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SUPPRESSIVE POTENTIAL OF SOME PERENNIAL GRASSES ON THE GROWTH AND DEVELOPMENT OF *AMBROSIA ARTEMISIIFOLIA*

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Abstract

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Common ragweed (*Ambrosia artemisiifolia*) is one of the worst invasive alien species in Europe with a strong negative impact on human health and agriculture. Therefore, search for effective methods for its control is crucial. The aim of this study was to test the suppressive potential of some perennial grasses on the growth and seed production of *A. artemisiifolia*. For this purpose, greenhouse and outdoor pot trials were conducted. The following grass species were used in different combinations – *Lolium perenne* 'Temprano', *Dactylis glomerata* 'Alba' and *Phleum pratense* 'Tundra'. Commercially available seeds of the grasses were obtained, whereas the seeds of *A. artemisiifolia* were collected from established populations in Kostinbrod town, West Bulgaria. For comparison with chemical control some trial variants were treated with Maton 600 EC (600 g/L 2,4 D ester). Fresh weight of biomass per plot, height of plants and the number of *A. artemisiifolia* plants were recorded three times in 2010–2011 in the greenhouse experiments and four times in 2011–2012 in the outdoor trials. Also, at the end of each vegetation season the seeds of *A. artemisiifolia* in each pot were collected and counted. The data was processed by the analysis of variance using F-test for testing significance and LSD for significance of difference between control and variants at levels of $P < 0.05$. The results showed that all the three grass species can effectively suppress the growth and seed formation in common ragweed, although *L. perenne* developed more rapidly from the first year, and thus expressed its suppressive capacity earlier than the other two species. At the time of last recording of the results there were no significant differences between the variants treated and not treated with herbicides except for the pure *A. artemisiifolia* stands (control trials). Thus, the study offers an effective means for control of *A. artemisiifolia* in waste lands and disturbed areas by combining the use of competitive perennial tuft-forming grasses and discontinued soil disturbance.

Key words: Ambrosia, control of invasive species, invasive species, suppressive potential

Introduction

Outside its native distribution range in North America, common ragweed (*Ambrosia artemisiifolia* L.) is among the invasive alien species that have a strong impact on agriculture and human health, and to lesser extent on the environment. The species invades a broad range of open disturbed areas (waste land, roadsides, railways, river banks) and causes considerable yield losses in field crops, such as in sunflower, maize and soybean. Common ragweed has highly allergenic pollen, which causes allergic rhinitis and severe asthma in over 20% of the population of affected areas (Bohren, 2008, Common Ragweed (*Ambrosia artemisiifolia* L.), http//www.ewrs.org/IW/ambrosia.asp). *Ambrosia*

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artemisiifolia is widespread in several European regions. In the past years much attention has been paid to the distribution of common ragweed in the Balkan countries (Konstantinovic et al., 2004; Soljan and Muratovich, 2004; Vrbnicanin et al., 2004). Recently, the species has been reported from numerous localities in Bulgaria (Dimitrov and Tzonev, 2002; Milanova and Nakova, 2002; Vladimirov, 2003, 2006, 2007; Valkova and Vladimirov, 2007; Petrova et al., 2013). Chemical and mechanical control methods have been developed and partially implemented in Europe, but sustainable control strategies to mitigate its spread into areas not yet invaded and to reduce its abundance in badly infested areas are lacking (Gerber et al., 2011). According to Basset and Crompton (1975) the efficacy of mechanical control is limited by the ability of *A. artemisiifolia* to produce new stems after cutting. The latter can rapidly produce flowers, which makes a second mechanical operation necessary. After the second mowing some plants of *A. artemisiifolia* regenerate again and form seeds (Valkova et al., 2009). The main conclusion given for chemical control is that some herbicides have a good level of efficacy against *A. artemisiifolia* (EFSA, 2007), but cannot prevent its population from flowering and setting seeds. In non-agricultural land, eradication of *A. artemisiifolia* using herbicides can be envisaged (Gauvrit and Chauvel, 2010), but often financial constraints and the need to protect the accompanying vegetation do not allow large-scale application of herbicides (Gerber et al., 2011). On non-crop areas, herbicide treatment of *A. artemisiifolia* at bud appearance (BBCH 53-55) with glufosinate or glyphosate gave the most effective control of both pollen and seed production (Gauvrit and Chauvel, 2010). In crops, the management of a competitive plant cover was found to reduce the biomass of *A. artemisiifolia* effectively, but again seed set could not be prevented (Buttenshou et al., 2009, Guidelines for management of common ragweed, *Ambrosia artemisiifolia*, http//www.EUPHRESCO.org). The main purpose of control is the reduction of *Ambrosia* seeds in the soil seed bank to prevent their germination and further development, respectively future flowering and seed ripening (Bohren et al., 2008). Surveys in literature and in the field showed that some perennial grass species suppress the density, growth and seed production of *A. artemisiifolia* (Mariyushkina, 1991; Kazinczi et al., 2008a, 2008b). Results from our previous experiments have shown that some perennial plants can suppress the growth and seed production of *A. artemisiifolia* (Valkova et al., 2009; Milanova et al., 2010).

