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INFLUENCE OF THE GRASS, BROADLEAF, AND MIXED WEED INFESTATION ON SOME AGRONOMIC TRAITS OF BARLEY (*HORDEUM VULGARE* L.)

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Abstract

Weeds are a main yield limiting factor for the crops as for the barley (*Hordeum vulgare* L.) as well. It is of great importance to know which weed associations are more harmful – the grass or the broadleaf ones? Therefore, a field experiment with the barley variety “Emon” on the experimental field of the Agricultural University of Plovdiv, Bulgaria was performed. The trial was conducted in two vegetation seasons of barley (2023/2024 and 2024/2025). The natural weed infestation on the field was presented by the broadleaf weeds Wild mustard (*Sinapis arvensis* L.) and Field chamomile (*Anthemis arvensis* L.) as well as the grass weeds Wild oat (*Avena fatua* L.) and Darnel ryegrass (*Lolium temulentum* Gaud.). The experiment included the following variants: 1. Untreated control; 2. Axial (50 g/L pinoxaden) – 0.90 l ha⁻¹ (controlling only the grass weeds); 3. Derby Super (150 g/kg florasulam + 300 g/kg aminopyralid) – 33 g ha⁻¹ (controlling only broadleaf weeds); 4. Axial One (45 g/l pinoxaden + 5 g/l florasulam) – 1.00 l ha⁻¹ (applied for mixed weed infestation). The obtained results showed that the uncontrolled broadleaf weeds at variant 2 suppressed the barley growth and development to a greater extent than the uncontrolled grass weed species at variant 3. The efficient herbicidal control of both grassy and broadleaf weeds at variant 4 contributed to the highest recorded values for the studied parameters such as plant height, ear length, 1000 grain weight, hectoliter seed mass as well as the highest grain yields.

Keywords: barley, weeds, growth, yields

INTRODUCTION

Barley (*Hordeum vulgare*) is a plant species of the Poaceae family and it is a major grain crop grown in temperate climates around the world. It is among the first domesticated cereals dating (Zohary and Hopf, 2000).

In 2024 the areas sown with barley in Bulgaria were 198 217 hectares and the average barley grain yields were 5.360 t ha⁻¹ (MAF, 2024).

The uncontrolled weeds growing together with the crops is the main limiting factor affecting the growth, development and productivity of the plants (Tonev et al., 2007; Tonev et al., 2019).

According to Woźniak (2020) the most frequent weed families infesting barley fields are Poaceae, Brassicaceae, Cyperaceae, and Fabaceae.

A great number of trials related to the control of the weeds in barley have been conducted. Atanasova (2010) discovered that at the barley varieties "Veslets", "Aheloy-2", "Emon", and "Perun" the highest weed control was obtained after application of the herbicide Weedmaster.

Al-Gburi et al. (2024) found that the application Saracen, Axial, and weed-free with 160 kg ha⁻¹ seeding rate decreased the weed density and the highest percentage of weed control efficacy was achieved.

According to Sevov et al. (2023), the highest weed control of the weed infestation of barley with *Sinapis arvensis* L., *Anthemis arvensis* L., *Galium aparine* L., *Consolida regalis* Gray., and *Viola arvensis* L. may be achieved after the treatment with Biathlon 4 D - 55 g ha⁻¹.

Pala (2020) conducted experiments with winter barley to evaluate the efficacy of four herbicides and their tank mixtures. After the combined application of pinoxaden + 2.4-D + florasulam in tank mixture the efficacy against weeds was the highest – 92%.

The objective of this study is to evaluate the influence of some uncontrolled grass and broadleaf weeds, and mixed weed infestation on several growth and productive parameters at barley.

MATERIALS AND METHODS

The experiment was conducted during the barley growing seasons - 2023/2024 and 2024/2025 at the experimental field of the Department of Agriculture and Herbiology at the Agricultural University - Plovdiv. The trial was set by the randomized block design in three replications. The size of the harvesting plots was 20 m².

