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The Effect of Nitrogen and Potassium Fertilizers on the Growth Parameters and the Yield Components of Two Sweet Sorghum Cultivars

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Abstract: The effect of nitrogen and potassium fertilizers on growth parameters and yield components of two sweet sorghum cultivars (*Sorghum bicolor* L. Moench) were studied. The experiment was assessed in split plot design with three replications. Three rates of N-fertilizer (0, 90, 180 kg Urea ha^{-1}), two rates of K-fertilizer (0 and 50 kg potassium sulfate ha^{-1}) assigned as main plots and two sweet sorghum cultivars (Rio and Keller) as subplots. Growth parameters including: Leaf Area (LA) at hard dough stage and pollination; Leaf Dry Weight (LDW), Stem Dry Weight (SDW), Total Dry Weight (TDW) at pollination and physiological maturity stages; and yield components at physiological maturity stage were determined. Results showed that application of N-fertilizer significantly increased LA, LDW, SDW, TDW, panicle dry weight and panicle height. K-fertilizer increases TDW and panicle dry weight. The highest measured parameters were obtained with the application of 180 kg Urea ha^{-1} and 50 kg potassium sulfate ha^{-1} in cv. Keller.

Key words: N fertilizer, K fertilizer, sweet sorghum, growth parameters, yield components

INTRODUCTION

Sweet sorghum (*Sorghum bicolor* L. Moench) is well adapted to sub-tropical and temperate regions of the word and is highly biomass productive and water efficient. It is consumed as food by human and the feeding stuff for animals and poultry (Kuikarni *et al*., 1995). Nutrient balance is one of the most important problems facing agriculture (Rego *et al*., 2003). The rapidly increasing importance of nitrogen fertilizer in the agriculture world has stimulated research to find methods of reducing the problems associated with the use of this fertilizer (Johnston, 2000). Nitrogen has a significant role in plant growth and cell division. Also, it is required for the development of the foliage. Mengel and Kirkby (2001) mentioned that corn and sorghum yield would have dropped by 41 and 19%, respectively, without N fertilizer application. Lehmann *et al*. (1999) reported that fertilized sorghum plants had significantly higher grain yield than the control. Pholsen and Sornsungnoen (2004) reported that an increase N-K20 rates significantly increased most growth parameters of sorghum plants. The yield responses to increase levels of nitrogen were smaller than when adequate amounts of P and K were applied. Pholsen and Sornsungnoen (2004) reported mean total dry weight of forage sorghum significantly increased with an increase in N-K rates. Vigorous plants were obtained, supplied with water and nutrient especially N and K (Mengel and Kirkby, 2001). Although the effect of K fertilizer on other plants has been reported (Bourk, 1985; Adeli and Varco, 2002) but there is no report regarding the effect of K-fertilizer on growth parameters of sweet sorghum. Therefore, it is of considerable value to carry out an experiment on growth parameters and yield components of sweet sorghum in relation to different rates of N and K fertilizers.

MATERIALS AND METHODS

The present study was carried out at the Isfahan University Research Station (31°, 31'N, 5°, 51' E, altitude 1550 m above sea level) Isfahan, Iran in 2004. Three rates of N fertilizer (0, 90, 180 kg Urea ha^{-1}) and two rates of K fertilizer (0 and 50 kg potassium sulfate ha^{-1}) and two sweet sorghum cultivars (Rio and Keller) were assessed in split plot design with three replications. The fertilizers assigned to main plots and the cultivars to subplots. Before planting, soil samples from 2 depths (0 -30 cm and 30-60 cm) were randomly taken and their properties including: EC, pH, CEC, total soil nitrogen, phosphate content, organic carbon percent, bulk density, particle density and soil texture were determined, according to Arnold (1986). In May, Seeds were planted in furrows with 10 m long and 0.5 m apart. Following establishments, the plants were thinned to 10 cm apart so that the final plant populations were 200,000 plants ha^{-1}. Growth parameters including: Leaf area at booting, pollination and hard dough stages, leaf dry weight, stem dry

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weight, total dry weight at booting, pollination and physiological maturity stages and yield components at physiological maturity stage were determined. Statistical analyses were performed using SAS computer program. The means were compared according to Duncan multiple rang test.

