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A STUDY OF SHOOT AND ROOT COMPETITION IN *AMARANTHUS HIBRIDUS*

SUMMARY

The pot experiment was carried out in a greenhouse of the Plant Protection Institute, Kostinbrod, in 2011 and 2012. Treatments included five levels of *Amaranthus hibridus* densities (1, 2, 4, 6, 8 plants per pot). Weed plants were harvested at 90 days after emergence. Shoot height, root length, fresh and dry weight of shoots and roots were determined. It was established Competition Index (CI) and Relative Competitive Ability Index (RCAI).

The results presented in this paper show that there was difference in the competitive ability of *Amaranthus hibridus* in intra-specific competition. The weed had a higher shoot competitive ability on 90 days after emergence. The Relative Competitive Ability Index (RCAI) of the weed in different densities was highest in the growth parameter - shoot height. It was found significant density x shoot competition interaction for shoot height and above-ground weight. There was also density x root competition interaction for root length and weight. Increasing the density from 2 to 8 plants per pot increased competition for light and nutrients and water. The radiation absorption through the weed canopy declined when density increased, which may explain the higher reduction in *Amaranthus hibridus* above-ground parameters 90 days after emergence. The results suggest that it may be possible to select crops for greater competitive ability against *Amaranthus hibridus*.

Key words: *Amaranthus hibridus,* density, shoot competition, root competition, growth parameters

INTRODUCTION

Understanding the mechanisms of competition between plant species can increase our knowledge about the outcome of competition. This understanding might be useful for weed management and can be applied in crop breeding for improved weed suppression.

The relative importance of shoot and root competition has recently been reviewed by (Wilson, 1988a). He found that in 14 out of 47 weed species shoot competition had a greater effect than root competition. The author pointed out that competitive imbalance in the weed was usually increased when there was higher resource input. The relative root and shoot growth of the weeds may be a critical parameter in determining the species potential to establish reliably in the

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face of competition. Root competition between plants can affect the ability of plants to compete for above-ground resource and hence, influence plant quality (Weiget and Jolliffe, 2003).

For *Amaranthus retroflexus* it was established that competition for light was one of the most important aspects in its competition, which was due to its height, its leaf (better: leaves) are position and its horizontal leaves (Izadi et al., 2005). In a competition situation *Amaranthus retroflexus* partitioned relatively more biomass to its stem (Makarian et al., 2005).

Root competition usually affected the balance between soil components more than shoot competition. In weed experiments, shoot competition was often more intense than root competition. There is little evidence to justify the common assumption that adding environmental resource reduces competitive effects; competitive imbalance was often greater at higher resource levels. Although positive interaction between shoot and root competition has often been considered a basic feature of competition, such interactions occurred rarely (Baston, 1988). Root and shoot growth are interrelate if one is modified then the other is as well. The relative importance of root competition was greatest when the weed was young and growing in a stand with the lowest density. It is probable that the above-ground interaction became more significant when plants were older or weeds were denser, mutual shading leading to the increased importance of above- ground interaction. Root growth stopped at an earlier stage than shoot growth as plants aged (Perera et al., 1992). According to Gibson, Foin and Hill, 1999, the importance of root competition and the relationship between root and shoot growth suggest that researchers should not rely solely on correlations between shoot traits and competitive ability as evidence that competition is primarily for light. Their results also suggest the importance of considering the whole plant when assessing for competitive ability.

Deneva and Nakova., 2002 concluded that P and K stimulate generally the root growth of *Ambrosia artemisiifolia*. The increasing of N levels affects positively the weed growth. The leaf area, fresh weight of leaves, stems and root per plant of *Iva xanthifolia* were significantly decreased as the density of the weed was increased. A greatest effect of reduction of stems and root was found at 8 and 16 plant densities. The presence of 8 weed plant per pot decreased fresh weight of stems and roots by 89-91%, 87-91%, respectively, as compared with control (Valkova, 2007).

Better understanding of competition processes can be used to predict the effects of management and to identify plant characteristics related to competitive ability (Bastians et al., 1997). This is difficult to achieve by empirical experiments alone because plant competition involves complex physiological processes that regulate resource acquisition, conversion of resources to plant biomass and response of plants to resource availability (Lindquist, 1997).

