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EFFECT OF DENSITY ON WEEDS SEED PRODUCTION AND BIOMASS AND SORGHUM YIELD ROTATED WITH DIFFERENT PLANTS

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ABSTRACT

The present study aimed at evaluating effect of crop rotation and planting density on sorghum yield, weed seed production and biomass. The experiment was conducted as split plots using completely randomized blocks design with three replications. The factors included prior cultivation at five levels: lentil, maize, wheat, bean, and rapeseed as main factor and sorghum density as secondary factor at four levels including 50 plants/m^2 (row spacing = 4 cm), 25 plants/m^2 (row spacing = 8 cm), 17 plants/m^2 (row spacing = 12 cm), and 12 plants/m^2 (row spacing = 16 cm). According to the results, maximum length of panicle, 1000 kernel weight, and biomass of sorghum was seen in densities of 12 and 17 plants/m^2. In these treatments, there was not any significant difference between densities of 12 and 17 plants/m^2. However, more density resulted in significantly decrease of these traits. Sorghum biomass in densities of 25 plants/m^2 and 50 plants/m^2 was 37.3% and 34.4% less than that of 12 plants/m^2, respectively. The highest biomass per area unit (1636g/m^2) was seen in wheat rotation and density of 50 plants/m^2. After this treatment, maximum biomass (1213 and 1170 g/m^2), was seen in bean and rapeseed rotations in the density of 50 plants/m^2.

Keywords: crop rotations, density, sorghum, weed.

INTRODUCTION

Sorghum is globally becoming an important crop. Rapid growth, relative resistance against drought, high percentage of protein, and high production potential has introduced this plant as an appropriate option to be cropped in arid regions of Iran. Also, it may be used as an appropriate second cultivation due to its high growth rate. According to the researches, the increasing plant density increased sorghum biomass production but the single plant biomass decreases (Mousavi, 2012; Mousavi *et al*., 2009) because, when the density exceeds the optimum, competition is intensified between crops and this results in decrease of crop growth and grain yield in the plant (Mahmoodi and Rahimi, 2009). According to the studies, agricultural operation such as adjusting inter-row and intra-row distances are of the most important operations to enhance crops yield and decrease competition of row-cultivated crops with weeds (Hossain *et al*., 2005).

During recent decades, weeds of row-cultivated crops have been globally controlled using chemical herbicides. Weeds are still a major problem in agriculture in spite of significant development in their chemical control because weeds canopy is changing in response to modern management methods. For example, less agricultural operation leads to increase of frequency of weeds and farmers respond to these changes through increasing application frequency of herbicides. In addition to environmental risks, more application of herbicides increases resistance of weeds against herbicides. Most weeds are found in many ecosystems due to their wide compatibility. Comparing with mono cropping, different crop rotations may lead to unstable environmental conditions and, thus, constrains weeds compatibility (Serajchi *et al*., 2013). Putting appropriate crops in sequence, weeds may be effectively controlled without any damage to other corps found in the sequence (Kirkegaard *et al*., 2008). Mousavi *et al*., (2012) studied effects of the densities of 12, 15, 25 and 50 plants/m^2 on yield and yield components of grain sorghum in Iran. According to their results, increasing plant density decreased 1000 kernel weight, number of grain per panicle, and harvest index. However, increase of number of panicle per area unit resulted more grain yield in higher densities.

Mousavi (2012) studied effects of the densities of 20, 30, 40 and 50 plants/m^2 on growth and yield of sorghum. According to their results, plant densities significantly affected number of tiller and stem diameter. Increasing plant density decreased the number of tiller per plant and stem diameter. Soleymani *et al.,* (2013) studied effect of the densities of 100000, 200000, 300000, 400000, 600000 plants/ha on sorghum yield and concluded that plant density significantly affected plant height, stem diameter, and stem fresh weight. Maximum fresh weight belonged to the density of 400000 plants/ha. Fromme *et al.,* (2012) reported a 25% decrease of sorghum yield due to decreasing planting distance. According to Bahrani and Dehghani Ghenateghestani (2004), the density of 50 plants/m^2 is the best one to produce sorghum.

