley varieties as well as their varietal response.

Material and methods

The study was conducted during 2011 – 2014 as a field experiment of the Institute of Agriculture, Karnobat, Bulgaria, in soil type - Leached smolnitza. To study the effect of herbicides on three varieties of malting barley (Emon, Vanessa and Vicky varieties) was set a field experiment by randomized block design in four replications in a plot size of 10 m^2. It was harvested within the optimal term 20 – 30 October, after a sunflower predecessor and N_{10} fertilization. The herbicides were applied during tillering stage, in optimal and double doses with knapsack sprayers (Table 1). The most common herbicides were used against broadleaf weeds (2-5) and combinations – against broadleaf + wild oat weeds (6 – 8). Crop tolerance was evaluated by the scale of the European Weed Research Society (*EWRS)* (1 – no effect on crop, 9 – complete crop death). After harvest yields reported.

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Results and discussion

The agrometeorological conditions over the years of study and particularly the amount of rainfall differed significantly, which also preconditioned the specific development of barley and the yield differences by years. 2011/2012 was characterized as comparatively dry, with rainfall amount during the vegetation period of 391 mm, which is 10% less than the mean multi-annual values for the same period (425 mm). The other two years – 2012/2013 and 2013/2014 had more substantial precipitation, which was extremely unevenly distributed over the months (Figure 1). In autumn 2011/2012, the dry weather with minimal precipitation made it extremely difficult for the pre-sowing and sowing preparation of winter barley. The crops emerged unevenly and with difficulty. The winter was cold but the thin snow layer protected the plants from frost damage. The frequent rains in April and May managed to improve vegetation conditions for winter barley.

The economic year of 2012/2013 was characterized with a very dry summer, mild and snowy autumn and winter. For the region of South-Eastern Bulgaria in June, July and August 2012, the rainfall was only 48.8 mm, which was 32% lower than the mean multi-annual data. This particularly impeded the soil cultivation for autumn crops. Most of the crops were sown within the optimal periods. October was

Table 1. Variants in field experiment

Variants	Dose kg (l).ha^{-1}
K - untreated and without weeds	-
Optimal doses	
SEKATOR OD (iodosulfuron + amidosulfuron)	0.10
ARAT(tritosulfuron + dicamba)	0.10
DERBY Super (florasulam + aminopyralid acid)	0.03
GRANSTAR SUPER (tribenuron methyl + thifensulfuron methyl)	0.04
AKSIAL PLUS (pinoxaden + florasulam)	1.00
HUSAR MAX (7.5 g/l mezosulfuron-methil + 7.5 jodosulfuron-methil + 22.5 g/l mefenpir-dietil)	1.00
PUMA SUPER 7.5 EW+ SEKATOR WG (fenoxaprop-P-ethyl + iodosulfuron + amidosulfuron)	1.0+0.10
Double doses	
SEKATOR OD (IODOSULFURON + AMIDOSULFURON)	0.20
ARAT (TRITOSULFURON + DICAMBA)	0.20
DERBY 175 SK (FLORASULAM + AMINOPYRALID ACID)	0.06
GRANSTAR SUPER (tribenuron methyl + thifensulfuron methyl)	0.08
AKSIAL PLUS (PINOXADEN + FLORASULAM)	2.00
HUSAR MAX (7.5 g/l mezosulfuron-methil + 7.5 jodosulfuron-methil + 22.5 g/l mefenpir-dietil)	2.00
PUMA SUPER 7.5 EW+ SEKATOR WG (FENOXAPROP-P-ETHYL + IODOSULFURON + AMIDOSULFURON)	2.0+0.20

very favorable for the plants in particular with its positive mean daily temperatures, which reached up to 21.4ºC, and the precipitation at the end of the month (92.1 mm). Therefore, the plants in some of the variants formed from 3rd leaf to 2nd tiller. In the winter period, a good snow cover reaching up to 24 cm protected the plants from the low radiation temperatures. Spring was cool and wet which allowed the plants to manifest their productive potential better.