RESULTS AND DISCUSSION

Growth parameters: Mean daily air temperatures during the growing season are presented in Fig. 1. Maximum and Minimum mean air temperatures at planting (June) was 32.9 and 14.4°C and at physiological maturity (Oct.) was 19.7 and 1°C, respectively. The main physical-chemical properties of soils are reported in Table 1. Soil texture at 0-30 cm dept was clay loam and at 30-60 cm was clay. Soil EC was less than 4 dS m^{-1} indicating that there was no salt hazard in the soil. Soil pH in both depths was neutral. The amount of soil nitrogen in both depths was not adequate for plant growth and development. Available

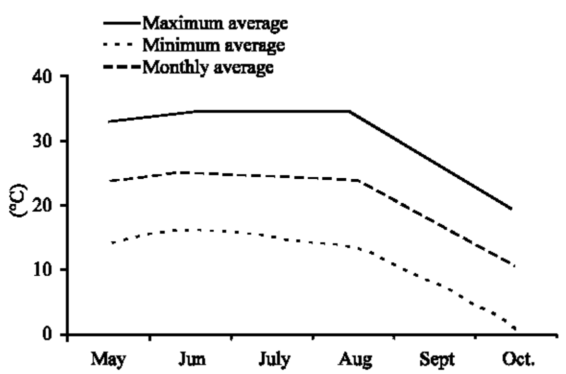

Fig. 1: Air temperature during growing season at the experiment site

potassium in both depths was excesses of plant need (Table 1). Clear effect of fertilizers on Leaf Area (LA), Leaf Dry Weight (LDW), Stem Dry Weight (SDW) and Total Dry Weight (TDW) was not found at booting stage (data are not shown) and it may be too early to evaluate the growth parameters of the sorghum plants at this growth stage. The effect of nitrogen fertilizer on LA, LDW, SDW, TDW and TDW at different growth stages was significant at 1% level (Table 2). The highest measurements were obtained with the application of 180 kg urea ha^{-1} and the lowest at control (Table 3). Nitrogen may effect on cell division and cell enlargement which consequently increase LA (Stals and Inze, 2001). The results indicated that the effect of potassium fertilizer on TDW was significant at pollination stage ($p<0.01$) and at physical maturity stage ($p<0.05$) (Table 2). The highest TDW was obtained with 50 kg sulfate potassium ha^{-1}. The interactions between N and K on LDW and TDW were significant (Table 2 and Fig. 2 and 3). The highest TDW was obtained with the application of 180 kg Urea ha^{-1} and 50 kg potassium sulfate ha^{-1} whereas increased amount of each N or K fertilizers didn't increase TDW. Pholsen and Sornsungnoen (2004) reported that the growth parameters increased up to certain rates of N-K_2O but higher rates did not increase those parameters. According to Pholsen and Sornsungnoen (2004) an increase in N-K rates increased LA per plant. The results showed that the effect of cultivars on all above growth parameters was significant $p<0.01$ (Table 3). Mean comparison between cultivars is presented in (Table 4)indicating that cv. keller had higher growth parameters than cv. Rio. Genotype differences, higher plant height and more node in cv. keller than cv. Rio can explain this observation.

Table 1: Soil properties at two different depths

Depth (cm)	EC (ds m^{-1})	pH	Total nitrogen (%)	Available potassium (ppm)	CEC (meq/100)	Sand (%)	Silt (%)	Clay (%)	Texture
0-30	2.13	7.5	0.17	220	16.5	9	41.4	49.6	Clay loam
30-60	1.26	7.7	0.12	230	16.5	7	37.4	55.6	Clay

Table 2: Sum of squares of leaf area, leaf dry weight, stem dry weight and total dry weight at different growth stages

		Leaf area (cm^2/plant)		Leaf dry weight (g m^{-2})		Stem dry weight (g m^{-2})		Total dry weight (g m^{-2})	
Source	df	Pollination	Hard doug	Pollination	Physiological maturity	Pollination	Physiological maturity	Pollination	Physiological maturity
Replication	2	4105293	109288703	906.6	1946	2658	55877	27606	131646
N	2	97441817**	828574510**	25731.0**	83632.0**	830802**	2310026**	1185556**	4305440*
K	1	53758586	19780390	672.7	1645	27848	36400	149597**	253406*
N*K	2	4956667	137343431*	7273.0**	12783.0**	31460	70995	130566**	148778*
Error	10	11114294	14059019	423.9	749.2	9424	20910**	11451	33613
Cultivar	1	75499150*	1241146214**	6489.0**	3149.0**	393052**	509703**	704091**	1238528**
N* Cultivar	2	3680346	5791701	1238	1707.0	6063	9796	8028	19491
K* Cultivar	1	9021864	55109321*	520.9	999.8	12666	605505	33414	22028
N*K* Cultivar	2	7177470	1131708	953.4	1240.0	23762*	25982	42883*	18360
Error	12	8991479	10876016	430.2	651.0	4910	13064	7436	38655