Simplification of agricultural systems causes environmental and agricultural disadvantages including stability of agriculture in relation with fertility, decrease of biodiversity, environmental problems, and soil erosion. It is necessary to use some technical innovations, e.g. crop rotation, to improve production potential and stabilize agricultural systems. Rotation deranges life cycle of pathogens and pests, lessens application rate of pesticides, decreases erosion, facilitates weeds control, enhances crops yield and increases soil fertility. Rotation is a system to maintenance natural resources and use plant resources effectively (ZareFeizabadi and Koocheki, 2012).

Specie combination of weeds highly depends on environmental heterogeneity which depends on type of plant and management operation (agricultural operation, fertilization, and application of herbicides). In comparison with monotonous environments, there are more various weeds in cultivation systems with high management diversity (Dornelas *et al*., 2009).

The present study aims at evaluating effect of planting density of sorghum and different prior cultivations on growth and biological yield of sorghum and seed production of weeds in different rotations.

MATERIALS AND METHODS

The experiment was conducted in 2013 at Agricultural Research Station of Islamic Azad University, Tabriz Branch located at 15th km. of east Tabriz with North longitude of 38° 3', latitude of 46° 27'and a 1360m altitude. It was conducted as split plots using completely randomized blocks design with three replications. In this experiment studied factors included prior cultivation at five levels: lentil, maize, wheat, bean, and rapeseed as main factors and sorghum density as secondary factor at four levels including 50 plants/m^2 (row spacing = 4 cm), 25 plants/m^2 (row spacing = 8 cm), 17 plants/m^2 (row spacing = 12 cm), and 12 plants/m^2 (row spacing = 16 cm). This study used 60 plots with dimensions of 5×10m. In every plot, there were five cultivation rows with the length of 10m and inter-row distance of 60cm. Once the field was prepared, sorghum seeds var. speed feed were cultivated in depth of 4cm and in rows with distance of 4, 8, 12, and 16cm from each other on May 2013. The seeds were sowed considering density of 50, 25, 17, and 12 plants/m^2 and were immediately irrigated. The field was irrigated every seven days. After stabilization of sorghum, the extra plants were thinned. In this experiment 150kg/ha nitrogen fertilizer at the time of planting and 150kg/ha at inflorescence stage were used.

After physiological maturity of sorghum, plants harvested and the traits of plant height, shoot dry weight, grain yield per plant, 1000 kernel weight, and biomass of sorghum per area unit were measured. After sorghum harvesting, in each plots the weeds were counted and their dry weight and seed number per plant was determined separately.

MSTATC statistical software was used to variance analysis and mean comparison of the traits. Also, the Figures were drawn using Excel. Duncan test at probability level of 5% was used to mean comparisons.

RESULTS AND DISCUSSIONS

The results of variance analysis for studied traits showed that in Table-1.

Plant height of sorghum: In this study, there was a significantly increase in height of sorghum due to increasing density. The highest height of sorghum (1.8m) was seen in the density of 50 plants/m^2 without significantly difference with the density of 25 plants/m^2. In planting density of 17 and 12 plants/m^2, height of sorghum was 1.46m and 1.37m respectively which was 23.2% and 23.8% less than planting density of 50 plants/m^2 (Figure-1). Different studies refer to similar results for sorghum. According to Snider *et al*., (2012), increase of plant density results in taller sorghum. Changing of competition rate among sorghum is one of the most important processes its intensity varies due to plant density variations. Less planting distance and more plant density will lead to more competition among sorghum to receive more light and therefore the plants will be taller (Wang *et al*., 2005). Most studies suggested that the less the inter-row distances had the higher crops because it results in more competition of plants to receive light. In appropriate planting densities, crops completely use environmental factors (water, air, light, soil factors) and inter-species and intra-species competition is at its lowest level (Rahnavard *et al*., 2010).

