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Interference of redroot pigweed (*Amaranthus retroflexus* L.) with soybean [*Glycine max* (L.) Merr.] in different fertilization systems

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Abstract

Information related to the density effects of redroot pigweed on soybean traits in different fertilization systems are lack. Therefore, field experiments were conducted during 2012 growing season. Experimental designs were arranged in split plots based on randomized complete block design. Main plots were consisted of six methods of fertilization including (N1): Farmyard manure (FYM); (N2): compost; (N3): chemical fertilizers; (N4): FYM + compost and (N5): FYM + compost + chemical fertilizers; and control (N6). Sub plots were there pigweed densities including (D1): 0, (D2): 10 and (D3): 20 plants m^{-2}. Results showed that Co-application of organic and chemical fertilizers (N5) to the soil increased leaf chlorophyll significantly. The highest grain nitrogen (7.6 %) was obtained from N5D1 treatment. The highest grain P and K content was obtained from N5 treatment. The maximum of LAI was observed in N5 treatment, there is no significant difference between the organic and chemical fertilizers treatments (N1, N2 and N3). Co-application of compost, farmyard manure and chemical fertilizer produced higher amounts of pod number per plant, grain number per pod and 100-grain weight. Since the highest amounts of grain yield components were obtained from N5 and D1 treatments, N5D1 produced the highest grain yield.

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Introduction

Competition between a crop and weeds for growth resources is the major cause of crop yield reduction by weeds. Weed density also has an impact on weed–crop competition. Redroot pigweed (*Amaranthus retroflexus* L.) is a common weed in soybean, corn, sugar beet and sunflower fields with a C4 photosynthetic pathway. It is one of the first weeds whose herbicide resistant biotypes have been observed in the fields (Holm et al., 1996). A rapid growth and tall plant traits make redroot pigweed extremely competitive with crops.

Soybean [*Glycine max* (L.) Merr.] is the most important rainy season crop in the semi-arid condition of Iran. Weeds emerging before or with the crop are very competitive (Dielman et al., 1995). Two redroot pigweed plants per meter emerging with soybean reduced crop yield by 12.3%, but emergence at the two-nodal stage of soybean caused no yield differences (Dielman et al., 1995). Depending on the density, early-emerging redroot pigweed reduced corn yield by 5 to 34% and sorghum yield by 46%, but late-emerging redroot pigweed was less competitive (Knezevic et al., 1997).
The ability of redroot pigweed to cause serious yield losses is documented for some crops such as cotton, soybean and snap beans (Aguyoh and Masiunas, 2003; Bensch et al., 2003; Culpepper et al., 2006). However, information related to the density effects of redroot pigweed in different fertilization systems are lack.

The degree of weed competition is influenced by the several other factors such as nutrient availability. The availability of nutrients has been affected by fertilization. Chemical fertilizers are the dominant fertilizers in Iranian soybean farms and application of organic fertilizers are not common. Application of organic manures such as farmyard manure (FYM) and compost can improve soil physical conditions and enhancement of biological nitrogen fixation by soybeans. This can lead to greater uptake of nitrogen by soybean in competition with redroot pigweed. Therefore, this study was conducted to evaluate the soybean response to different pigweed density in integrated fertilization system.

Materials and methods

The trial was conducted in Botany Garden of Hamedan, the northwest region of Iran in 2012 growing season. The soil type is sandy loam (100 g/kg clay, 460 g/kg silt, and 440 g/kg sand) with a water holding capacity of 272 g/kg. The experimental design was a split plot based on randomized complete block design with three replications. Main plots were six strategies of supplying the basal fertilizer requirements of canola including (N1): 5 t FYM/ha; (N2): 5 t compost/ha; (N3): 50 kg triple super phosphate/ha + 30 kg Urea/ha; (N4): 2.5 t FYM/ha + 2.5 t compost/ha, (N5): 2.5 t FYM/ha + 2.5 t compost/ha + 25 kg triple super phosphate/ha + 15 kg Urea/ha and (N6): Control (without fertilizer). Sub plots were there pigweed densities including (D1): 0, (D2): 10 and (D3): 20 plants m^{-2}. Redroot pigweed seed was purchased from a commercial supplier and sown in a 1-cm-deep furrow; seeds were sprinkled by hands into this furrow, covered with soil, and firmly packed.

