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ANALYSIS OF THE ABOVEGROUND AND ROOTS BIOMASS OF REDROOT PIGWEED (*AMARANTHUS RETROFLEXUS* L.) DEPENDING ON PLANT DENSITY

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Abstract. The experiment aimed at comparison of the fresh and dry biomass of aboveground parts and roots of redroot pigweed (*Amaranthus retroflexus* L.) depending on plant density. A micro-plot (1m^2 plots) experiment was set up in 2012 at the experimental station Totem Field at UBC, Vancouver, Canada, as a randomized block design with four replications per treatment. Three different densities of redroot pigweed were studied: 10, 30 and 50 pcs per 1 m^2. Seeds were sown in two terms: I – 18th July and II – 6th August. Plants sown in the I term were of higher biomass and more diversed whereas plants sown in the II term developed smaller amounts of aboveground and root biomass. We conclude that in the later term of emergence root competition and seed production play more important role than aboveground competition.

Key words: *Amaranthus retroflexus*, density, term of sowing, biomass categories

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Introduction

Redroot pigweed (*Amaranthus retroflexus* L.) is a common, annual and spring weed, in the maize and root-crops (Mowszowicz 1986). In a population, plants of redroot pigweed exhibit large diversification of both, biomass accumulation and reproductive effort, which relate to the plant fitness (Wang *et al.* 2006). These traits may also influence the competitive potential of redroot pigweed against crop, depending on their emergence time. According to Weaver (1984), Weaver & McWilliams (1980) and Costea *et al.* (2004) plant morphology, i.e. length of stems, their diameter and number of branches are very changeable and depend on the environmental conditions. As a determining or stimulating factor, which can be displayed by the amount of biomass, can be both, density and timing of specimens' emergence (Martin & Field 1988; Nagashima 1999).

The aim of our study was to compare the biomass of aboveground parts and roots of redroot pigweed (*A. retroflexus*) plants, depending on their density in the two different sowing times.

Material and methods

The field experiment was carried out at the Totem Field experimental station of the University of British Columbia in Vancouver, in the vegetative season 2012. A micro-plot experiment was composed of 24 plots of 1 m^2 area each, with three different plant densities: 10, 30, 50 plants per 1 m^2, with 4 replications per treatment. Chemical parameters of soil: pH 6.3, organic matter – 7.4%, total C – 4.48%, total N – 0.2014%; soil texture: sand – 78.9%, silt – 16.3%, clay – 4.8%.

A. retroflexus seeds were sown manually into the soil at a depth of 1-1.5 cm in the first experiment (I) in the early term, 18th July. The second experiment (II) was sown 4 weeks later, on 6th August. The distance between plants in rows and interrows was 20-25 cm. For the measurements, 10 plants in the flowering phase were dug out of soil from each plot with a total number of 40 plants per each density. The fresh mass of aboveground parts as well as of the roots was assessed after digging. The dry mass was assessed after drying plant material (roots and aboveground parts in the separate paper bags)

Table 1. Fresh mass and dry mass (g) of aboveground parts and roots of redroot pigweed in the I experiment.

Parameters	Density pcs/1 m^2		
	10	30	50
Fresh mass of aboveground parts	263.8 b*	237.7 ab	169.6 a
Fresh mass of roots	28.4 b	23.3 ab	19.3 a
Dry mass of aboveground parts	40.0 b	36.6 ab	29.1 a
Dry mass of roots	12.1 b	10.7 ab	10.2 a

* Different letters relate to the significant differences at p=0.05.

Table 2. Fresh and dry mass (g) of aboveground parts and roots of redroot pigweed in the II experiment.

Parameters	Density pcs/1 m^2		
	10	30	50
Fresh mass of aboveground parts	24.83 a*	33.23 a	27.69 a
Fresh mass of roots	6.56 a	10.06 b	10.56 b
Dry mass of aboveground parts	8.41 a	12.49 b	11.93 b
Dry mass of roots	3.12 a	4.43 a	5.14 a

* Different letters relate to the significant differences at p=0.05.

in the drier at 105°C for 48 hours.

Both experiments were analyzed separately. One way ANOVA was performed for the data. Means were separated using Duncan test at p=0.05. For the aboveground parts and roots the weight categories were distinguished and their frequencies displayed on the graphs.

Results and discussion

In the first experiment (I) plants of redroot pigweed developed significantly higher aboveground and root biomass, when grown at the lowest density (Tab. 1). Similar relationships were noted for the dry mass. This is a result of low intraspecies competition and thus the possibility for a more intensive branching and vegetative growth (Cheplick 2001; Wang *et al.* 2006).