1000 kernel weight: In this study, maximum 1000 kernel weight of sorghum, (4.6g and 4.5g) was seen in density of 12 and 17 plants/m^2, respectively. There were not any significantly differences between these treatments considering 1000 kernel weight. However, more increase of plant density resulted in significantly decrease of 1000 kernel weight. Minimum 1000 kernel weight of sorghum (3.2g) was obtained in 50 plants/m^2 density which was 30.4% less than that of 12 plants/m^2. In 25 plants/m^2 density, weight 1000 kernel weight was 3.7g which was 19.5% less than that of 12 plants/m^2 (Figure-2).

Grain yield per plant: Seed production in plants depends on different genetic and environmental factors. Plant density is one of the most important environmental factors affecting seed production in crops including sorghum. In this study, increase of plant density resulted in significantly decrease of grain weight of sorghum. Maximum grain yield in (8.2 and 7.4g/plant) belonged to planting density of 12 and 17 plants/m^2. There was not any significantly difference between densities of 12 and 17 plants/m^2 considering grain yield of sorghum. In densities of 25 and 50 plants/m^2, grain yield was less than lower densities. Grain yield was 5.5g and 4.5g in densities of 25 and 50 plants/m^2 which were 32.9% and 45.1% less than of 12 plant/m^2, respectively. There was not any significantly difference between densities of 25 and 50 plant/m^2 considering grain yield of sorghum (Figure-3). The seed production rate in plants depends on two important yield components, i.e. number of grains and 1000 seed weight. According to the studies, plant density affects both mentioned components depending on type of the plant. According to Conley *et al*., (2005), increase of plant density decreases number of grains and 1000 kernel weight of sorghum. Variation of plant density as an important yield component affects seed production rate per area unit.

Shoot dry weight of sorghum: According to results, maximum shoot dry weights of sorghum (29.6g) was observed in wheat as prior cultivation which was not significantly different from that of lentil as prior cultivation. Minimum shoot dry weights of sorghum (19.9g) belonged to lentil rotation treatment as the prior cultivation. Therefore, there was a 9.7g difference between rotation treatments considering shoot dry weights of sorghum (Figure-4). In this study, increase of plant density resulted in significantly decrease shoot dry weight of sorghum. Maximum shoot dry weight (29.1g) was seen in density of 12 plants/m^2 which was not significantly different from that of density of 17 plants/m^2. Also, shoot dry weight in density of 25 and 50 plants/m^2 was less than that of 12 and 14 plants/m^2. Shoot dry weight in density of 25 and 50 plants/m^2 was 29.9% and 32.3% less than density of 12 plants/m^2. There was not any significantly difference between density of 25 and 50 plants/m^2 considering shoot dry weight (Figure-5). According to other researchers, increase of plant density leads to decrease of shoot dry weight of sorghum.

Sorghum biomass: Mean comparison of sorghum biomass being affected by density and different prior cultivations, it was made clear that maximum sorghum biomass (1636g/m^2) was seen in wheat treatment as prior cultivation and density of 50 plants/m^2. In low densities, there was less biomass of sorghum. More decrease was seen in sorghum biomass due to decrease of density. In wheat as prior cultivation and in densities of 25, 17 and 12 plants/m^2, sorghum biomass was 47%, 57% and 72.1% less than density of 50 plants/m^2. In bean rotation as prior cultivation maximum sorghum biomass was seen in the density of 50 plants/m^2 while it was less in lower densities in comparison with that of 50 plants/m^2. In densities of 25, 17 and 12 plants/m^2, sorghum biomass was 42.7%, 54.3% and 62.9% less than density of 50 plants/m^2 respectively. In rapeseed rotation, maximum sorghum biomass (1170g/m^2) was seen in density of 50 plants/m^2. However, in densities of 25, 17 and 12 plants/m^2, sorghum biomass was 49.7%, 53.9% and 59.2% less than density of 50 plants/m^2 respectively. There was obtained similar results for lentil and maize rotations. In lentil rotation, in densities of 25, 17 and 12 plants/m^2, sorghum biomass was 48.5%, 51.4% and 61.4% less than density of 50 plants/m^2 respectively. In rapeseed rotation, in densities of 25, 17 and 12 plants/m^2, sorghum biomass was 19.8%, 37% and 55% less than density of 50 plants/m^2, respectively. Therefore, the least difference between density treatments considering biomass belonged to maize rotation (Figure-6). In high density conditions, more sun radiation was absorbed by plants because of high plant population and leaf area index (Lone *et al*., 2009). Thus, it leads to more absorption of sun light per area unit, more production of assimilate and more grain yield.