The FYM and compost were also analyzed for chemical and nutrients properties (Table 1). FYM, compost and chemical fertilizer were added to plots before sowing soybean. Soybean and pigweed seeds were planted on April 10, 2012. Main plot size was 5×10 m and spaces between main plots were two meter. All weeds other than redroot pigweed were removed by hand, interrow cultivation, and through selective herbicides throughout the growing season.
Chlorophyll readings were taken with a hand-held dual wavelength meter (SPAD 502, Chlorophyll meter, Minolta Camera Co., Ltd., Japan) at the flowering stage. Leaf area of each subsample determined using a leaf area meter (LI-COR instruments, USA). Leaf area index (LAI) was calculated as total leaf area per sample divided by the sampled area. After soybean harvesting, seeds were collected to determine the soybean grain yield and yield components. Area harvested was 2 × 10 m for each sub plot. Grain yield of soybean was adjusted to

9% moisture content. The nitrogen content of the matured seeds was determined by Microkjeldhal method. The phosphorus content of matured seeds was determined by vanado molybdate phosphoric acid yellow colour method. Also, the potassium content was determined by Flame Photometer model-EEL (AOAC, 1990).

The data collected in this study was subjected to analysis of variance (ANOVA). Procedure GLM was used for the analysis of variance and to test differences between treatments. Means comparison was done through LSD test by using a SAS statistical package (SAS Institute, 2002).

Results and discussion

Leaf chlorophyll

According to the analysis of variance, leaf chlorophyll was significantly affected by different fertilization system and pigweed density does not significant effect on leaf chlorophyll (Table 2). It is reported that nitrogen availability is the most limiting factor of crop yield in organic farming, because of insufficient decay of added organic matter or immobilization of nitrogen by soil microorganisms (Clark et al., 1999). In the present study, the comparison of SPAD value between treatments (Table 2) indicated that the severe competition for nitrogen was occurred between soybean and pigweeds, and this competition was alleviated by application of organic manure. Simultaneous application of organic and chemical fertilizers (N5) to the soil increased leaf chlorophyll significantly. Regarding the key role of nitrogen in chlorophyll structure, it seems that supply of this element by combination application of organic and chemical fertilizers is the main reason for increasing leaf chlorophyll. Correlation between nitrogen and chlorophyll content has been reported in previous studies (Dordas and Sioulas, 2008). Followed by N5 treatment and the least was N4 treatment (Table 2). Increasing leaf chlorophyll content in these treatments is related to more mineral elements such as iron, magnesium, and manganese provided by simultaneous application of compost and farm manure.

Table 1. Chemical characteristics of FYM and compost applied to the soil.

Characteristic	pH	N	P	K	Ca	Mg	Zn	Cu
		(%)			(ppm)			
FYM	7.42	0.44	0.42	0.30	766	1210	11	23
Compost	7.23	0.68	1.11	0.45	1687	1786	81	288

Nutrient uptake by soybean

Fertilization, pigweed density and their interactions had a significant effect on grain nitrogen content. The highest grain nitrogen (7.6 %) was obtained from N5D1 treatment (Fig. 1). In this treatment organic and chemical fertilizers were applied when no redroot pigweed was present. It was also found that in high pigweed density the farmyard manure and compost application (N4D3), soybean plant have a more grain nitrogen in compared to chemical fertilizer used (N3D3) (Fig. 1). It seems that with application of chemical fertilizer, most of rhizosphere nitrogen is absorbed by the weed, but in organic manure application, the gradual release of nitrogen was occurred and soybean was more successful in competition. Even the high density of pigweed in organic manures may cause to prominence of soybean in competitive. Hatch et al. (2007) reported that incorporation of farmyard manure to the soil had beneficial effects of increasing biological nitrogen fixation, dry matter, and N yields in red clover.