Plants sown in the later term (II experiment) developed by about 10-times lower biomass, as compared to the I experiment (Tab. 2). In this experiment there was no influence of the plant density on aboveground and root fresh mass. The lower diversity in biomass accumulation could be a result of a shorter time for development, and for this reason plants do not invest in the biomass production, instead the effort is placed upon the generative development (Wang *et al.* 2006).

Comparing the trends of changes of root biomass between the different densities it was observed, that in the I experiment (early sowing) the root biomass was significantly decreasing with the increased plant density (Tab. 1). For the delayed term of sowing (II experiment), there was a reverse trend noted (Tab. 2).

For the fresh mass of plants in the I experiment there were 14 and 7 weight-categories distinguished, for aboveground parts and roots, respectively. The aboveground parts were categorized every 50 grams (Fig. 1) and roots were categorized every 10 grams (Fig. 2). The frequencies of plants per each category were differentiated, depending on their density (Fig. 1). At the lowest density (10 pcs per 1m^2) plants developed the highest biomass, and the largest share of plants was in the categories 70-120 g and 120-170 g. Single plants of this density were noted also in the highest categories >520 g, where no plants of higher densities (30 and 50 pcs per 1m^2) were observed. For the density of 30 pcs per 1m^2 the highest number of plants was noted for the lower weight-categories: 120-170 g and 220-270 g – 270-320 g. Also plants of the highest density of 50 pcs · m^{-2} developed the lowest biomass, which is represented by the highest frequencies of plants in the lowest weight-categories: from 70 to 220 g (Fig. 1).

The distribution of root biomass of redroot pigweed was similar to the aboveground parts. Plants of the lowest density developed the biggest root system. Roots of plants of this density were found in the all categories, with the highest frequency in the 10-20 g root-weight-category. Plants of 30 pcs per 1 m^2 density developed the higher number of roots in the weight-categories of 10-20 g and 20-30 g. Roots of plants of the highest density were found only in the two lowest weight-categories 0-10 g and 10-20 g (Fig. 2).

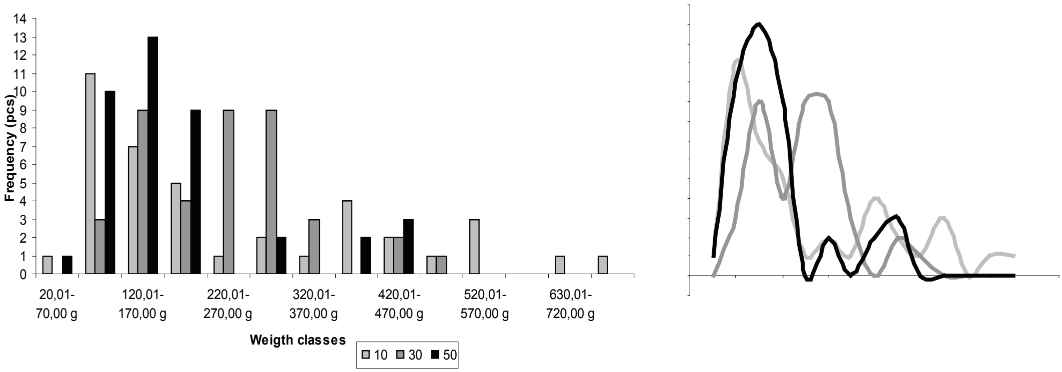

Fig. 1. Fresh mass of aboveground parts of redroot pigweed in the experiment I.

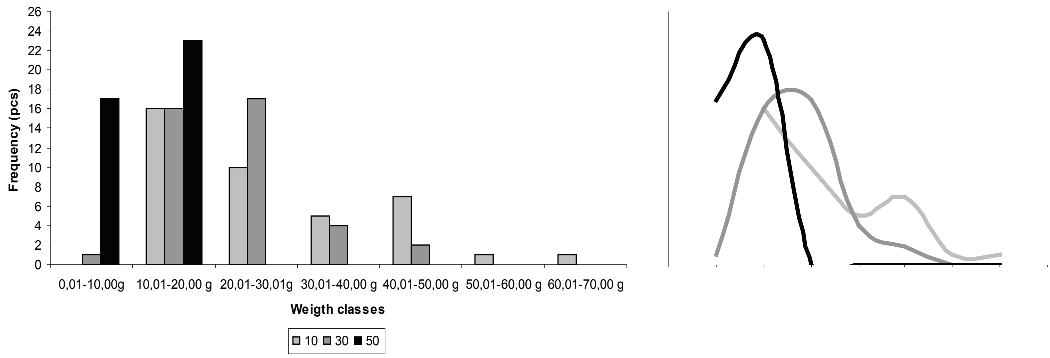

Fig. 2. Fresh mass of roots of redroot pigweed in the experiment I.