The study described here was designed to compare the competitive ability of various densities of *Amaranthus hibrid*us and to separate the effects of intra-specific competition for above-ground and below-ground resources.

MATERIAL AND METHODS

A pot experiment was conducted at the Plant Protection Institute, Kostinbrod in glasshouse during 2011 and 2012. The soil was a sandy clay loam containing 73,3% sand, 19,5% clay, 1,07% organic mater and with pH 6,4. The pot value was 18 cm diameter, 4000 cm^3 volume. Pots were filled with 2 kg of air dried soil. The seeds of *Amaranthus hibridus* were collected in the region of Kostinbrod. Their germination was more than 82%. Treatments included five levels of Amaranthus hibridus densities (1, 2, 4, 6, 8 plants per pot) and applied 1 rates of nitrogen - 1 gram per pot, corresponding to 140 kg N/ha. There were four replicates for each variant. After emergence, seedling were thinned to 1, 2, 4, 6 and 8 plants per pot. Weed plants were grown at temperatures from 18 to 25o. Regular watering was applied to avoid a moisture deficit in the substrate.

Weed plants were harvested at 90 days after emergence(DAE). Shoot height, root length, fresh and dry weight of shoots and roots were determined for each variant and every plant in harvested period.

The competition index (CI) for each variant in studied morphological parameters were calculated based on the formulae given by Kroh & Stefenson (1980) at wich : Competition Index = mean plant parameter of the weed species in a treatment : mean plant parameter of the weed species in pure stand. Relative Competitive Ability Index (RCAI) = sum of the competitive indices for the particular parameters in all treatments. Statistica 5,0. The tables and figures are based on the average data over the period 2011-2012. Software was used to produce and compare the curves relating the densities of the weed to some *Amaranthus hibridus* morphological parameters, using a simple and fitted model. Estimation method was Quasi Newton.

RESULTS AND DISCUSSION

Our results showed that the shoot height, root length, above-ground fresh and dry weight, root fresh and dry weight of Amaranthus hibridus were significantly decreased as the density of the weed was increased. The intra-specific competition affects mainly these parameters (Fig.1).

Shoot competition tended to decrease the height of *Amaranthus hibridus*. Root competition had already reduced the height of the weed, when the measurements were made 90 days after emergence. There was significant shoot competition x root competition for the height of Amaranthus hibridus.

Increasing the density of *Amaranthus hibridus* from 2 to 8 per pot decreased all the measured attributes of the weed.

There was a significant density x shoot competition interaction for shoot height and weight. There was also density x root competition interaction for length and both root weight. In the intraspecific competition Amaranthus hibridus had a higher shoot competitive ability than that root competitive ability on 90 days after emergence.