The aim of this study was to determine the suppressive potential of some perennial grass species and their mixture on the growth and development of *A. artemisiifolia* as a means of control of the latter species.

Materials and Methods

The study was conducted during the period 2010–2012 in the experimental base of the Plant Protection Institute, Kostinbrod, Bulgaria. In 2010 the pot trials were carried out in greenhouse conditions during the vegetation season. Screening of several grass species and mixture of them was conducted in four replications. The sowing (in rate 40 g/m^2) was done on 08.05.2010 in pots (736 cm^2 soil surface) with rye-grass – *Lolium perenne* L. 'Temprano', cock's foot – *Dactylis glomerata* L. 'Alba' and timothy – *Phleum pratense* L. 'Tundra'. The grass species were grown following the normal practices (fertilization, irrigation, time of cutting). One hundred seeds of *A. artemisiifolia* were sown per pot, containing sandy clay loam soil (48.7% sand, 42.8% clay, pH (KCL) 5.8%, organic matter content 2.43%). The seeds of common ragweed were collected in the region of Kostinbrod town.

The following trial plan was applied:

1. *A. artemisiifolia* – control
2. *A. artemisiifolia* + *Ph. pratense*
3. *A. artemisiifolia* + *L. perenne*
4. *A. artemisiifolia* + *D. glomerata*
5. *A. artemisiifolia* + *Ph. pratense* + *L. perenne* (1:1)
6. *A. artemisiifolia* + *Ph. pratense* + *D. glomerata* (1:1)
7. *A. artemisiifolia* + *L. perenne* + *D. glomerata* (1:1)
8. *A. artemisiifolia* + *L. perenne* + *D. glomerata* + *Ph. pratense* (1:1:1)

For the comparison with chemical control the same variants were treated with Maton 600 EC (600 g/L 2,4 D ester) in rate 1200 ml/ha in the stage of *A. artemisiifolia* 13-14-16 BBCH and grass plants 13 BBCH. Fresh weight of biomass per plot, height of plants and the number of *A. artemisiifolia* plants were recorded three times (03.07.2010, 17.08.2010, 27.05.2011) in the phenophase of *A. artemisiifolia* 51-55 BBCH (in control).

In 2011 the same variants (with exception of V2: *A. artemisiifolia* + *Ph. pratense* and V6: *A. artemisiifolia* + *Ph. pratense* + *D. glomerata*) were conducted in containers (1809 cm^2 soil surface) at outdoor conditions. The sowing (in rate 40 g/m^2) was done on 01.04.2011 with the same variety of grass species. The grass species were grown following the normal practices. Three hundred seeds of *A. artemisiifolia* were sown per container, containing sandy clay loam soil (48.7% sand, 42.8% clay, pH (KCL) 5.8%, organic matter content 2.43%). The seeds of *A. artemisiifolia* were collected in the region of Kostinbrod. Fresh weight of biomass per container, height of plants and the number of *A. artemisiifolia* plants were recorded four times (05.07.2011, 19.08.2011, 06.10.2011, 01.06.2012) in the stage of *A. artemisiifolia*

51-55 BBCH (in control). At the end of vegetation season (mid-October) the seeds of *A. artemisiifolia* were collected and counted from each pot. The data was processed by the analysis of variance using F-test for testing significance and LSD for significance of difference between control and variants at levels of P<0.05.

