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PRODUCTIVITY OF VELVETLEAF (*ABUTILON THEOPHRASTI* MEDIK.) DEPEND ON ITS DENSITY IN CORN

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Abstract. Field experiments were conducted in 2006 and 2008 at experimental field in Padinska Skela near Belgrade to quantify productivity of velvetleaf (*Abutilon theophrasti* Medik.) in corn. The density of velvetleaf artificially created and it ranged from 1 to 8 plants m^{-1} of corn row. Productivity of velvetleaf were estimate based on plant aboveground biomass and parameters of capsule (number of capsules m^{-2}, number of capsules $plant^{-1}$, diameter of capsule, number of locules $capsule^{-1}$) and seed (seed weight m^{-2}, seed weight $plant^{-1}$, weight of 100 seeds) production. Differences between years in plant aboveground biomass of velvetleaf at the stage of inflorescence, as well as in some capsule and seed production parameters were very prominent. Generally, velvetleaf productivity in corn depends of its density, that is with increasing density of population decreases yield.

Keywords: aboveground biomass, capsule production, corn, seed production, velvetleaf.

Introduction

Numerically, most weed seedling populations in corn and other row crop fields are described by the negative binomial distribution [JOHNSON et al., 1995; WILES et al., 1992]. Spatially, weed seed and seedling distributions vary from areas of very high population density to areas where no weeds are found [MORTENSON et al., 1995]. From this point of view, *Abutilon theophrasti* and like some others, *Amaranthus retroflexus, A. hybridus, Ambrosia artemisiifolia*, *Datura stramonium, Chenopodium album, Ch. hybridum, Galium aparine, Lactuca serriola, Xanthium strumarium,* etc. are predominant annual weed species found in corn and other row crops in Serbia where occupied more than 50 % arable fields [VRBNICANIN et al., 2008a,b; 2009].

Velvetleaf (*Abutilon theophrasti* Medik.) is self-compatible autogamous annual, which produce large fruits each of which may contain relatively large number of seeds (> 1800 seeds per plant) [VRBNICANIN and SINZAR, 2003]. This species is an important weed in many countries in all around the world, which causes significant crop yield losses [WARWICK and BLACK, 1988]. It is invasive alien species and one of major weeds in arable crops (summer row crops) in some parts of Serbia [VRBNICANIN et al., 2008a]. This species is increasing in importance due to population expansion and development of herbicide resistance [GRAY et al., 1995].

Many researchers were studied effects of different weed species on crop productivity and yield losses [ARSLAN et al., 2006; ZAFAR et al., 2010] and more of them were evaluated those problems in the case of corn and weeds including velvetleaf [LINDQUIST et al., 1995, 1996; TEASDALE and CAVIGELLI, 2010]. On the other hand, few studies have investigated competition effects on weed productivity [TEASDALE 1998; WEAVER, 1986]. Some efforts have been made to investigate the effects of crop density on weed population size, growth and reproduction [LINDQUIST et al., 1996; TEASDALE 1998], but few studies were focused the effects of weed density in crop with constant density [LINDQUIST et al., 1996; WEAVER, 1986].

Velvetleaf biomass and seed production depend of different factors as time of velvetleaf emergence, crop density, available light [TEASDALE 1998, BENVENUTI et al., 1994, BELLO et al., 1995]. Therefore, velvetleaf productivity in corn was between 100 and 18000 seeds m^{-2} depend on time of velvetleaf emerging [CARDINA et al., 1995]. Steinmaus and Norris (2002) showed that competitive interaction between corn and velvetleaf reduced velvetleaf biomass from 1370 g to 21 g dry weight $plant^{-1}$. In soybean, velvetleaf seed production was 40.37 and 48.93 seeds $plant^{-1}$ depends on year [LINDQUIST et al., 1996]. This suggests that, without effective management,

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velvetleaf plant density may increase significantly.