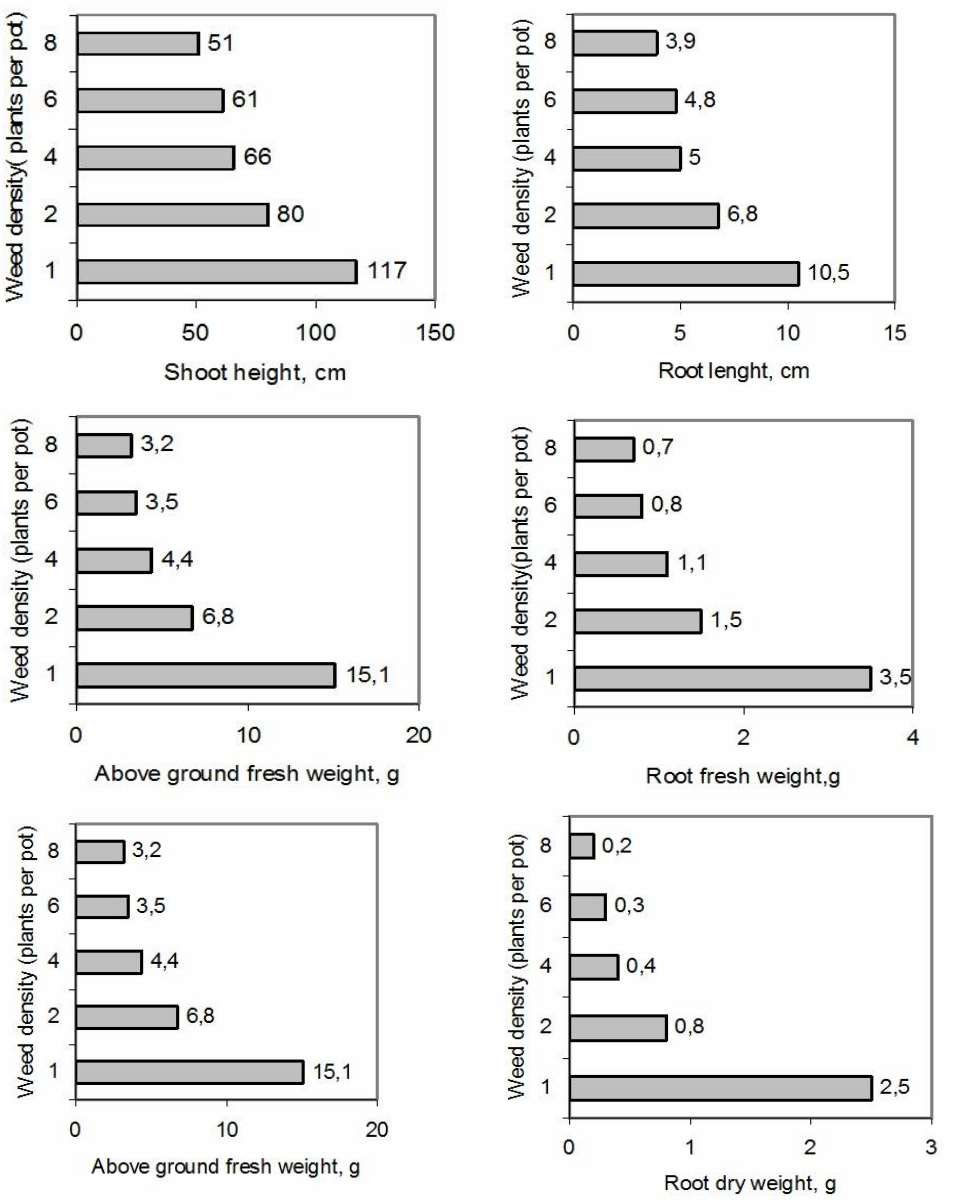

Figure 1. Effect of different density of *Amaranthus hibidu*s of some morphological parameters (90 days after emergence).

In this study (Table 1) the Competition Index (CI) of Amaranthus hibridus in terms of morphological parameters (90 days after emergence) decreased when his proportion per pot increased. The Relative Competitive Ability Index (RCAI) of *Amaranthus hibridus* was highest in the parameter – shoot height. This indicated that competition for aerial resources was greater than that soil resources

Table 1. Competition indices (CI) and Relative Competitive Ability Index (RCAI) of *Amarantus hibridus* in a replacement series experiment

Weed density (plants per pot)	Shoot height	Root length	Above ground fresh weight	Above ground dry weight	Root fresh weight	Root dry weight
2	0.68	0.64	0.45	0.43	0.42	0.32
4	0.56	0.47	0.29	0.19	0.28	0.16
6	0.51	0.45	0.23	0.12	0.22	0.12
8	0.43	0.37	0.21	0.11	0.22	0.08
RCAI	2.18	1.93	1.18	0.85	1.14	0.68

The relative severity of root and shoot competition will depend on the extent to which soil resource (nutrients and water) are supplied. In our case when adequate resource are given, then light becomes the limiting factor. There is evidence to support this view in the present study, where increasing the density from 2 to 8 plants per pot increased competition of Amaranthus hibridus, i.e increased competition for light and nutrients and water. Although light became a more important limiting factor, and nitrogen and water became less important, when plants were older (in the case 90 days after emergence). The same trends are reported for *Amaranthus hibridus* under intra-specific competition (Maluf, 1999).

The regression models were significantly fitted to the some dates of morphological parameters. The regression lines shows that at four weed densities, Amaranthus hibridus shoot height and root length decreased with an increased number plants per pot. Intercept values was greater in height than this in root length. The reduction of the height was greater. It is most likely that the reduction of height in mixed stands relative to its production in pure stand was due to a reduced light interception, as in all treatments an ample supply of water and nutrient was provided. The radiation transmitted through the weed canopy declined when weed density increase, which may explain the more reduction in Amaranthus hibridus above-ground parameters (Fig.2 and Fig.3).

