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Non Chemical Management of Weeds Effects on Forage Sorghum Production

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ABSTRACT

To assess the effect of non chemical management of weed control on forage Sorghum (*Sorghum bicolor*) a field study was conducted in Varamin, Iran during 2010 crop year in a three- replicated- split factorial experiment laid out in randomized complete block design with four weeding levels (W_1= one time cultivation at 3-leaf stage using a duck foot cultivator, W_2= two times cultivation at 3 and 5-leaf stages using a duck foot cultivator, W_3= hand weeding throughout growing season and W_4= without weeding) as main plots, and two plant density levels (D_1= 190000, and D_2= 266000 plant ha^{-1}) and two plant pattern levels (P_1= one-row and P_2= two-row) as sub plots. Weed density, weed biomass, number of leaves (NL), stem diameter (SD), number of tillers (NT), plant height (PH), leaf area index (LAI), dry matter yield (DM yield), dry matter digestibility (DMD), water soluble carbohydrates (WSC), crude protein (CP), acid detergent fiber (ADF), total ash (ASH), and crude fiber (CF) where measured. The results revealed that the highest weed density and biomass observed in not weeding treatment. There was not significant difference among one time cultivation at 3-leaf stage and two times cultivation at 3 and 5-leaf stages from the weed density and biomass point of view. The lowest NL, SD, and NT observed in not weeding treatment. Increasing plant density decreased DM yield, PH, SD and NL of sorghum. Two-row plant pattern showed a significant preference in comparison to one-row plant pattern from the DM yield point of view although the highest CP obtained in one-row plant pattern. The highest DMD obtained in P_2D_2. The highest ASH obtained in W_2D_2 and W_2P_2.

Key words: Non chemical management, Weed control, Forage Sorghum, Cultivation, Plants density, Plants pattern

INTRODUCTION

Forage sorghum (*Sorghum bicolor*) is an annual very similar to corn in the vegetative stage that is used for silage, hay, grazing. Weeds may adversely affect sorghum production by competing for light, nutrients, and water. In addition, weeds may decrease yield quality, increase insect and disease pressure, and increase harvest difficulty (Zimdahl, 1999). The selection of a weed management strategy is a complex task that involves agronomic,

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economic, regulatory, and environmental considerations. Coordinating the use of multiple crop management operations that are innately weed suppressive; in contrast, more conventional methods rely almost exclusively on herbicides and cultivation for weed control is one of the integrated weed management objectives (Gressel and Wyse, 1992). Utilizing common agronomic factors, such as planting date, plant density, planting pattern and crop cultivar, an integrated approach strives to create an environment in which crop growth is favored over that of weeds. Light interception by weeds can be reduced through cultural practices and the appropriate selection of crop cultivars. Shading of weeds was positively correlated with crop population densities and was greater with more uniform distribution of crop plants (Blackshaw 1993; Bello *et al*., 1995 Forcella *et al*., 1992). Greater leaf area expansion rates increased the ability of tall fescue (*Festuca arundinacea* Schreb.) to suppress weeds Forcella (1987). Differences in wild oat suppression by wheat and barley (*Hordeum vulgare* L.) were attributed to differences in light interception between the two crop species (Lanning *et al*., 1997). Currently, sufficient data on non chemical management of weed control is lacking. Therefore, the key objectives of the present study were to determine the effect of cultivation, plant density and plant pattern on weed control and forage sorghum production.