Weed seed production in crops has previously been ignored but it is now gaining in importance because of our need to understand weed fecundity [NORRIS, 1996]. Elimination of weed seed production for a few years can lead to the incorporation of fewer weed seeds into the seed bank [HARTZLER, 1996]. Approaches to crop production that successfully reduce weed seed production can benefit farming systems by reducing management inputs and costs. Therefore, weed-management techniques that reduce weed seed production are desirable and need to be investigated in order to provide new approaches to weed management. But, the first step in that process is determination of weed productivity.

The research was conducted to characterize the effects of velvetleaf density on its aboveground biomass, capsule and seed production in corn.

Material and Methods

Two field experiments were conducted in 2006 and again in 2008. The site is located in the experimental field in Padinska Skela near Belgrade (Serbia). Studies were conducted in conventional tillage corn at experimental field, which has a alluvial black marsh soil. Soil preparation consisted of primary and secondary tillage, as well as cultural practices was conducted according to local practices for corn production. The corn hybrid Dukat was selected for study. Crop was sown on 06 May, 2006 and 28 April, 2008. The experimental plots were 5.0 m x 4.2 m and consisted of 6 rows of corn with 70 cm between-row and 25 cm in-row spacing. Velvetleaf plants were established by hand planting seeds in specific locations depend of treatment. There were a total of four treatments representative of different velvetleaf plants density with 1 (D_1), 2 (D_2), 4 (D_3) and 8 (D_4) plants m^{-1} of corn row. Each velvetleaf planting location was thinned to one sample plant upon emergence to insure density. Both seasons other weeds were controlled through-out by hand weeding. Rainfall *(Table 1)* provided water necessity. Fertilizer was applied as 92 kg N, in the form of urea, before sowing. The experiment was laid out in the randomized complete block design with four replications.

Table 1.

Monthly rainfall and average temperature from May to September in 2006 and 2008 at Padinska Skela, Serbia.

Month	Year			
	2006		2008	
	Rainfall (mm)	Average temperature (°C)	Rainfall (mm)	Average temperature (°C)
May	34.6	15.5	49.0	17.1
June	135.6	18.7	39.6	21.0
July	14.8	22.0	42.0	21.1
August	98.8	18.9	35.0	21.3
September	27.2	17.0	70.0	14.8
Total	311.0		235.6	

At the stage of inflorescence velvetleaf plants were randomly selected, and cut at the soil line for aboveground biomass measurement. After seed maturity capsules from four plant $plot^{-1}$ were collected and reproductive fitness were measured: number of capsules m^{-2}, number of capsules $plant^{-1}$, and diameter of capsule, number of locules $capsule^{-1}$, seed weight m^{-2}, seed weight $plant^{-1}$, and weight of 100 seeds.

The results were processed using software Statistica 5.0 by the descriptive statistics and student´s t-test.

Results

Biomass production

High relative variability in

aboveground biomass of velevetleaf between treatments (D_1, D_2, D_3, D_4) was confirmed (Figure 1). At the stage of inflorescence plants produced 96.67-215.53 g biomass in 2006 year and 45.62-86.63 g in 2008, depend on its density. Therefore, biomass was approximately 2.5 times grater in 2006 than in 2008. Velvetleaf biomass productions were decreased as its density increased. The highest biomass was obtained in treatment D_1 (215.53 g in 2006, and 86.63 g in 2008), while the lowest was obtained in treatment D_4 (96.67 g in 2006, and 45.62 g in 2008), for both years. Also, clear evidenced those treatments D_3 and D_4 differed significantly (P < 0.05) from treatments D_1 and D_2 *(Table 2)*. But differences were no detected between D_1 and D_2 (in both years) as well as between D_3 and D_4 (only in 2006).