Dry weight of weeds: According to the results related to knotgrass (*Polygonum aviculare*), lambsquarters (*Chenopodium album*), redroot pigweed (*Amaranthus retroflexus*), and Camel thorn (*Alhagi camelorum*), only redroot pigweed was seen in all rotation. Highest dry weight of *Amaranthus retroflexus* was seen in rapeseed treatment and then lentil rotations. Lowest dry weight of *Amaranthus retroflexus* belonged to wheat rotation where shoot dry weight of *Amaranthus retroflexus* was 68% less than that of rapeseed. In this study, *Chenopodium album* was not seen in wheat rotation while maximum dry weight of *Chenopodium album* was seen in lentil rotation. After lentil rotation, maize, bean, and rapeseed rotations showed maximum dry weight of *Chenopodium album*. *Polygonum aviculare* was observed only in wheat, bean and rapeseed rotations. Dry weight of *Polygonum aviculare* in rapeseed rotation was much more than that of wheat and bean rotations such that in wheat and bean rotations, it was 95.3% and 90.6% less than that of rapeseed. *Alhagi camelorum* was seen only in maize, bean and rapeseed rotations. Maximum dry weight of *Alhagi camelorum* belonged to bean and then rapeseed rotations (Table-2).

Number of weeds produced seeds: *Amaranthus retroflexus* and *Chenopodium album* produced significantly amount of seeds. Due to non-germination of its plants, there was not produced any seed in wheat rotation in *Chenopodium album*. Maximum seeds production rate (n=19368) was seen in lentil rotation treatment. Then maize, bean and rapeseed rotations produced maximum seeds (13537, 10041, and 937), respectively. In *Amaranthus retroflexus*, maximum number of produced seeds (7366) belonged to lentil treatment. The next ranks were occupied by bean and rapeseed rotations treatments (6166 and 6589) respectively. Minimum number of seeds (3300) was seen in wheat rotation treatment. In *Polygonum aviculare* maximum number of produced seeds (353) was observed in rapeseed rotation and then was seen in bean rotation (216). In *Alhagi camelorum* maximum number of produced seeds (297) was observed in bean treatment and then was seen in rapeseed treatment (143). There were produced only 25 seeds in *Alhagi camelorum* in maize rotation (Table-3).

Seed weight in weeds: In this study, *Polygonum aviculare* was germinated in wheat, bean and rapeseed rotations where maximum and minimum weight of seeds was seen in rapeseed and wheat rotation treatment, respectively. *Chenopodium album* was germinated in lentil, maize, bean and rapeseed rotation treatments, and maximum weight of seed in this weed was seen in lentil rotation and then maize, bean and rapeseed rotations demonstrated maximum weight of seed per plant. Maximum weight of seed in *Amaranthus retroflexus* was observed in lentil rotation and the next ranks were occupied by bean and rapeseed rotations. Minimum weight of seed belonged to wheat rotation treatment. Maximum weight of weed seed in *Alhagi camelorum* belonged to bean rotation and then was seen in rapeseed rotation (Table-4).