The economic year of 2013/2014 also had a very dry summer, with 65% less precipitation for July, August and September than the norm. Pre-sowing soil cultivation was very difficult, and so was sowing. The crops emerged slowly and unevenly. Autumn was warm, which allowed the plants to develop and complete their vegetation until the upcoming low temperatures. Spring was cool, wet and with abundant rainfall. It had a negative effect on the

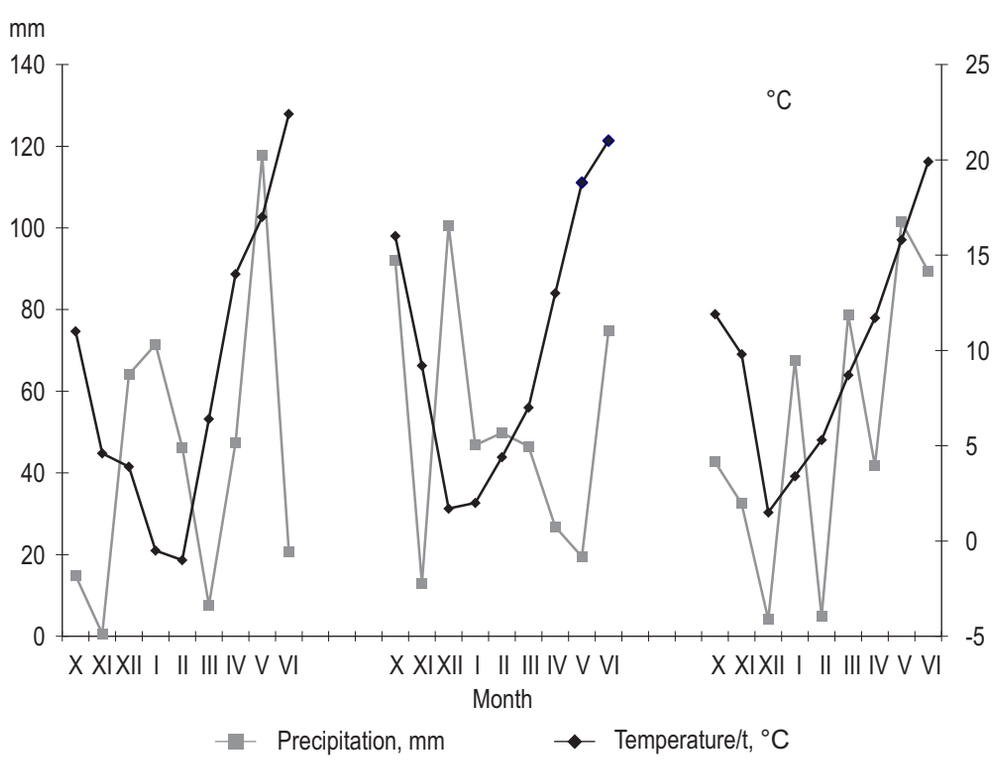

Figure 1. Rainfall and temperature distribution during the growth period (2011 – 2014)

development of cereal crops – there were numerous diseases and during the grain-filling stage there was lodging of the crops under certain conditions.

The phonological observations in the trial conducted on the 7th and 14th day after application showed no visible signs of phytotoxicity (by the EWERS scale) for the three varieties. Grain yield varied significantly over the years. In both the first and last years of the study, the yields of the three cultivars were comparatively low and higher in the second year.

Research on the Emon cultivar as standard compared to the other cultivars was included in the articles of Atanasova (2014) and Atanasova and Maneva (2014). Average for the years, the yield was lower compared to the other cultivars (5.82 t/ha^{-1}). It was established that the two-rowed Emon barley variety was tolerant to treatment with Secator OD, Arat, Granstar Super and Puma Super 7.5 EW + Secator OD in optimal rates. Data from the analysis of variance showed that after treatment with optimal rates the yield variability was mostly preconditioned by the meteorological conditions of the year – 90.55%. Significantly lower was the effect of herbicides – 5.74%. After double-rate application, the effect of the year was reduced to 76.63%, whereas the effect of herbicides increased up to 15.28%. Emon manifested high tolerance to herbicides at optimal rates. However, after application of double rates, its susceptibility increased.