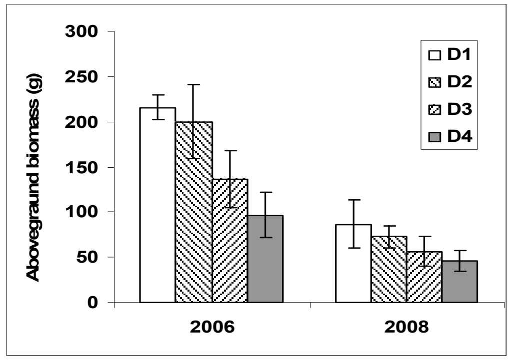

Figure 1. Means ±SD of aboveground biomass of velvetleaf depend on its density in corn row. Bars represent the standard deviation of the mean. (D_1= 1 plant m^{-1}, D_2= 2 plant m^{-1}, D_3= 4 plant m^{-1}, D_4= 8 plant m^{-1}).

Table 2.

Level of the differences between tretments for aboveground biomass of velvetleaf density in corn row.
(D_1= 1 plant m^{-1}, D_2= 2 plant m^{-1}, D_3= 4 plant m^{-1}, D_4= 8 plant m^{-1}).

	2006			2008		
Density	D_1	D_2	D_3	D_1	D_2	D_3
D_2	n.s.			n.s.		
D_3	**	*		**	**	
D_4	**	*	n.s.	**	**	*

n.s. o significant differences; P < 0.01**; P < 0.05*; t-test

Capsule production

According to results of two years *(Figure 2)*, capsule production (number per area or plant) of velvetleaf depend of its density in corn, while, diameter of capsules and number of locules in capsule are not in relation with plant density. Total number of capsules produced m^{-2} increased, while number of capsules $plant^{-1}$ tended to decrease with increasing plant density *(Figure 2a,b)*. The average number of capsules m^{-2} ranged from 8.5 (D_1) to 37.32 (D_4) in 2006, and from 6.07 (D_1) to 25.92 (D_4) in 2008. At the same time, the average number of capsules per plant were between 22.60 (D_4) and 35.70 (D_1) in 2006, and between 15.59 (D_1) and 25.50 (D_4) in 2008. Also, number of capsules per area m^2 confirmed significant differences (P<0.05) between all treatments, except D_1 and D_2 (Table 3). The same relation between treatments confirmed for number of capsules $plant^{-1}$, except for D_3 and D_4 treatments, where were no significantly differed in 2006 *(Table 3)*.

Diameter of capsule and number of locules $capsule^{-1}$ did not vary among any velvetleaf density in both years *(Figure 2c,d)*. Therefore, there was no significant effect (P>0.05) of velvetleaf density on the diameter of capsule and number of locules $capsule^{-1}$ *(Table 3)*. The average diameter of capsule was about 3 cm, while the average number of locules $capsule^{-1}$ was about 14.