The study was conducted with the Bulgarian barley variety "Emon" with a density of 500 plants/m².

Trial design:

1. Mixed weed infestation – Untreated control;
2. Grass weeds control – application of Axial (50 g/l pinoxaden) – 0,90 l ha⁻¹;
3. Broadleaf weeds control – Derby Super (150 g/kg florasulam + 300 g/kg aminopirid-K) – 33 g ha⁻¹;
4. Mixed weed infestation control – Axial One (45 g/l pinoxaden + 5 g/l florasulam) – 1,00 l ha⁻¹.

The herbicides were applied at crop growth stage end of tillering of barley.

Herbicide efficacy was assessed using the 10-score EWRS visual scale 14, 28 and 56 days after treatment. Herbicide selectivity was assessed using the 9-score EWRS scale on days 7 and 14 after treatment.

Table 1. Weed species and average number / m² on the field before the weed control:

Species	Density of the weeds / m ²	
	2024	2025
1. Wild mustard (<i>Sinapis arvensis</i> L.)	35	30
2. Corn chamomile (<i>Anthemis arvensis</i> L.)	32	38
3. Wild oat (<i>Avena fatua</i> L.)	29	41
4. Darnel ryegrass (<i>Lolium rigidum</i> Gaud.)	37	43
Total weed number	133	152

The following indicators of barley were measured:

Plant height (m) – by measuring twenty plants per plot = sixty plants total;

Ear length (cm) – by measuring twenty ear per plot = sixty ears total;

- Grain yields (t ha⁻¹) - by harvesting the entire experimental plot of all three replications of each variant. The harvest was carried out with a combine for plot trials of the company Wintersteiger®;

- 1000 grain weight (g) was reported by the methodology of Tonev et al. (2018). The reporting is in three replications.

- Hectoliter seed mass (kg) was reported by the methodology of Tonev et al. (2018). Three samples from each variant were analyzed.

For statistical data processing, the Duncan method was used with the SPSS 19 program. Differences were considered significant at p<0.05.

RESULTS AND DISCUSSION

The amount of precipitation, as well as the average minimum and maximum temperatures during the barley growing season, are presented in Table 2. According to the meteorological data, we can determine how agrometeorological conditions affect the plant development.

In the first experimental year (2023/2024) the crop was sown in October. The amount of precipitation in this month was insufficient (4.2 mm) for germination and emergence (Table 2). The beginning of plant development began in November, during which the amount of precipitation was 22.7 mm. From the table it is clear that in terms of moisture during the vegetation period, no other period was identified during which the crop experienced a water deficit.

In the second experimental year (2024/2025) the amount of precipitation in October, when barley was sown, was also low. Vegetation began in November and in this experimental year, when 52.8 mm of precipitation fell.

The minimum and maximum temperatures are relatively favorable for plant development. Despite the high winter temperatures, no negative impact of the warm winter months on the growth and development of crops was found (Table 2).

Based on the analysis of meteorological data, we can indicate the study years as relatively favorable for the growth, development and realization of the productive potential of barley.

There is a number of researchers studying for chemical weed control in barley (Saghir, 1977; Samson et al., 1996; Tawaha et al., 2002; Gaweda et al.

2014; Sevov et al., 2023). Our obtained results for the herbicidal control of the weeds in the study are shown in the next four tables.

Table 2. Average monthly precipitation, minimum and maximum air temperatures for the vegetation periods of barley

Years/ Months	Precipitation		min t	max t	min t	max t
	2023/ 2024	2024/ 2025	2023/ 2024	2023/ 2024	2024/ 2025	2024/ 2025
October	4.2	2.3	8.6	26.5	5.3	23.9
November	22.7	52.8	3.9	15.8	-0.4	14.1
December	150.1	51.1	3.2	12.1	2.1	9.7
January	22.6	47.8	-1.9	9.9	-1.9	10.9
February	25.3	6.8	2.6	17.4	-3.2	8.3
March	67.2	39.3	4.9	17.7	3.3	19.3
April	72.8	37.3	8.4	25.8	5.6	20.0
May	55.1	74.5	11.2	24.3	10.6	25.2
June	11.5	5.3	17.5	35.1	15.4	34.9

The results obtained for the efficacy of the herbicides are presented in 4 tables. The efficacy against all weeds was lower on the first reporting date and increased by the third reporting date.