The results showed that different methods of fertilization and pigweed density had a significant effect on grain phosphorus and potassium contents. The highest grain P and K content was obtained from N5 treatment (Table 2). Combined application of compost and farm manure increased soil enzymatic activity such as phosphatase and P availability was increased for plant (Mohammadi et al., 2011). Organic manure increased the ability of Bacillus sp. to produce organic acid such as gluconic, citric and fumaric acids under P-limiting conditions may increase the solubility of poorly soluble phosphorus (Veneklaas et al., 2003). Triple super phosphate fertilizer (N3) in comparison with compost and farm manure significantly increased grain P contents. The maximum grain P and K of soybean reached when no redroot pigweed was present. Not surprisingly, the lowest grain P and K for soybean was recorded in the plots with highest weed density. At the highest densities of redroot pigweed, grain P and K of soybean was reduced by 155.5% and 39.65% in comparison with control, respectively.

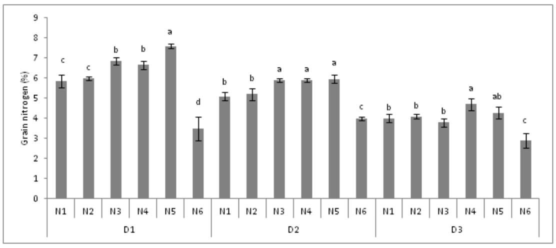

Fig. 1. Interactive effects of fertilization and pigweed density on soybean grain nitrogen. (N1: FYM; N2: compost; N3: chemical fertilizers; N4: FYM + compost; N5: FYM + compost + chemical fertilizer & D1: 0; D2: 10; D3: 20 pigweed in m2; bars indicate the standard error of means).

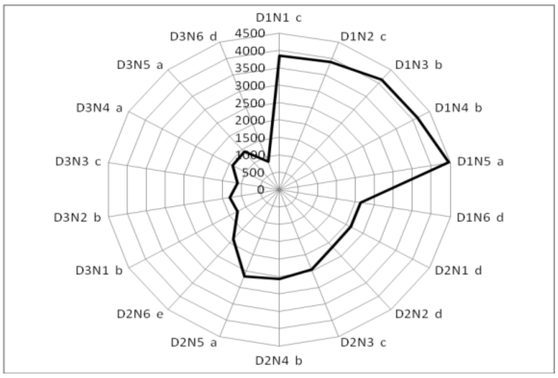

Fig. 2. Interactive effects (radar graph) of fertilization and pigweed density on soybean grain yield. (N1: FYM; N2: compost; N3: chemical fertilizers; N4: FYM + compost; N5: FYM + compost + chemical fertilizer & D1: 0; D2: 10; D3: 20 pigweed in m^2; Mean values in each pigweed density (D) with the same letter(s) are not significantly different using LSD tests at 5% of probability).

Leaf area index

Analysis of variance showed that various fertilization methods and pigweed density had significant effects on leaf area index (LAI). The maximum of LAI was observed in N5 treatment, there is no significant difference between the organic and chemical fertilizers treatments (N1, N2 and N3) (Table 2). Shanmugam and Veeraputhran (2000) stated that application of organic manure stimulated the growth of plants with more number of tillers and broader leaves in plant that could be the possible reason for the increased leaf area.

LAI can be used to indicate the effect of weed competition on crop yield and quality. An increase in redroot pigweed density reduced soybean LAI from 5.1 at 0 redroot pigweed plants m^{-1} to approximately 3.7 at 20 plants m^{-1} (Table 2). The height advantage and large leaf area of redroot pigweed shaded the soybean, which contributed to the reductions in soybean LAI. Our results are consistent with earlier studies in which a reduction in LAI of crops other than soybean is influenced by density of a weed (Chikoye et al. 1995; Mosier and Oliver 1995).