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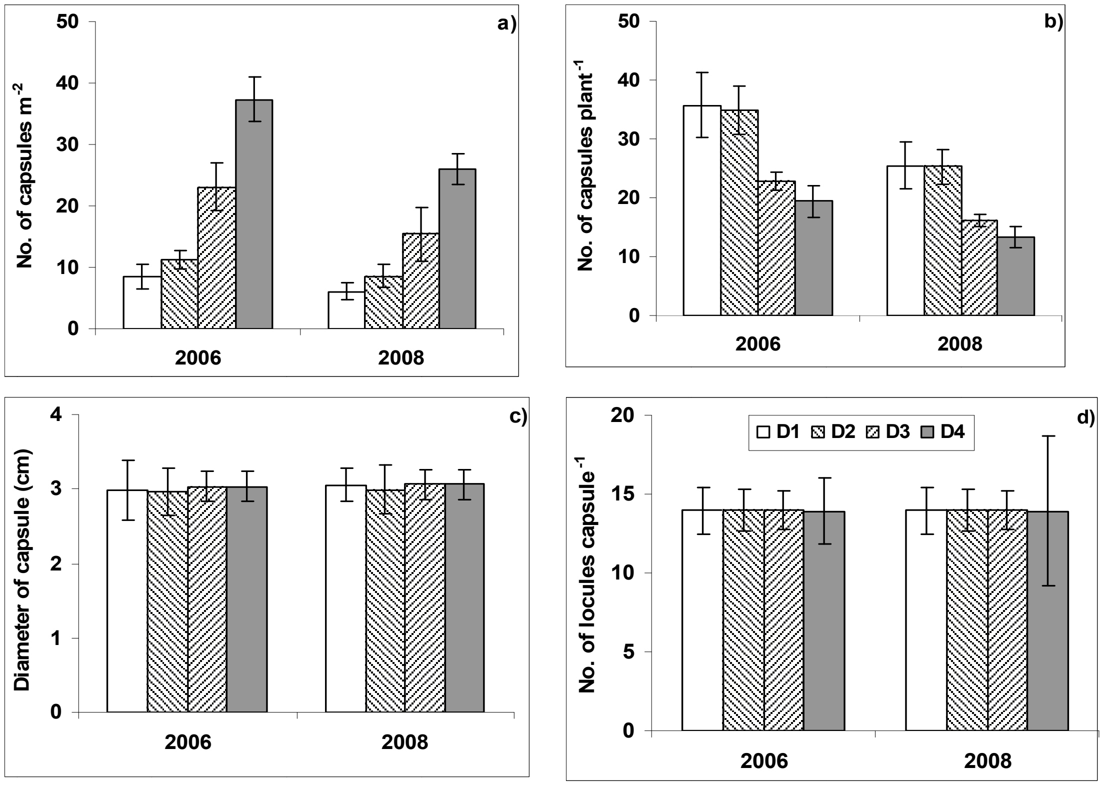

Figure 2. Means ±SD of capsule production of velvetleaf depend on its density in corn row: a) number of capsules m^{-2}; b) number of capsules $plant^{-1}$; c) diameter of capsule; d) number of locules $capsule^{-1}$. Bars represent the standard deviation of the mean. (D_1= 1 plant m^{-1}, D_2= 2 plant m^{-1}, D_3= 4 plant m^{-1}, D_4= 8 plant m^{-1})

Table 3.

Level of the differences between tretments for capsule production depend on its density in corn row. (D_1= 1 plant m^{-1}, D_2= 2 plant m^{-1}, D_3= 4 plant m^{-1}, D_4= 8 plant m^{-1}).

		2006			2008		
Density		D_1	D_2	D_3	D_1	D_2	D_3
No. of capsules m^{-2}	D_2	n.s.			n.s.		
	D_3	**	**		**	*	
	D_4	**	**	**	**	**	**
No. of capsules $plant^{-1}$	D_2	n.s.			n.s.		
	D_3	**	**		**	**	
	D_4	**	**	n.s.	**	**	*
Diameter of capsule	D_2	n.s.			n.s.		
	D_3	n.s.	n.s.		n.s.	n.s.	
	D_4	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
No. of locules $capsule^{-1}$	D_2	n.s.			n.s.		
	D_3	n.s.	n.s.		n.s.	n.s.	
	D_4	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

n.s. o significant differences; $P < 0.01$; $P < 0.05$*; t-test**

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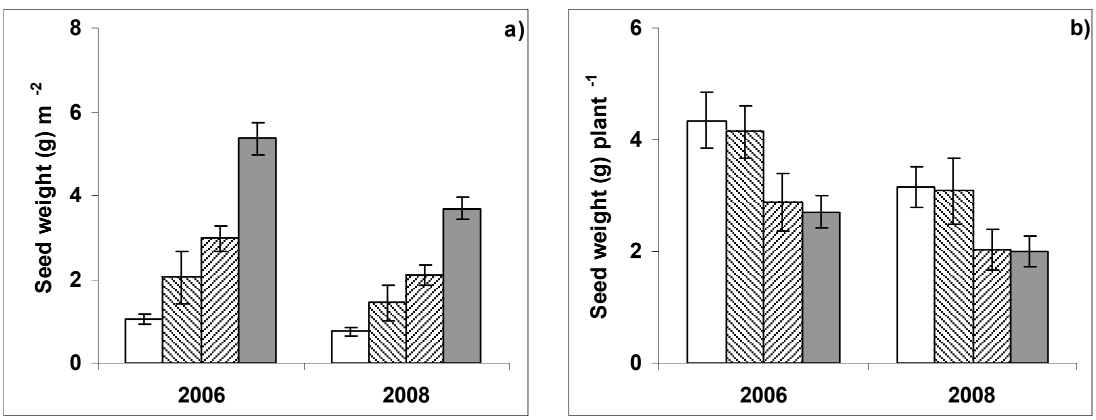
Seed production