Results and Discussion

The results from the first cutting during the investigation in 2010 showed that stronger inhibition effect on the number, height and fresh weight of *A. artemisiifolia* plants was achieved by variants: *A. artemisiifolia* + *L. perenne* (V3), *A. artemisiifolia* + *L. perenne* + *D. glomerata* (V7) and *A. artemisiifolia* + *L. perenne* + *D. glomerata* + *Ph. pratense* (V8) (Table 1). The reduction of fresh weight per one ragweed plant was 91.02%, 86.18% and 83.36%, respectively. It was observed also negative effect on the emergence of *Ambrosia*-plants. The number of plants in the same variants decreased with 35.76%, 41.21% and 32.12%, respectively, compared to control. Significant negative effect on the emergence and growth of ragweed has been recorded in the variants with treatment of 2,4 D ester, including control (pure stand). It was established the same trend in reducing the number of stems, height and fresh weight per one stem in variants V3, V7 and V8 during the second cutting (Table 2). No regrew of stems in variant 8. There was reduction in fresh weight (g per one stem) in *A. artemisiifolia* + *L. perenne* (V3) and *A. artemisiifolia* + *L. perenne* + *D. glomerata* (V7) with 62.21% and 67.18%, respectively. At the time of first and second cutting there was no any significant negative effect of stands of *Ph. pratense* (V2) and *D. glomerata* (V4) and mixture of them (V6) on the growth of *A. artemisiifolia*. That was due to the slow rate of growth and development of the sward. At the end of vegetation season the average number of *Ambrosia* seeds per pot in the variants was counted: V1 (control) – no treatment with 2,4 D ester – 274 seeds; V2 – 54 seeds; V3 – 0 seeds; V4 – 17 seeds, V5 – 19 seeds; V6 – 15 seeds, V7 – 0 seeds and V8 – 0 seeds.

There were no any seeds of *A. artemisiifolia* in all variants treated with 2,4 D ester.

The results in the second year (Table 3) showed that the best suppressive effect on the ragweed emergence, growth and development had stands of *L. perenne* (V3), *L. perenne* + *D. glomerata* (V7) and *L. perenne* + *D. glomerata* + *Ph. pratense* (V8). It was recorded the inhibition of fresh weight per plant of ragweed in all variants, compared to control. There were no considerable differences between variants treated and not treated with 2,4 D ester.

Table 1

Influence of some perennial grass species on the growth and formation of aboveground biomass of *Ambrosia artemisiifolia* – first cutting, 2010

Variants	Without treatment of 2,4 D ester						With treatment of 2,4 D ester					
	Number of plants per pot	Percent of control	Height/cm per plant	Percent of control	Fresh weight per plant	Percent of control	Number of plants per pot	Percent of control	Height/cm per plant	Percent of control	Fresh weight per plant	Percent of control
V1	41.25	100	17.4	100	0.757	100	2.75	100	3.61	100	0.146	100
V2	37.5	90.9	20.05	115.22	0.788	104.02	0	0	0	0	0	0
V3	26.5	64.24	6.66	38.28	0.068	8.98	1.25	45.46	1.5	41.55	0.02	13.69
V4	36	87.27	16.48	94.71	0.585	77.21	0	0	0	0	0	0
V5	40	96.97	10.68	61.38	0.159	20.97	0	0	0	0	0	0
V6	30.25	73.33	14.7	84.48	0.496	65.52	0	0	0	0	0	0
V7	24.25	58.79	7.03	40.37	0.105	13.84	0	0	0	0	0	0
V8	28	67.88	7.5	43.1	0.126	16.64	0	0	0	0	0	0
F:	49.9		465.16		161.28		8.26		9.16		51.43	
Sd:	1.304		0.448		0.344		0.496		0.61		0.01	
$LSD_{0.05}$	2.675		0.7		1.017		1.017		1.253		0.02	

*Variants: **V1** – A. artemisiifolia pure stand (control); **V2** – A. artemisiifolia + Ph. pratense; **V3** – A. artemisiifolia + L. perenne; **V4** – A. artemisiifolia + D. glomerata; **V5** – A. artemisiifolia + Ph. pratense + L. perenne; **V6** – A. artemisiifolia + Ph. pratense + D. glomerata; **V7** – A. artemisiifolia + L. perenne + D. glomerata; **V8** – A. artemisiifolia + L. perenne + G. glomerata + Ph. Pretense

Table 2

Influence of some perennial grass species on the growth and formation of aboveground biomass of *Ambrosia artemisiifolia* – second cutting, 2010