The Vanessa cultivar had a higher yield than Emon in all of the three years of study - 5.82 t/ha^{-1} for Emon (Atanasova, 2014) and 6.17 t/ha^{-1} for Vanessa. In the variants treated with Derby Super, Granstar Super and Puma Super 7.5 EV + Secator OD at optimal rates, there were no proven differences compared to the weeded check plot. With all the other variants, the yield was proven to be lower, especially after application of double-rate herbicides. The greatest reduction in yield was observed after treatment with Hussar Max at optimal and double rate and Puma Super 7.5 EV + Secator OD at double rate (Table 2).

Table 2. Grain yield of malting barley variety Vanessa, t.ha^{-1}

Variants	Dose kg (l).ha^{-1}	2012	2013	2014	Average for period
K - untreated and without weeds		5.48	7.02	60.2	6.17
Optimal dose					
SEKATOR OD (iodosulfuron + amidosulfuron)	0.10	5.10	6.95	5.97	6.00
ARAT(tritosulfuron + dicamba)	0.10	5.05	6.15	5.98	5.72
DERBY Super (florasulam + aminopyralid acid)	0.03	5.38	7.07	5.90	5.85
GRANSTAR SUPER (tribenuron methyl + thifensulfuron methyl)	0.04	5.30	6.73	5.60	5.87
AKSIAL PLUS (pinoxaden + florasulam)	1.00	4.58	6.52	5.62	5.57
HUSAR MAX (7.5 g/l mezosulfuron-methil + 7.5 jodosulfuron-methil + 22.5 g/l mefenpir-dietil)	1.00	4.36	6.10	4.77	5.07
PUMA SUPER 7.5 EW+ SEKATOR WG (fenoxaprop-P-ethyl + iodosulfuron + amidosulfuron)	1.0+0.10	5.46	7.02	5.34	5.94
Double dose					
SEKATOR OD (iodosulfuron + amidosulfuron)	0.20	4.32	6.75	5.82	5.63
ARAT(tritosulfuron + dicamba)	0.20	4.74	5.75	5.85	5.44
DERBY Super (florasulam + aminopyralid acid)	0.06	5.02	6.72	5.47	5.99
GRANSTAR SUPER (tribenuron methyl + thifensulfuron methyl)	0.08	5.16	6.77	5.47	5.80
AKSIAL PLUS (pinoxaden + florasulam)	2.00	4.10	6.70	5.35	5.28
HUSAR MAX (7.5 g/l mezosulfuron-methil + 7.5 jodosulfuron-methil + 22.5 g/l mefenpir-dietil)	2.00	3.86	5.82	4.27	4.65
PUMA SUPER 7.5 EW+ SEKATOR WG (fenoxaprop-P-ethyl + iodosulfuron + amidosulfuron)	2.00+0.20	4.84	6.45	4.77	5.35
	GD 5 %	0.2021	0.1301	0.2206	
	GD 1 %	0.2802	0.1804	0.3057	
	GD 0.1%	0.3892	0.2506	0.4248	

Table 3. Analysis of variance for grain yield from variety Vanessa treated with herbicides, average 2011 – 2013

Source of variability	Doses of herbicides					
	Optimal			Double		
	SQ	df	η^2(%)	SQ	df	η^2(%)
Total	13.5530	23		19.9125	23	
Years	10.1653	2	75.00	13.3050	2	66.82
Herbicides	2.3613	7	17.42	4.7606	7	23.91
Residuals	1.0263	14	7.57	1.8468	14	9.27

Data from the analysis of variance (Table 3) showed that after treatment at optimal rates the yield variability was preconditioned at 75% by the meteorological conditions of the year and at 17% by the application of herbicides. Upon increase of the rates, the effect of herbicides increased up to 23.91%, whereas the effect of the meteorological conditions dropped down to 66.82%. The yield of Vanessa was affected by the increase of herbicide rates.