Data presented in Figure 3 show the seed production of velvetleaf plants depend of its density in corn. Those results indicate that velvetleaf seed production m^{-2} and $plant^{-1}$ depend on its density in corn, while relation between weight of 100 seeds and plant density was not confirmed.

Generally, increased plant density caused increased seed weight m^{-2} and decreased seed weight $plant^{-1}$ in both years. The average seed weight m^{-2} tend to increase from 1.08g (D_1) to 5.36g (D_4) in 2006 and from 0.76g (D_1) to 3.70g (D_4) in 2008, with increasing velvetleaf density. On the other hand, seed weight $plant^{-1}$ was in range from 3.24g (D_4) to 4.35g (D_1) in 2006, and from 2.17g (D_4) to 3.15g (D_1) in 2008. The average weight of 100 seeds was similar (about 0.9 g) in all treatments in both years.

Statistical processing of data (Table 4) confirm significant differences ($P < 0.05$) between all treatments for seed weight per m^2. Also, seed weight per plant for treatments D_3 and D_4 differed significantly ($P < 0.05$) compared to treatments D_1 and D_2, while no differences between D_1 and D_2 as well as between D_3 and D_4. Plant density has no significant effects ($P > 0.05$) to weight of 100 seeds.



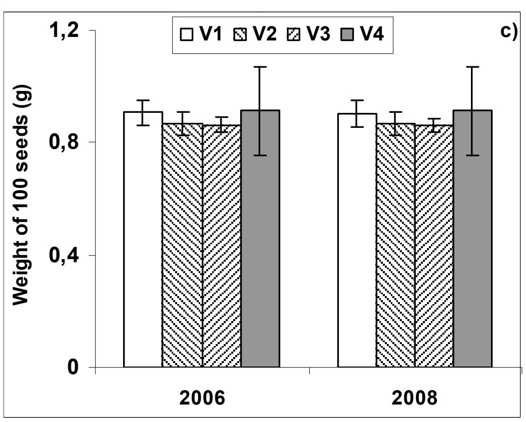


Figure 3. Means ±SD of seed production of velvetleaf depend on its density in corn: a) seed weight m^{-2}; b) seed weight $plant^{-1}$; c) weight of 100 seeds. Bars represent the standard deviation of the mean. (D_1= 1 plant m^{-1}, D_2= 2 plant m^{-1}, D_3= 4 plant m^{-1}, D_4= 8 plant m^{-1}).

Table 4.

Level of the differences between tretments for seed production of velvetleaf depend on its density in corn row. (D_1= 1 plant m^{-1}, D_2= 2 plant m^{-1}, D_3= 4 plant m^{-1}, D_4= 8 plant m^{-1}).

		2006			2008		
Density		D_1	D_2	D_3	D_1	D_2	D_3
Seed weight (g) m^{-2}	D_2	*			*		
	D_3	**	*		**	*	
	D_4	**	**	*	**	**	*
Seed weight (g) $plant^{-1}$	D_2	n.s.			n.s.		
	D_3	**	*		**	*	
	D_4	**	**	n.s.	**	*	n.s.
Weight of 100 seeds (g)	D_2	n.s.			n.s.		
	D_3	n.s.	n.s.		n.s.	n.s.	
	D_4	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

n.s. o significant differences; $P < 0.01$**; $P < 0.05$*; t-test

Discussion

A fundamental understanding of relations between different factors and weed species productivity will have important implications for future weed management practices. More research is needed on understanding the long-term influence of weed species productivity on agricultural production and on managing of crops to reduce weed seed production and the soil seed bank.