MATERIALS AND METHODS

To assess the non chemical management effects of weed control on forage sorghum fields an experiment was carried out at the experimental farm of Weed Research Department of Plant Protection Research Institute located in Varamin, Iran (51°39′39″ E, 35°19′30″ N; 915 m Elevation) during 2010 crop year. Varamin has a dry and hot climate. Average annual of rainfall, humidity and maximum and minimum temperatures in Varamin are 161 mm, 52%, 24.4°C, and 8.4°C, respectively. The soil type where the experiment took place was a loam soil. A split factorial experiment in the form of randomized complete block design with three replications was used for this study. Four weeding levels (W_1= one time cultivation at 3-leaf stage using a duck foot cultivator, W_2= two times cultivation at 3 and 5-leaf stages using a duck foot cultivator, W_3= hand weeding throughout growing season and W_4= without weeding) as main plots, and the factorial combinations of two plant density levels (D_1= 190000, and D_2= 266000 plant ha^{-1}) and two plant pattern levels (P_1= one-row and P_2= two-row) as sub plots were used. Each experimental plot extended in an 6×3 m^2 area and the distance between rows considered 75 cm. The intra-row spaces were 7 and 5 for D_1 and D_2, respectively, in one-row plant pattern and 14 and 10 for D_1 and D_2, respectively, in two-row plant pattern. The sorghum (*Sorghum bicolor*) cultivar 'Pegah' was used in the experiment. Seeds were planted on 24 May 2010. Irrigation was performed at intervals of 7 days. The plants were thinned at 20 June 2010 for keeping desirable distances and replanting was done if needed. At harvest stage (10-20% of flowering) plants were cut from 10-15 cm above soil level. The weeds number was recorded 30 days after second cultivation for each weed species separately using 0.5×0.75 m^2 quadrate. Also their dry weight was determined after drying in oven at 75°C for 48 h. At harvest stage 6 plants from the middle of each plot were harvested randomly and the plant height (PH), number of leaves (NL), stem diameter (SD) and number of tillers (NT) were recorded. Fresh matter yield was estimated at a 3 m^2 harvest area from the middle of each plot. 2 kg-samples of fresh matter from each plot were uses for dry matter (DM) yield estimation. Also qualitative traits of forage were determined using Near Infrared Refrectance Spectroscopy (NIRS). Dry Matter Digestibility (DMD), Water Soluble Carbohydrates (WSC), Crude Protein (CP), Acid Detergent Fiber (ADF), Total Ash (ASH), and Crude Fiber (CF) where measured.

Statistical analyses of data were performed using SAS and MSTATC software. A factorial analysis of variance (ANOVA) was performed for all parameters. In addition the Duncan's Multiple Range Test (DMRT) (P = 0.05) was used to conduct mean comparison.