CONCLUSIONS

Maximum 1000 kernel weight, shoot dry weight and biomass of sorghum were seen in densities of 12 and 17 plants/m^2. In these treatments, there was not any significantly difference between densities of 12 and 17 plants/m^2 but increase of density resulted in significant decrease of these traits. Maximum biomass (1636 g/m^2) was observed in density of 50 plants/m^2 in wheat rotation. Then, maximum biomass was seen in the density of 50 plants/m^2 and bean (1213 g/$m^{2)}$ and rapeseed (1170 g/m^2), respectively.

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Table-1. Variance analysis of the understudy traits of sorghum.

S.O.V	df	Plant height	grain yield	1000 kernel weight	Shoot dry weight	Sorghum biomass
Replication	2	0.002	0.047	0.022	3.417	2025.205
prior cultivation	4	0.159	3.741	0.88	156.782**	152435.600**
Main error	8	0.103	1.754	0.502	20.844	12562.04
Density	3	0.725**	42.627**	6.601**	273.096**	1673283.762**
prior cultivation×density	12	0.03	1.248	0.305	23.471	42845.099**
Error	30	0.048	2.546	0.358	18.387	8546.372
Variation coefficient (%)		13.56	24.74	14.74	17.45	12.54

* and ** : significant at 5% and 1% probability levels, respectively

Table-2. Shoot dry weights of weeds.

	Shoot dry weight of knotgrass (g)	**Shoot dry weight of pigweed** (g)	**Shoot dry weight of lambs quarters** (g)	**Shoot dry weight of camel thorn** (g)
Lentil	0	9.24	3.82	0
Maize	0	4.7	2.36	0.28
Wheat	0.24	0	1.50	0
Bean	0.45	3.32	2.55	1.71
Rapeseed	1.41	3.11	4.41	1.03

Table-3. Number of seeds produced in weeds.

	No. of knotgrass seeds	No. of lambs quarters seeds	No. of pigweed seeds	No. of camel thorn seeds
Lentil	0	19368.3	7366.7	0
Maize	0	13537.5	5166.7	25
Wheat	83.3	0	3300	0
Bean	216.7	10041.7	6166.7	297.8
Rapeseed	353.8	9375	6589.8	143.8

Table-4. Weight of seeds produced in weeds.

	Weight of knotgrass seeds	Weight of lambs quarters seeds	Weight of pigweed seeds	Weight of camel thorn seeds
Lentil	0	50.36	6.96	0
Maize	0	35.14	4.65	0.04
Wheat	0.21	0	2.99	0
Bean	0.33	26.11	5.47	0.49
Rapeseed	0.38	24.38	5.91	0.21

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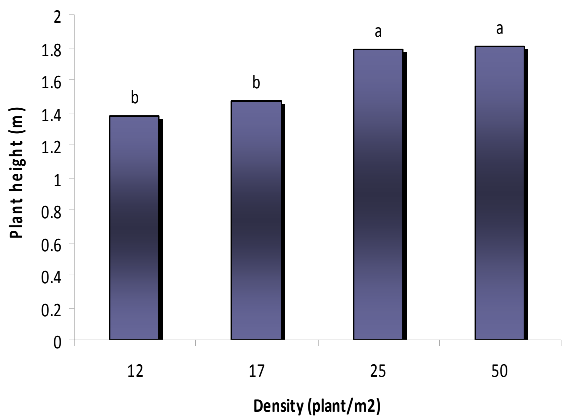

Figure-1. The effect of plant density on sorghum height.

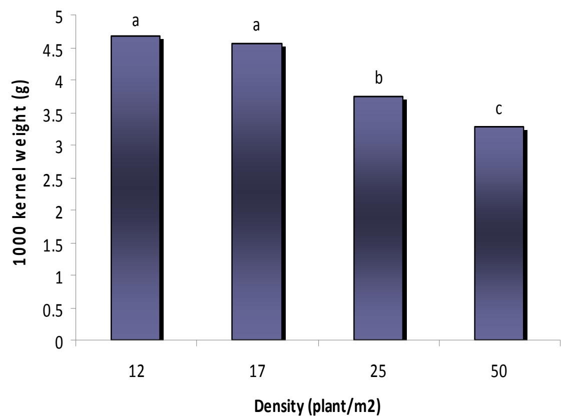

Figure-2. The effect of plant density on 1000 kernel weight of sorghum.