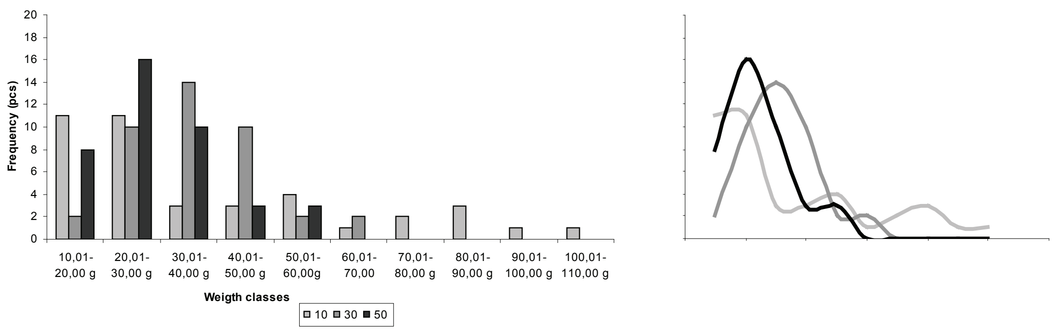

Fig. 3. Dry mass of redroot pigweed aboveground parts in the experiment I.

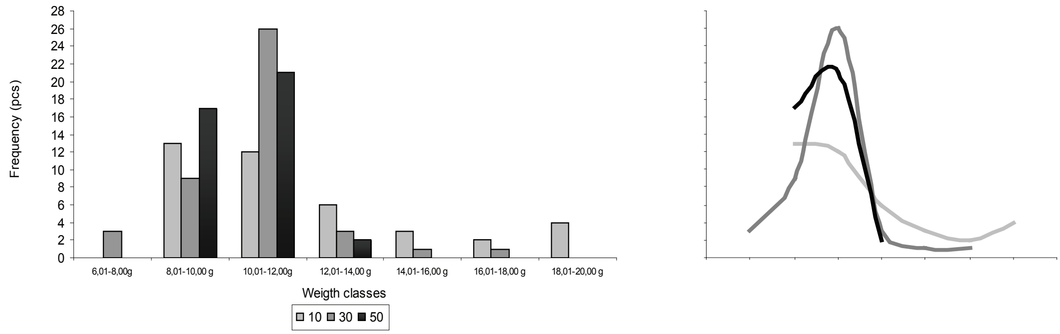

Fig. 4. Dry mass of redroot pigweed roots in the experiment I.

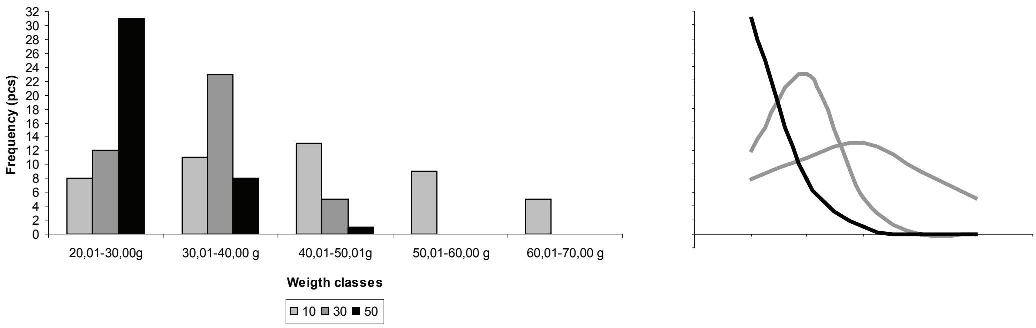

Fig. 5. Fresh mass of aboveground parts of redroot pigweed in the experiment II.

The distribution of the dry mass of aboveground parts (Fig. 3) and roots (Fig. 4) of redroot pigweed was very similar to the distribution of the fresh mass (Fig. 1-2).

As expected, the fresh mass of aboveground parts of redroot pigweed depended on their density. In the I experiment the distribution of plants of the lowest density within all categories was similar (Fig. 5). As for the plants of the highest density, visibly higher frequency was noted for the lowest weight-category. Plants of this density were not noted in the highest weight-categories. Interestingly, the highest frequency of fresh mass of roots was noted for plants of all densities in the weight-category 10-12 g, and within this category the highest frequency was noted for roots of the highest density (Fig. 6).

In the II experiment the share of dry mass of the aboveground parts of redroot pigweed was different from the share of the fresh mass but also similar for the three densities tested, except for the highest weight-category, where plants of the lowest density had the highest frequency (Fig. 7). The distribution of root biomass was more differentiated (Fig. 8). Roots of the lowest density dominated in the two weight-categories: 3-4 g and 5-6 g, also the single roots for this density were noted in the highest weight-categories. Roots of the medium density dominated in the same weight-categories, as the roots of the lowest density. Roots of the highest density were located in the categories from 1-6 g, but the highest number of roots was noted for the highest weight-category for this density: 5-6 g. (Fig. 8).