During the first year of study, Vicky had yield at level like the weeded check plot in all its variants at optimal rates, except when treated with Hussar Max. After double-rate treatment, productivity manifested decrease in all the variants, except after treatment with Derby Super. During the second year of the study, which was the most favorable for the barley development, the tendency remained the same. During the last year of the study drop in yield was seen in the variants with Arat, Derby Super and Hussar Max applied at optimal rates. At double rates the yield was reduced for all the variants, except after treatment with Granstar Super (Table 4).

Table 4. Grain yield of malting barley variety Vicky, t.ha^{-1}

Variants	Dose kg (l).ha^{-1}	2012	2013	2014	Average for period
K - untreated and without weeds		5.42	7.55	7.12	6.69
Optimal dose					
SEKATOR OD (iodosulfuron + amidosulfuron)	0.10	5.39	7.45	7.27	6.67
ARAT(tritosulfuron + dicamba)	0.10	5.40	7.39	6.90	6.56
DERBY Super (florasulam + aminopyralid acid)	0.03	5.34	7.56	6.94	6.61
GRANSTAR SUPER (tribenuron methyl + thifensulfuron methyl)	0.04	5.38	7.50	7.07	6.65
AKSIAL PLUS (pinoxaden + florasulam)	1.00	5.23	7.45	7.02	6.56
HUSAR MAX (7.5 g/l mezosulfuron-methil + 7.5 jodosulfuron-methil + 22.5 g/l mefenpir-dietil)	1.00	4.61	6.12	5.30	5.34
PUMA SUPER 7.5 EW+ SEKATOR WG (fenoxaprop-P-ethyl + iodosulfuron + amidosulfuron)	1.0+0.10	5.32	7.44	7.02	6.59
Double dose					
SEKATOR OD (iodosulfuron + amidosulfuron)	0.20	4.81	7.41	6.72	6.31
ARAT(tritosulfuron + dicamba)	0.20	4.98	6.82	6.50	6.10
DERBY Super (florasulam + aminopyralid acid)	0.06	5.28	7.32	6.77	6.45
GRANSTAR SUPER (tribenuron methyl + thifensulfuron methyl)	0.08	5.14	7.50	7.00	6.54
AKSIAL PLUS (pinoxaden + florasulam)	2.00	4.81	7.22	6.85	6.29
HUSAR MAX (7.5 g/l mezosulfuron-methil + 7.5 jodosulfuron-methil + 22.5 g/l mefenpir-dietil)	2.00	3.87	5.81	5.20	4.96
PUMA SUPER 7.5 EW+ SEKATOR WG (fenoxaprop-P-ethyl + iodosulfuron + amidosulfuron)	2.00+0.20	5.27	6.65	6.68	6.20
GD 5 %		0.1482	0.2403	0.1149	
GD 1 %		0.2055	0.3331	0.1592	
GD 0.1%		0.2854	0.4628	0.2212	

Average for the period of study, it was established that Vicky responded well to treatment at optima rates with all the herbicides except for Hussar Max. After double-rate treatment, only Granstar Super didn't have negative effect on the grain yield.

Data from the analysis of variance (Table 5) showed that after treatment with herbicides at optimal rates, the yield of Vicky was significantly affected by the year conditions (79%) and far less by herbicides (18%). After application of double rates, the year conditions decreased to 74%, whereas the part of the herbicides increased up to 23%.