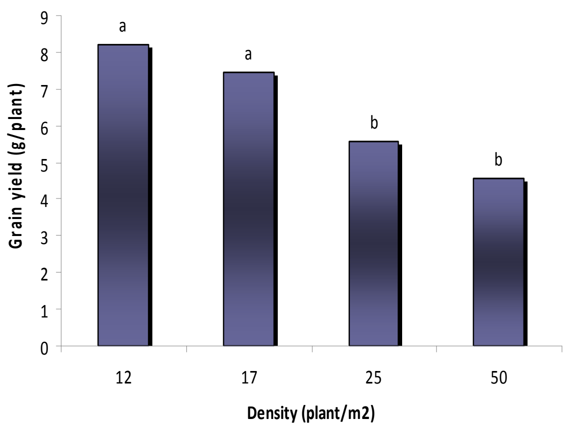

Figure-3. The effect of plant density on grain yield of sorghum.

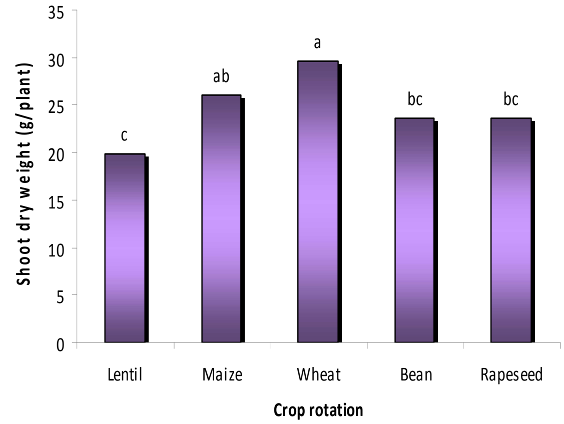

Figure-4. The effect of prior cultivation on shoot dry weight of sorghum.

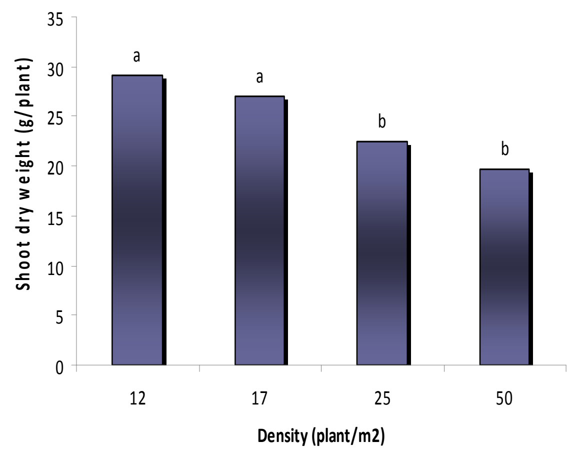

Figure-5. The effect of plant density on shoot dry weight of sorghum.

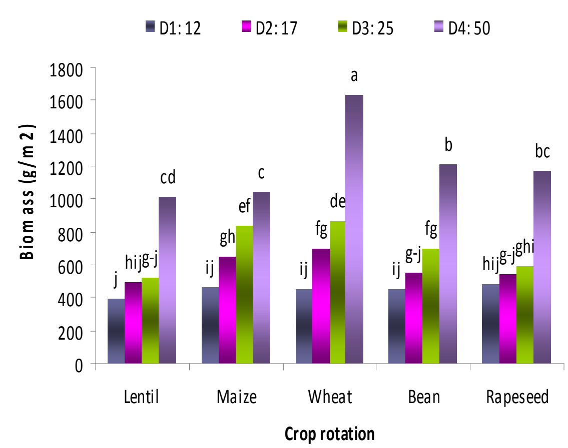

Figure-6. The effect of biomass of plant density and crop rotation on sorghum biomass.

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