Variants*	Without treatment of 2,4 D ester						With treatment of 2,4 D ester					
	Number of stems per pot	Percent of control	Height/cm for stem	Percent of control	Fresh weight/g per stem	Percent of control	Number of stems per pot	Percent of control	Height/cm for pot	Percent of control	Fresh weight/g per stem	Percent of control
V1	47	100	39.58	100	2.514	100	1.75	100	16.92	100	3.833	100
V2	33.5	71.28	35.95	90.83	3.429	136.42	0	0	0	0	0	0
V3	1.5	3.19	12.75	32.21	0.95	37.79	0	0	0	0	0	0
V4	3.25	6.91	32.72	82.67	2.2	87.5	0.25	14.29	7.5	44.33	0.425	11.09
V5	3.5	7.45	18.25	46.11	1.638	65.14	0	0	0	0	0	0
V6	3.25	6.91	22.19	56.06	2.813	111.87	0.25	14.29	9.5	56.15	0.875	22.83
V7	0.75	1.6	12	30.32	0.825	32.82	0	0	0	0	0	0
V8	0	0	0	0	0	0	0	0	0	0	0	0
F:	358.05		35.46		41.61		15		4.52		16.83	
Sd:	1.35		3.304		2.525		0.221		4.84		0.459	
$LSD_{0.05}$	2.769		6.77		5.177		0.452		9.224		0.941	

*Variants: **V1** – A. artemisiifolia pure stand (control); **V2** – A. artemisiifolia + Ph. pratense; **V3** – A. artemisiifolia + L. perenne; **V4** – A. artemisiifolia + D. glomerata; **V5** – A. artemisiifolia + Ph. pratense + L. perenne; **V6** – A. artemisiifolia + Ph. pratense + D. glomerata; **V7** – A. artemisiifolia + L. perenne + D. glomerata; **V8** – A. artemisiifolia + L. perenne + G. glomerata + Ph. pratense

Table 3

Influence of some perennial grass species on the growth and formation of aboveground biomass of *Ambrosia artemisiifolia* – third cuttig, 2011

Variants*	Without treatment of 2,4 D ester						With treatment of 2,4 D ester					
	Number of plants per pot	Percent of control	Height/cm per plant	Percent of control	Fresh weight/g per plant	Percent of control	Number of plants per pot	Percent of control	Height/cm per plant	Percent of control	Fresh weight/g per plant	Percent of control
V1	10.5	100	8.41	100	5.554	100	7.25	100	17.08	100	5.524	100
V2	9.5	90.48	4.15	49.35	0.229	4.12	14	193.1	23.18	135.69	1.95	35.3
V3	6.25	59.52	6.18	73.42	0.196	3.52	4.5	62.07	6.35	37.18	0.424	7.68
V4	17.25	164.29	4.3	51.07	0.109	1.96	18.05	255.17	4.25	24.88	0.103	1.86
V5	15	142.85	6.55	77.88	0.165	2.97	14.25	196.55	5.3	31.03	0.165	2.99
V6	25.25	240.48	4.25	52.62	0.112	2	19.25	265.52	5.24	30.66	0.167	3.02
V7	5.5	52.38	5.3	63	0.153	2.75	8.75	120.69	5.7	33.37	0.191	3.46
V8	3.25	30.95	5.08	60.43	0.152	2.74	5	68.97	3.6	21.09	0.134	2.43
F:	278.66		26.32		134.78		113.14		475.51		692.88	
Sd:	0.617		0.407		0.073		0.778		0.467		0.102	
$LSD_{0.05}$	1.264		0.834		0.151		1.59		0.958		0.209	

*Variants: **V1** – A. artemisiifolia pure stand (control); **V2** – A. artemisiifolia + Ph. pratense; **V3** – A. artemisiifolia + L. perenne; **V4** – A. artemisiifolia + D. glomerata; **V5** – A. artemisiifolia + Ph. pratense + L. perenne; **V6** – A. artemisiifolia + Ph. pratense + D. glomerata; **V7** – A. artemisiifolia + L. perenne + D. glomerata; **V8** – A. artemisiifolia + L. perenne + G. glomerata + Ph. pratense

Table 4

Influence of some grass species and mixture of them on the growth and formation of aboveground biomass of *Ambrosia artemisiifolia*, 2011