Grain yield and yield components

Analysis of variance showed that fertilization methods and pigweed density had significant effects on pod number per plant, grain number per pod and 100-grain weight. Co-application of compost, farmyard manure and chemical fertilizer produced higher amounts of pod number per plant, grain number per pod and 100-grain weight (Table 2). The existence of appropriate amount of moisture, nutrients, and the lack of pathogens are the most important factors for pods fertility and seed production. Simultaneous application of compost, farmyard manure, and chemical fertilizer significantly increased pod number per plant, grain number per pod and 100-grain weight which is attributed more nutrients provision. Rudresh et al. (2005) emphasized that nutrients availability plays an impartment role in increasing seed number per pod. Despite the increase in 100 grain weight in N3 compared to N4, there was no significant difference between them. However, combined application of compost and farm manure in comparison with individual application of them increased 100 grain weight (Table 2).

Table 2. Effects of fertilization and pigweed density on agronomic soybean traits.

Treatments	Leaf chlorophyll (spad number)	Grain phosphorus (mg/100 g)	Grain potassium (mg/100 g)	Leaf area index	Pod no. per plant	Grain no. per pod	100-grain weight (g)
Fertilization							
FYM (N1)	31.1 c	215.6 b	1010.2 b	4.1 b	18.8 c	2.1 c	13.9 b
Compost (N2)	31.7 c	204.7 c	959.3 c	4.1 b	17.9 c	2.3 bc	13.7 b
Chemical fertilizers (N3)	30.2 d	230.2 b	873.7 d	4.9 b	21.4 b	2.4 b	14.9 a
FYM + compost (N4)	34.8 b	223.1 b	1190.2 a	4.9 b	21.6 b	2.4 b	14.8 a
FYM+compost+chemical (N5)	36.9 a	249.6 a	1198.1 a	5.1 a	27.1 a	2.8 a	15.1 a
Control (N6)	24.1 e	173.7 d	473.7 d	3.4 c	8.9 d	1.7 d	13.5 b
Pigweed density							
0 (D1)	31.5 a	322.2 a	1134.1 a	5.1 a	23.3 a	2.7 a	16.3 a
10 (D2)	31.4 a	200.1 b	910.9 b	4.4 b	20.2 b	2.1 b	14.2 b
20 (D3)	31.4 a	126.3 c	812.2 c	3.7 c	14.3 c	1.9 b	13.2 b

Mean values in each column with the same letter(s) are not significantly different using LSD tests at 5% of probability.

Soybean grain yields were also affected by fertilization and pigweed density. Two-way interactions of fertilization × pigweed density significantly made effect on grain yield. Since the highest amounts of grain yield components were obtained from N5 and D1 treatments, N5D1 produced the highest grain yield (Fig. 2). For justification of this difference, it could be stated that along with meeting plant need to phosphorus, adding compost and farmyard manure to soil could provide micro elements for plant in weed free condition. Increasing densities of redroot pigweed resulted in more soybean yield losses. Compost applied in the current study has been shown to contain elevated concentrations of micro elements including zinc, magnesium and calcium. Moreover, it seems that organic manure causes improving soil structure and optimizing root growth conditions by providing organic matter and nutrients. Also, applying the organic manure in high pigweed infected plots (N4D3) increased soil organic matter and releasing of nutrient was occurred gradually. This can lead to greater uptake of nitrogen by soybean in competition with redroot pigweed. Moreover, organic fertilizers with improving soil physical properties provided suitable conditions for root development and biological nitrogen fixation (Ouedraogo et al., 2001). All of fertilization treatments had a lower gain yield in D3 plots compared to other pigweed densities (Fig. 2).

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