RESULTS AND DISCUSSION

The results of analyses of variance revealed that the simple effect of weeding was significant on weed density, weed biomass, NL, SD, and NT at P= 0.05 and was not significant on PH, LAI, DM yield, DMD, WSC, CP, ADF, ASH, and CF. The simple effect of plant density was significant on number of leaves, stem diameter, PH, and DM yield at P= 0.05 and was not significant on other assessed traits. The simple effect of plant pattern was significant on DM yield and CP at P= 0.05 and was not significant on other studied traits. Study the interaction effects of treatments showed that none of the interaction effects of treatments were not significant on assessed traits except the interaction effect of D×P on DMD and the interaction effects of W×D and W×P on ASH (Table 1). The results of mean comparisons revealed that the highest weed density and biomass observed in not weeding treatment. There was no significant difference among one time cultivation at 3-leaf stage and two times cultivation at 3 and 5-leaf stages from the weed density and biomass point of view although these treatments showed a significant preference in comparison to hand weeding throughout growing season treatment in higher weed number and biomass. Also not weeding treatment had not a significant difference with one time and two times cultivation treatments from the weed biomass point of view which was due to high density of weeds caused despite of cultivation, remained weeds after cultivation compensated reduction of weed biomass resulted by reduction of weed number followed by cultivation using the space of omitted weeds (Table 2). The results of mean comparisons revealed that increasing plant density decreased DM yield which could be due to increase of competition among sorghum plants in high densities. Also two-row plant pattern showed a significant preference in comparison to one-row plant pattern from the DM yield point of view. Increasing plant density decreased PH (Table 2). There was a positive correlation among PH and DM yield (r= 0.66), WSC (r= 0.48), CF (r= 0.56), NT (r= 0.33), NL (r= 0.42) and LAI (r= 0.42) and there was a negative correlation among PH and DMD (r= -0.31) and ASH (r= -0.51) (Table 6). The lowest SD observed in not weeding treatment. There was not significant difference among one time cultivation at 3-leaf stage, two times cultivation at 3 and 5-leaf stages and hand weeding throughout growing season from the SD point of view. Increasing plant density decreased SD. The lowest NL observed in not weeding treatment although there was not significant difference among treatments. Increasing plant density decreased NL (Table 2). There was a positive correlation among NL and DM yield (r= 0.38) and NT (r= 0.31) (Table 6). The lowest NT observed in not weeding treatment although there was not significant difference among treatments (Table 2). There was a positive correlation among NT and DM yield (r= 0.5) and there was a negative correlation among NT and ASH (r= -0.29) (Table 2). The highest DMD obtained in two-row plant pattern and 266000 plant density and the lowest DMD obtained in two-row plant pattern and 190000 plant density (Table 3). There was a negative correlation among DMD and DM yield (r= -0.45) and ADF (r= -0.88) (Table 6). The highest ASH obtained in two times cultivation at 3 and 5-leaf stages with 266000 plant density and two times cultivation at 3 and 5-leaf stages with two-row plant pattern. The lowest ASH obtained in not weeding with 190000 plant density and one time cultivation at 3-leaf stage with two-row plant pattern (Table 4-5). One-row plant pattern showed a significant preference in comparison to two-row plant pattern from the CP point of view (Table 2). (Rajcan and Swanton, 2001) believed that maize-weed competition is a series of complex processes, which is triggered by the FR/R signal and followed by the development of shade avoidance characteristics accompanied by a reduction in the plant's ability to absorb nutrients and water, and to photosynthesize. They recognize that resource limitation occurs in a maize-weed association, however, this may be more of an effect rather than a cause of competition. Plants respond to neighboring plants by developing shade avoidance characteristics such as thin leaves, elongated internodes, heavier stems, low leaf to stem dry weight ratio, or low root to shoot dry weight ratio. This response occurs even when neighboring plants are very small. The shade avoidance response is triggered by the low red to far-red ratio of the light reflected from the nearby vegetation (Ballare *et al*., 1990). As well, light reflected upward underneath the crop canopy can alter plant dry matter allocation (Kasperbauer and Hunt, 1998 Hunt et al., 1989). (Gautier et al., 1999) stated that the R:FR ratio is clearly involved in the regulation of tiller production in perennial grasses, and a reduction in the R:FR ratio decreases tillering. Some studies indicate that mutual shading reduced light interception per plant and a lower R:FR ratio at the bases of plants was linked to a reduced number of tillers. (Derigibus *et al.*, 1985) showed that the R:FR ratio could serve as a signal to indicate canopy cover or leaf density. This signal then interacts with others related to the availability of various resources (water, assimilates, nutrients, etc.) to determine the rate of tiller formation or death. Jones (1985) reported that environmental conditions favoring main stem also favor tillering. Thus, reduced competition for light, nutrients, and water favors tiller production. (Carmi *et al.*, 2006) stated that plant density did not affect significantly plant height or dry matter yield of forage sorghum at either harvest, but did affect dry matter digestibility at early heading. (Habyarimana *et al*., 2004) reported high stand density (20 plants m^{-2}) outyield the low one (10 plants m^{-2}) under humid conditions whilst the two population stands have statistically comparable biomass yields under water stressed environments. (Berenguer and Faci, 2001) concluded that the different established plant densities did not significantly affect sorghum aerial dry matter, grain yield and harvest index. They concluded that a greater tiller production, a greater number of grains per panicle and a higher weight of grains compensated the smaller number of plants per m^2 of the lower plant densities. Marsalis *et al*., (2010) observed that there was no effect of planting rates on dry matter (DM) yield, neutral detergent fiber (NDF), neutral detergent fiber digestibility (NDFD) or net energy for lactation (NE_L). They also reported at the low nitrogen rate, increasing planting rates to medium or high resulted in reduced crude protein (CP). (Snider *et al*., 2012) reported that narrower row spacing (19 cm) provides the maximum yield benefit by significantly increasing stem density, and low seeding rates (116,000 seeds ha^{-1}) are preferable because higher seeding rates do not positively affect yield and may cause morphological changes (i.e. taller plants with thinner stems) conducive to lodging. (Baumhardt *et al*., 2005) reported that as the initial plant population increased, mean tiller number decreased from 1.82 with the low population to over-all means of 1.47 and 1.13 for the medium and high plant populations, respectively. Increasing in-row plant density by varying row spacing or plant population significantly decreased tiller numbers and were consistent with field measurements by (Jones and Johnson, 1991) and (Staggenborg *et al*., 1999). That is, cultural practices used to increase in-row plant density may also suppress tiller number possibly because of competition among plants for nutrients or because of increased light interception with higher populations (Lafarge et al., 2002). (El-henawy *et al*., 2008) indicated that corn yield, yield components, and IWUE increased with decreasing plant population densities. (Balkcom *et al*., 2011) studied the effects of row configuration, plant density and hybrid on maize. Their results indicated that row configuration had little effect on weed biomass compared to plant density and hybrid. Leaf area index increased with higher plant density and the twin-row configuration, but LAI also varied with hybrid based on interactions between hybrid and plant density or row configuration. Row configuration had little impact on maize yields, while plant density had the most effect on yields. Plant density also interacted with hybrid or row configuration at multiple locations, although maize yields did not always increase with higher plant density. Maize yield increases with twin rows were minimal and may not justify twin row conversion under dryland conditions, but growers that already utilize twin-row equipment will not suffer yield decreases by planting twin rows. (Carruthers *et al*., 1998) reported that the density and biomasses of monocot weeds, either on or between the corn rows, were not affected by cultivation or intercropping. The density and biomass of dicot weeds on corn rows were reduced by some intercrop systems. A more effective dicot weed control was observed in delay seeded treatments, which allowed extra interrow cultivations.