Table 5. Analysis of variance for grain yield from variety Vicky treated by herbicides, average 2012 – 2014

Source of variability	Doses of herbicides					
	Optimal			Double		
	SQ	df	η^2(%)	SQ	df	η^2(%)
Total	23.4711	23		26.0593	23	
Years	18.5781	2	79.15	19.4396	2	74.60
Herbicides	4.3393	7	18.49	6.0052	7	23.04
Residuals	0.5536	14	2.36	0.6145	14	2.36

When we compare the data from the analysis of variance regarding the effect of herbicides and year conditions on the yield of malting barley varieties, we can draw the conclusion that the yield of Emon was the most stable regarding the herbicides applied at optimal rates (5%), followed by Vanessa (17%) and Vicky (18%). After application of the herbicides at double rates, their role increased up to 15% with Emon, and up to 23% with Vanessa and Vicky.

Conclusions

In variety Vanessa during the treatment with Derby Super, Granstar Super, Sekator OD and combination of Puma Super 7.5 EW + Sekator OD in optimal doses, the yield does not differ from weed control. Variety Vicky endures well the treatment with optimal doses in all of the tested herbicides, except for Husar Max. At treatment with double doses, only Granstar Super does not affect negatively the yield of grain. Comparing the data from ANOVA about the role of herbicides and year conditions on the malting barley varieties it can be concluded that the yield of variety Emon is the most stable in regard to herbicides applied in optimal doses (5%), followed by Vanessa (17%) and Vicky (18%). At application of herbicides in double doses, their influence is increased – in variety Emon up to 15%, and in varieties Vanessa and Vicky up to 23%.

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Papers shall be submitted at the editorial office typed on standard typing pages (A4, 30 lines per page, 62 characters per line). The editors recommend up to 15 pages for full research paper (including abstract references, tables, figures and other appendices)

The manuscript should be structured as follows: Title, Names of authors and affiliation address, Abstract, List of keywords, Introduction, Material and methods,Results, Discussion, Conclusion, Acknowledgements (if any), References, Tables, Figures.

The title needs to be as concise and informative about the nature of research. It should be written with small letter /bold, 14/ without any abbreviations.

Names and affiliation of authors The names of the authors should be presented from the initials of first names followed by the family names. The complete address and name of the institution should be stated next. The affiliation of authors are designated by different signs. For the author who is going to be corresponding by the editorial board and readers, an E-mail address and telephone number should be presented as footnote on the first page. Corresponding author is indicated with *.

Abstract should be not more than 350 words. It should be clearly stated what new findings have been made in the course of research. Abbreviations and references to authors are inadmissible in the summary. It should be understandable without having read the paper and should be in one paragraph.

Keywords: Up to maximum of 5 keywords should be selected not repeating the title but giving the essence of study.

The introduction must answer the following questions: What is known and what is new on the studied issue? What necessitated the research problem, described in the paper? What is your hypothesis and goal ?

Material and methods: The objects of research, organization of experiments, chemical analyses, statistical and other methods and conditions applied for the experiments should be described in detail. A criterion of sufficient information is to be possible for others to repeat the experiment in order to verify results.

Results are presented in understandable tables and figures, accompanied by the statistical parameters needed for the evaluation. Data from tables and figures should not be repeated in the text. **Tables** should be as simple and as few as possible. Each table should have its own explanatory title and to be typed on a separate page. They should be outside the main body of the text and an indication should be given where it should be inserted.

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Discussion: The objective of this section is to indicate the scientific significance of the study. By comparing the results and conclusions of other scientists the contribution of the study for expanding or modifying existing knowledge is pointed out clearly and convincingly to the reader.

Conclusion: The most important consequences for the science and practice resulting from the conducted research should be summarized in a few sentences. The conclusions shouldn't be numbered and no new paragraphs be used. Contributions are the core of conclusions.

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Todorov N and Mitev J, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows,IXth International Conference on Production Diseases in Farm Animals, September 11–14, Berlin, Germany.

Thesis:

Hristova D, 2013. Investigation on genetic diversity in local sheep breeds using DNA markers. Thesis for PhD, Trakia University, Stara Zagora, Bulgaria, (Bg).

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