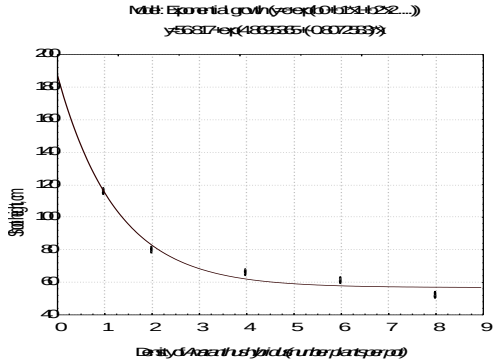

Figure 2. Relationship between density of Amaranthus hibridus and shoots hight

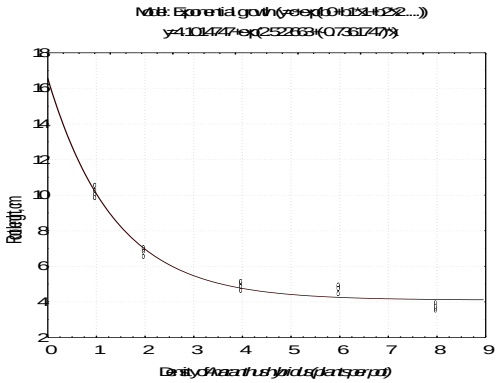

Figure 3. Relationship between density of Amaranthus hibridus and Rooth lenght

Some authors think that the mathematical modelling shows good prediction abilities and the technique could be used as a basis for an integrated weed management system based on the intra-specific weed competition (Maneva, Deneva, 1995).

CONCLUSIONS

Main characteristics of Intra-species competition of *Amaranthus hibridus*– shoot height, root length, above-ground fresh and dry weight, root fresh and dry weight in 90 days after emergence were explored. Increasing the density of *Amaranthus hibridus* from 2 to 8 per pot decreased all the measured attributes of the weed.

In the intra-species competition *Amaranthus hibridus* had a higher shoot competitive ability than that root competitive ability on 90 days after emergence.

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PROUČAVANJE KOMPETICIJE IZMEĐU IZDANKA I KORIJENA KOD *AMARANTHUS HIBRIDUS*

SAŽETAK

Eksperiment u sudovima su sprovedeni u stakleniku Instituta za zaštitu bilja, Kostinbrod, 2011 i 2012. godine. Tretmani su uključivali pet nivoa gustine biljaka *Amaranthus hibridus* (1, 2, 4, 6, 8 biljaka po sudu). Korovske biljke su se brale 90 dana od izbijanja. Utvrđene su visina izdanka, dužina korijena, svježa i suva masa izdanka i korijena. Određen je Indeks kompeticije (CI) i Indeks relativne kompetitivne sposobnosti (RCAI).

Rezultati koji su prezentovani u ovom radu ukazuju na postojanje razlika u kompetitivnoj sposobnosti *Amaranthus hibridus*-a kod kompeticije unutar vrste. Korov je imao veću kompetitivnu sposobnost izdanka 90 dana nakon izbijanja. Indeks relativne kompetativne sposobnosti (RCAI) korova kod različite gustine je bio najveći kod parametra rasta – visine izdanka. Otkriveno je kao značajna interakcija gustina x kompeticije izdanka za visinu izdanka i težinu iznad površine zemljišta. Takođe je postojala interakcija između gustine x kopeticije korijena kod dužine i težine korijena. Povećanje gustine sa 2 do 8 biljaka po sudu je povećavala kompeticiju prema svjetlosti i hranljivim sastojcima i vodi. Absorpcija zračenja kroz nadzemni sklop biljke je opala sa povećanjem gustine, što može objasniti veće smanjenje nadzemnih parametara *Amaranthus hibridus*-a 90 dana od izbijanja. Rezultati ukazuju da je moguće odabrati usjeve koji imaju veću kompetativnu sposobnost od *Amaranthus hibridusa.*

Ključne riječi: *Amaranthus hibridus,* gustina, kompeticija izdanka, kompeticija unutar vrste, parametri rasta