Table 3 presents the efficacy of the herbicides against Wild mustard (*S. arvensis*).

Table 3. Efficacy of the herbicides against Wild mustard, %

Variants	2024			2025			Average		
	14 days	28 days	56 days	14 days	28 days	56 days	14 days	28 days	56 days
1. Untreated control	-	-	-	-	-	-	-	-	-
2. Axial – 0,90 l ha ⁻¹	0	0	0	0	0	0	0	0	0
3. Derby Super – 33 g ha ⁻¹	90	95	100	85	100	100	87,5	97,5	100
4. Axial One – 1.00 l ha ⁻¹	85	100	100	95	95	100	90	97,5	100

On average for the period, on the 14th day after treatment, 87.5% efficacy was found for treatment with Derby Super – 33 g ha⁻¹ and 90% efficacy for treatment with Axial One – 1.00 l ha⁻¹. On the next reporting date, the efficacy increased and reached 97.5% on average for the experimental years for both herbicides. On the 56th day after treatment, on average for the experimental conditions, the efficacy against Wild mustard reached 100% for Derby Super and Axial One.

The efficacy of the herbicide Axial – 0.90 l ha⁻¹ against Wild mustard was 0%, since the active ingredient of the product only controls grass weeds only.

The efficacy data of the tested herbicides against Corn chamomile (*A. arvensis*) are presented in Table 4. On average for the period, on the 14th day after treatment, 82.5% efficacy was found for the treatment with Derby Super – 33 g ha⁻¹ and 75% efficacy for the treatment with Axial One – 1.00 l ha⁻¹. On average for the experimental years on the next reporting date, the efficacy increased and reached 97.5% and 87.5% respectively for the treatment with Derby Super and Axial One.

On the 56th day after treatment, on average for the experimental conditions, the efficacy against field mustard reached 100% for Derby Super and Axial One. As with the weed field mustard, the efficacy of the herbicide preparation Axial – 0.90 l ha⁻¹ against Corn chamomile was 0%, since the active substance of the product controls only grass weeds.

Table 4. Efficacy of the herbicides against Corn chamomile, %

Variants	2024			2025			Average		
	14 days	28 days	56 days	14 days	28 days	56 days	14 days	28 days	56 days
1. Untreated control	-	-	-	-	-	-	-	-	-
2. Axial – 0,90 l ha ⁻¹	0	0	0	0	0	0	0	0	0
3. Derby Super – 33 g ha ⁻¹	80	100	100	85	95	100	82,5	97,5	100
4. Axial One – 1.00 l ha ⁻¹	75	85	100	75	90	100	75	87,5	100

The efficacy of herbicides against Wild oat (*A. fatua*) is presented in Table 5. On average for the period, on the 14th day after treatment, 67.5% efficacy was found for the treatment with Axial – 090 l ha⁻¹ and 60% efficacy for the treatment with Axial One – 1.00 l ha⁻¹. On average for the experimental years on the next reporting date, the efficacy increased and reached 85% and 82.5% respectively for the treatment with Axial and Axial One.

On the 56th day after treatment, on average for the experimental conditions, the efficacy against the Wild oat reached 100% for Axial and Axial One.

The efficacy of the herbicide preparation Derby Super – 33 g ha⁻¹ against Wild oat was 0%, since the active substances of the product control only broadleaf weed species.