Variants*	Without treatment of 2,4 D ester						With treatment of 2,4 D ester					
First cutting	Number of plants per container	Percent of control	Height/cm per plant	Percent of control	Weight/g per plant	Percent of control	Number of plants per container	Percent of control	Height/cm per plant	Percent of control	Weight/g per plant	Percent of control
V1	82.25	100	35.58	100	3.6	100	0	0	0	0	0	0
V3	46.5	56.53	10.23	28.75	0.119	3.31	0	0	0	0	0	0
V4	8.5	10.33	10.5	29.51	0.108	3	0	0	0	0	0	0
V5	1.5	1.85	7	19.67	0.112	3.13	0	0	0	0	0	0
V7	3	3.65	3.25	9.13	0.058	1.62	0	0	0	0	0	0
V8	1.25	1.52	10.15	28.53	0.115	3.19	0	0	0	0	0	0
F:	579.24		358.51		149.4							
Sd:	1.97		0.86		0.053							
LSD $_{0.05}$	4.111		1.796		0.109							
Second cutting												
V1	33.5	100	55.23	100	7.69	100	0	0	0	0	0	0
V3	3.75	11.19	7.15	12.95	0.126	1.64	0	0	0	0	0	0
V4	1	2.99	1.56	2.83	0.05	0.65	0	0	0	0	0	0
V5	2.25	6.72	14.33	25.96	0.163	2.11	0	0	0	0	0	0
V7	1.25	3.73	4.17	7.55	0.08	1.04	0	0	0	0	0	0
V8	0	0	0	0	0	0	0	0	0	0	0	0
F:	697.9		456.99		751.19							
Sd:	0.699		1.386		0.056							
LSD $_{0.05}$	1.461		2.896		0.105							

*Variants: V1 – A. artemisiifolia pure stand (control); V3 – A. artemisiifolia + L. perenne; V4 – A. artemisiifolia + D. glomerata; V5 – A. artemisiifolia + Ph. pratense + L. perenne; V7 – A. artemisiifolia + L. perenne + D. glomerata; V8 – A. artemisiifolia + L. perenne + G. glomerata + Ph. pratense

Regarding the outdoor experiments, the data from the first cutting in 2011 (Table 4), showed the best suppressive effect on the ragweed emergence had the stands of *L. perenne* + *Ph. pratense* (V5), *L. perenne* + *D. glomerata* (V7) and *L. perenne* + *D. glomerata* + *Ph. pratense* (V8). Fresh biomass decreased in all variants without treatment of 2,4 D ester in the range of 96.69% to 98.38%, compared to corresponding control. There were no any ragweed plants in the variants treated with 2,4 D ester. Significant negative effect of investigated perennial grass species on the emergence, growth and development of *A. artemisiifolia* has been observed during the second cutting (Table 4). The number of stems per container decreased in the range of 88.81% to 100% in all variants (V2–V8). Inhibition of fresh weight (g per stem) has been in the range of 97.89% to 100%. At the time of third cutting no any plants of *Ambrosia* were recorded in variants V2–V8 (both with and without treatment by 2,4 D ester). This fact was attributed to the formation of a dense stand of perennial grasses, which covered entirely the whole surface area. Kossola and Gross (1999) found that, although both above- and belowground competition suppress growth of a colonizing plant, belowground competition was the dominant factor in the suppression of annual *A. artemisiifolia*. The average number of ragweed stems was 54 per container in pure stand (control without treatment by 2,4 D ester). At the end of vegetation season, formation of ragweed seeds was recorded only in the control without treatment by 2,4 D ester – 349 seeds per container. In the next year no any *Ambrosia*-plants were observed in variants V2–V8. Only in pure stands were recorded ragweed plants: 41 individuals in control without treatment by 2,4 D ester and 24 plants in control treated by 2,4 D ester. Our results are in accordance with Kazinczi et al. (2008a, 2008b) who reported that *A. artemisiifolia* was dominant in the first two years after soil cultivation of wastelands. After three years its abundance decreases.

Conclusions

The results of this study as well as our previous experiments (Valkova et al., 2009; Milanova et al., 2010) have shown that some tuft-forming perennial plants can suppress the growth and seed production of *A. artemisiifolia*. This suggests that proper management of the native vegetation or seeding of competitive perennial plants (preferably native to the respective area), combined with discontinuation of any disturbance of soil substrate, can be an effective means for control of *A. artemisiifolia* in waste lands and disturbed areas.

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