The above results are confirmed by the literature. Also, when in the favorable conditions, plants tend to develop higher biomass, and canopy architecture is more diverse (Wang *et al.* 2006).

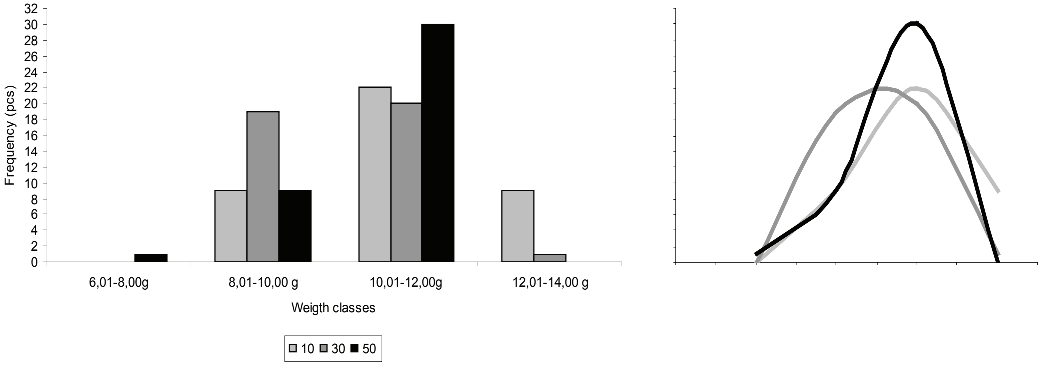

Fig. 6. Fresh mass of roots of redroot pigweed in the experiment II.

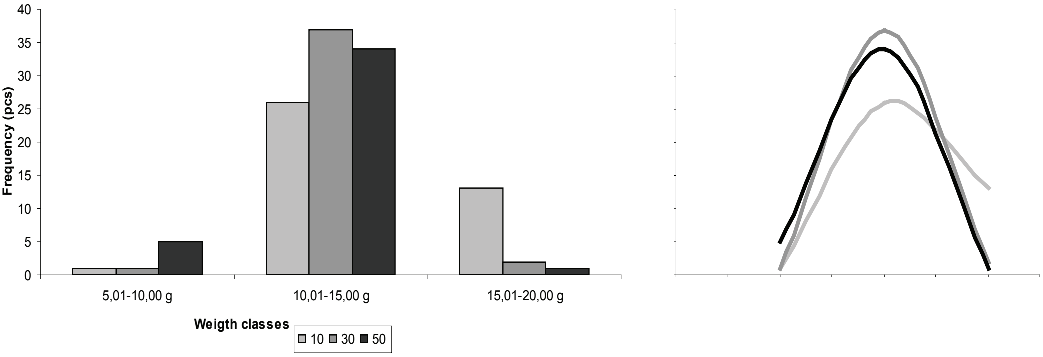

Fig. 7. Dry mass of redroot pigweed aboveground parts, experiment II.

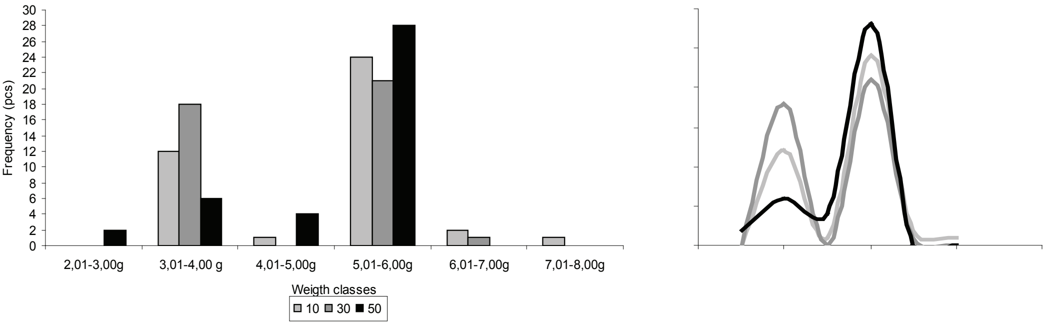

Fig. 8. Dry mass of redroot pigweed roots, experiment II.

Conclusions

In the earlier time of emergence the increased density of redroot pigweed was a cause of decreased plant biomass. Later time of sowing resulted in a decreased aboveground biomass accumulation, and their increased homogeneity, as compared to the earlier time of sowing. At the same time the role of root competition was higher, which can suggest that in the delayed time of emergence the main effort is put into the production of seeds.

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