Table 5. Efficacy of the herbicides against Wild oat, %

Variants	2024			2025			Average		
	14 days	28 days	56 days	14 days	28 days	56 days	14 days	28 days	56 days
1. Untreated control	-	-	-	-	-	-	-	-	-
2. Axial – 0,90 l ha ⁻¹	65	85	100	70	85	100	67,5	85	100
3. Derby Super – 33 g ha ⁻¹	0	0	0	0	0	0	0	0	0
4. Axial One – 1.00 l ha ⁻¹	60	80	100	70	85	100	65	82,5	100

The efficacy of herbicides against Darnel ryegrass (*L. rigidum*) is presented in Table 6. On average for the period, on the 14th day after treatment, 72.5% efficacy was found for the treatment with Axial – 0.90 l ha⁻¹ and 67.5% efficacy for the treatment with Axial One – 1.00 l ha⁻¹. On average for the experimental years on the next reporting date, the efficacy increased and reached 92.5% and 87.5 respectively for the treatment with Axial and Axial One.

On the 56th day after treatment, on average for the experimental conditions, the efficacy against ryegrass reached 100% for Axial and Axial One.

The efficacy of the herbicide preparation Derby Super – 33 g ha⁻¹ against this weed was 0%, since the active substances of the product control only broadleaf weeds.

Table 6. Efficacy of the herbicides against Darnel ryegrass, %

Variants	2024			2025			Average		
	14 days	28 days	56 days	14 days	28 days	56 days	14 days	28 days	56 days
1. Untreated control	-	-	-	-	-	-	-	-	-
2. Axial – 0,90 l ha ⁻¹	75	95	100	70	90	100	72,5	92,5	100
3. Derby Super – 33 g ha ⁻¹	0	0	0	0	0	0	0	0	0
4. Axial One – 1.00 l ha ⁻¹	70	90	100	65	85	100	67,5	87,5	100

After finding of different scientist, the height of the crops is influenced by the weed infestation and the weed control as well (Neshev et al. 2020; Yankova et al., 2020; Yanev et al., 2021; Sevov et al., 2023). Table 7 presents the results established regarding the height of the plants at the end of the barley vegetation in the current trial.

Table 7. Plant height at the end of the vegetation, m

Variants	2024	2025	Average
1. Untreated control	0.86 c	0.79 c	0.83
2. Axial – 0,90 l ha ⁻¹	0.97 b	0.90 b	0.94
3. Derby Super – 33 g ha ⁻¹	1.02 a	0.96 b	0.99
4. Axial One – 1.00 l ha ⁻¹	1.07 a	1.02 a	1.05

Numbers with different letters are significantly different according to Duncan's test ($p < 0.05$)

All variants in which herbicide treatment against weeds was carried out have higher values for their height. The tallest were the plants from variant 4 (Axial One – 1.00 l ha⁻¹) – 1.05 m on average for the period of the experiment. On average for the two experimental years, the lowest are the plants from the control – 0.83 m followed by those of variant 2 (Axial – 90 l ha⁻¹) – 0.94 m, where only the grass weeds were controlled.

The results obtained regarding the length of a barley ear at the end of the growing season are presented in Table 8. All variants in which herbicide treatment against weeds was performed had higher values for the length of the ear. The longest ears were measured for the plants from variant 4 (Axial One – 1.00 l ha⁻¹) – 12.89 cm on average for the period. On average for the two experimental years, the shortest ears were measured for the plants from the control – 9.24 cm.

Table 8. Length of barley ears, cm

Variants	2024	2025	Average
1. Untreated control	9.46 c	9.02 d	9.24
2. Axial – 0,90 l ha ⁻¹	11.15 ab	11.41 c	11.28
3. Derby Super – 33 g ha ⁻¹	11.98 a	12.30 b	12.14
4. Axial One – 1.00 l ha ⁻¹	12.69 a	13.08 a	12.89

Numbers with different letters are significantly different according to Duncan's test ($p < 0.05$)

The uncontrolled weed flora diminishes the yields of the crops (Metwally et al., 2000; Barros et al., 2011; Neshev et al. 2020; Yankova et al., 2020; Yanev et al., 2021; Farahat et al., 2022; Naeem et al., 2022; Sevov et al., 2023). It is

confirmed by our obtained results that are presented in Table 9. As with the biometric indicators, all variants in which herbicide treatment against weeds was performed showed higher results.