This results provide an overview of effects of intra-specific competition through different velvetleaf density (1, 2, 4, and 8 pants m^{-1} in the row crop) on its production (aboveground biomass, capsule and seed production) in corn. Some investigations indicate that weed biomass production is strongly influenced by the choice of plant density, row spacing, and the degree of competition from the crop and the genotype [JORDAN 1993; TOLLENAAR et al. 1994]. It is well documented that velvetleaf biomass and seed production is significantly reduced when competing with corn relative to plants grown in monoculture [STEINMAUS and NORRIS 2002; TEASDALE 1998]. Nurse and DiTommaso (2005) showed that the competitive status of velvetleaf relative to that of corn had a significant effect on velvetleaf seed production and on the ability of seeds produced to germinate. But, the effect of intra-specific competition of weeds in crop with constant density is not well known.

This research shows that velvetleaf aboveground biomass was 2.5 times grater in 2006 than in 2008 indicating agroecological conditions (2006 and 2008 differed in amount and timetable of rainfall) had significant effect on this parameter. This observation agrees, in part, with those made in Bello et al. (1995), which found great impact of amount of rainfall on velvetleaf biomass accumulation. At the same time, filed environments had significant effect on some capsule (number of capsules m^{-2}, number of capsules $plant^{-1}$) and seed (seed weight m^{-2}, seed weight $plant^{-1}$) production parameters, while diameter of capsule, number of locules $capsule^{-1}$ and weight of 100 seeds were not influenced by filed environmentals. These results are consistent with those reported by Cardina et al. (1995) showing that growing conditions influence velvetleaf seed production in corn. However, Lindquist et al. (1995) have shown velvetleaf seed production in soybean was not influenced by year.

Growth and biomass production of most plants is density dependent (McLachlan et al., 1993; Murphy et al., 1996), so it would be expected that increasing velvetleaf density would decrease aboveground biomass production. Our results targeting effects of velvetleaf density on its aboveground biomass in corn agree with those expectations. Therefore, impact of velvetleaf density on its biomass was very prominent.

The data presented in Figure 2 and

Table 2 confirms high effect of velvetleaf density on capsule production. Number of capsules m^{-2} was significantly different between all treatments except between treatments with low velvetleaf density (D_1 and D_2). Relation between treatments for number of capsules $plant^{-1}$ was same, with exception for 2006, when there were no differences between treatments D_3 and D_4 .Other capsule production parameters (diameter of capsule, number of locules per capsule) were not influenced by plant density. These findings are particularly consistent to results contributed by Weaver (1986), who found jimsonweed density had significant impact on number of capsules produced per plant and the number of seeds per capsule.

In our study impact of velvetleaf density (ranged 1-8 plants m^{-1} of corn row) to its seed production in corn was very prominent *(Figure3, Table3)*. Contrary, in the experiment with soybean Linquist et al. (1995) found that velvetleaf seed production in soybean was not influenced by velvetleaf density. The similar results were obtained for seed production m^{-2} of jimsonweed (*Datura stramonium* L.) in soybean [WEAVER, 1986].

Conclusion

In closing, the impact of intra-specific competition of velvetleaf at different population density (ranged 1-8 plants m^{-1} in corn row) in corn was very prominent. Namely, aboveground biomass, number of capsules and seed weight per plant is decreasing, while number of capsules and seed weight per m^2 is increasing with increasing velvetleaf density. Diameter of capsule, number of locules per capsule and weight of 100 seeds were similar in all velvetleaf densities.

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