Conclusion

This study provides new findings about the effect of cultivation, plant density and plant pattern on weed control and forage sorghum production. The results showed that there was not significant difference among one time cultivation at 3-leaf stage, two times cultivation at 3 and 5-leaf stages and not weeding treatment from the weed density and biomass point of view. Also plant density and pattern had not significant effects on weed number and biomass. It can be concluded cultivation is only useful in low weed densities and high weed densities could compensate the reduction of weed number followed by cultivation by increasing their biomass.

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Table 1: Analyses of variance for assessed traits

SOV	DF	WD	WB	PH	NL	SD	LAI	NT	DMY	DMD	WSC	CP	ADF	ASH	CF
Replication	2	11425.02	17.18	4.08	0.099	0.043	0.0021	0.685	4.98	2.133	0.821	5.787	8.053	0.158	6.159
Weeding (W)	3	78183.64*	283.33*	2.253^{ns}	0.245*	0.448*	0.0088^{ns}	4.106*	8.56^{ns}	4.7^{ns}	0.111^{ns}	1.272^{ns}	3.353^{ns}	0.696^{ns}	2.501^{ns}
Error	6	3558.49	7.33	3.578	0.069	0.044	0.0516	0.337	23.68	4.53	0.274	1.373	5.016	1.105	4.384
Plant density (D)	1	0.33^{ns}	2.34^{ns}	12.44*	0.458*	0.343*	0.0085^{ns}	0.02^{ns}	10.52*	6.885^{ns}	0.042^{ns}	5.024^{ns}	6.923^{ns}	0.787^{ns}	2.576^{ns}
Plant pattern (P)	1	1260.75^{ns}	0.56^{ns}	0.149^{ns}	0.025^{ns}	0.052^{ns}	0.1010^{ns}	0.035^{ns}	9.13*	0.145^{ns}	0.13^{ns}	5.887*	4.896^{ns}	0.286^{ns}	2.167^{ns}
W× D	3	326.55^{ns}	7.6^{ns}	4.067^{ns}	0.012^{ns}	0.016^{ns}	0.0036^{ns}	0.037^{ns}	1.88^{ns}	5.321^{ns}	0.162^{ns}	0.839^{ns}	6.019^{ns}	0.696*	2.874^{ns}
W× P	3	489.19^{ns}	1.66^{ns}	0.59^{ns}	0.078^{ns}	0.048^{ns}	0.0096^{ns}	0.356^{ns}	0.52^{ns}	3.972^{ns}	0.135^{ns}	2.687^{ns}	2.233^{ns}	0.749*	1.012^{ns}
D× P	1	48^{ns}	1.82^{ns}	0.551^{ns}	0.136^{ns}	0.039^{ns}	0.0002^{ns}	0.55^{ns}	5.19^{ns}	12.628*	0.022^{ns}	0.239^{ns}	10.953^{ns}	0.058^{ns}	1.817^{ns}
W× D× P	3	326.44^{ns}	1.38^{ns}	2.196^{ns}	0.032^{ns}	0.050^{ns}	0.0111^{ns}	0.131^{ns}	4.36^{ns}	0.149^{ns}	0.184^{ns}	3.502^{ns}	0.62^{ns}	0.140^{ns}	2.979^{ns}
Error	24	656.8	2.55	2.475	1.345	0.025	0.03	0.21	2.1	2.91	0.109	1.348	3.467	0.207	1.165
Total	47	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CV (%)	_	23.72	18.97	13.067	7.667	4.733	22.79	17.525	26.28	5.45	11.014		5.648		2.389