Table 9. Barley grain yield, t ha⁻¹

Variants	2024	2025	Average	Percent of yield increase compared to the control
1. Untreated control	3.04 c	3.59 c	3.32	100%
2. Axial – 0,90 l ha ⁻¹	5.19 b	5.46 b	5.32	+60%
3. Derby Super – 33 g ha ⁻¹	5.89 a	5.97 b	5.93	+79%
4. Axial One – 1.00 l ha ⁻¹	6.31 a	6.58 a	6.45	+94%

Numbers with different letters are significantly different according to Duncan's test ($p < 0.05$)

The highest yields were recorded for variant 4 (Axial One – 1.00 l ha⁻¹) – 6.45 t ha⁻¹ on average for the period. This variant resulted in a 94% increase in yields compared to the untreated control. On average for the two years, the control had the lowest yields – 3.332 t ha⁻¹. In variant 2 (Axial – 0.90 l ha⁻¹), where only grass weeds were controlled, the yields were 5.32 t ha⁻¹. At variant 2, the increase in yield compared to the control was 60%, and in variant 3, where only broadleaf weeds were controlled, the yields were 5.93 t ha⁻¹, and the percentage increase in yield compared to the control was higher – by 79%.

Table 10 presents the found results concerning the 1000 grain weight of the barley seeds. All variants in which herbicide treatment against weeds was carried out have higher values for this parameter. The highest values for this indicator were recorded in variant 4 (Axial One) – 42.55 g on average for the period. On average for the two experimental years, the control stands out with the lowest values for the 1000 grain weight – 37.15 g. In variant 2 (Axial), where only cereal weeds were controlled, the absolute mass of seeds was 40.90 g, and in variant 3 (Derby Super), where only broadleaf weeds were controlled, the absolute mass of seeds was 41.90 g.

Table 10. 1000 grain weight, g

Variants	2024	2025	Average
1. Untreated control	37.50 c	36.80 c	37.15
2. Axial – 0,90 l ha ⁻¹	41.60 b	40.20 b	40.90
3. Derby Super – 33 g ha ⁻¹	42.30 a	41.50 a	41.90
4. Axial One – 1.00 l ha ⁻¹	42.90 a	42.20 a	42.55

Numbers with different letters are significantly different according to Duncan's test ($p < 0.05$)

Table 11 presents the established results concerning the hectoliter mass of barley seeds. The highest values for this indicator were recorded in variant 4 (Axial One) – 71.75 kg on average for the trial period. On average for the two experimental years, the control was with the lowest values – 67.80 kg. In variant 2 (Axial), where only the grass weeds were controlled, the hectoliter seed mass was 70.60 kg. In variant 3 (Derby Super), where only broadleaf weeds were controlled, the hectoliter seed mass was 71.35 kg,

Table 11. Hectoliter seed mass, kg

Variants	2024	2025	Average
1. Untreated control	67.10 c	68.50 c	67.80
2. Axial – 0,90 l ha ⁻¹	70.00 b	71.20 ab	70.60
3. Derby Super – 33 g ha ⁻¹	70.90 b	71.80 a	71.35
4. Axial One – 1.00 l ha ⁻¹	71.20 a	72.30 a	71.75

Numbers with different letters are significantly different according to Duncan's test ($p < 0.05$)

CONCLUSIONS

After the application with Derby Super and Axial One high efficacy against the Wild mustard and the Corn chamomile was recorded. After the application with Axial and Axial One high efficacy against the Wild oat and Darnel raygrass was found.

The highest results for the plant height, ear length, grain yield, 1000 grain weight and hectoliter seed weight were reported when all weeds are controlled – treatment 4 (Axial One).

The uncontrolled broadleaf weeds in variant 2 (Axial) suppress barley to a higher extent than the uncontrolled grass weeds in variant 3 (Derby Super), where higher results were reported for the studied indicators.

The lowest results from the study of all indicators were reported in the untreated control where high weed infestations was developing together with the crop.

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