Notes. **, *- significant at 1% and 5% respectively, ns- not significant.

Table 2: Simple effects of treatments on assessed traits.

Treatment	Mean							
	WD	**WB**	**DFY**	**PH**	**NL**	**SD**	**NT**	**CP**
Weeding (W)								
W_1	135b	155.14a			3.13ab	3.38a	2.48bc	
W_2	100b	105.09a			3.16ab	3.41a	3.31a	
W_3	2c	1.16b			3.33a	3.51a	2.77ab	
W_4	195a	134.19a			2.97b	3.06b	1.91c	
Plant density (D)								
D_1			5.98a	13.18a	13.18a	3.43a		
D_2			5.04b	12.17b	12.17b	3.26b		
Plant pattern (P)								
P_1			5.07b					9.8b
P_2			5.94a					10.5a

Note. Any two means sharing a common letter do not differ significantly from each other at 5% probability.

Table 3: interaction effect of plant density and plant pattern on DMD

DMD	P_1	P_2
D_1	61.777ab	60.91b
D_2	62.045ab	62.693a

Note. Any two means sharing a common letter do not differ significantly from each other at 5% probability.

Table 4: interaction effect of plant density and weeding on ASH

ASH	W_1	W_2	W_3	W_4
D_1	8.271b	8.441ab	7.708ab	8.71c
D_2	8.141bc	8.888a	8.558ab	8.268ab

Note. Any two means sharing a common letter do not differ significantly from each other at 5% probability.

Table 5: interaction effect of plant pattern and weeding on ASH

ASH	W_1	W_2	W_3	W_4
P_1	8.601ab	8.456ab	8.148ab	8.546bc
P_2	7.811c	8.873a	8.118bc	8.331bc

Note. Any two means sharing a common letter do not differ significantly from each other at 5% probability.

Table 6: Correlation coefficient among assessed traits

	DFY	**ASH**	**ADF**	**WSC**	**CF**	**DMD**	**NT**	**NL**	**LAI**	**PH**
DFY	1									
ASH	-0.48^{ns}	1								
ADF	0.184^{ns}	0.25^{ns}	1							
WSC	0.43**	-0.66**	-0.52**	1						
CF	0.36*	-0.59**	-0.06^{ns}	0.3*	1					
DMD	-0.45**	0.001^{ns}	-0.88**	0.25^{ns}	-0.16^{ns}	1				
NT	0.5**	-0.29*	0.04^{ns}	0.14^{ns}	0.22^{ns}	-0.19^{ns}	1			
NL	0.38**	-0.05^{ns}	0.01^{ns}	0.17^{ns}	0.19^{ns}	-0.16^{ns}	0.31*	1		
LAI	0.43**	-0.16^{ns}	0.08^{ns}	0.17^{ns}	0.07^{ns}	-0.23^{ns}	0.32*	0.29*	1	
PH	0.66**	-0.51**	-0.02^{ns}	0.48**	0.56**	-0.31*	0.33*	0.42**	0.42**	1

Notes. **, *- significant at 1% and 5% respectively, ns- not significant.