** and * Significant at 1 and 5%, respectively

Table 3: Means of leaf area, leaf dry weight, stem dry weight and total dry weight at different growth stages. Values within one column followed by the same letter are not significantly different at p<0.05

	Mean							
	Leaf area (cm^2/plant)		Leaf dry weight (g m^{-2})		Stem dry weight (g m^{-2})		Total dry weight (g m^{-2})	
Treatments	Pollination	Hard doug	Pollination	Physiological maturity	Pollination	Physiological maturity	Pollination	Physiological maturity
Fertilizer urea (kg ha^{-1})								
0	64358c	20442c	924.9c	326.5c	155.6c	941c	1379c	1653c
90	73852b	28272b	1188b	411.6b	136.2b	1415b	1676b	2367b
180	82371a	37052a	1451a	493.5a	157.9a	1817a	2008a	2843a
Potassium sulfate (kg ha^{-1})								
0	72305	22717b	1160	403.8a	120.5b	1359a	1623b	2204b
50	74749	34460a	1216	417.3a	179.3a	1423a	1752a	2372a
Cultivar								
Rio	72079b	22717b	1084b	401.2a	130.6b	1272b	1213b	2102b
Keller	74795a	34460a	1293a	419.9a	169.2a	1510a	1546a	2473a

Table 4: Means of leaf area, leaf dry weight, stem dry weight and total dry weight at booting stages

	Mean			
Treatments Fertilizer	Leaf area (cm^2)	Leaf dry weight (g m^{-2})	Stem dry weight (g m^{-2})	Total dry weight (g m^{-2})
N kg ha^{-1}				
0	142.0a	3.94a	1.95	5.44
90	122.0a	3.26	1.85	5.19
180	124.1a	3.60	2012	5.27
K kg ha^{-1}				
0	123.9a	3.48	1.89	5.07
50	117.5a	3.74	2.06	5.83
Cultivar				
Rio	141.4a	3.71	2.07	5.63
Keller	117.5a	3.45	1.88	5.27

Table 5: Sum of squares of panicle dry weight, number of grain in panicle, hundred grain weight and panicle high in physiological maturity stage

Treatments	df	Panicle dry weight	No. of grain in panicle	Hundred grain weight	Panicle height
Replication	2	42392	349128	0.01	15.5
N	2	90901*	230478	0.23	39.68**
K	1	73995*	196544	0.12	9.0
N*K	2	17004	82832	0.01	0.83
Error	10	13453	125291	0.08	4.23
Cultivar	1	117529*	1668403**	0.06	68.34**
N*Cultivar	2	7192	79760	0.02	8.95
K* Cultivar	1	16690	180342	0.01	0.36
N*K* Cultivar	2	8991	12413	0.02	3.09
Error	12	16893	166822	0.04	4.04

** and * Significant at 1 and 5%, respectively

Table 6: Means of panicle dry weight, number of grain in panicle, hundred grain weight and Panicle high in physiological maturity stage. As affected by the treatments. Values within one column followed by the same letter are not significantly different at p<0.05

Treatments	Mean			
Fertilizer	Panicle dry weight	No. of grain in panicle	100 grain weight	Panicle high
Urea (kg ha^{-1})				
0	385.9b	908.0a	1.78a	19.6b
90	540.5a	1175.7a	1.97a	21.3ab
180	523.6a	1104.2a	2.05a	23.2a
Potassium sulfate (kg ha^{-1})				
0	441.0b	988.7a	1.88a	20.9a
50	536.7a	1136.5a	1.99a	21.9a
Cultivar				
Rio	429.2b	847.3b	1.98a	22.8b
Keller	543.5a	1277.9a	1.89a	20.0a

Yield components: The effect of nitrogen fertilizer on panicle dry weight and panicle height was significant at 1 and 5% level respectively (Table 5). Mean comparison for panicle height and panicle dry weight is presented in

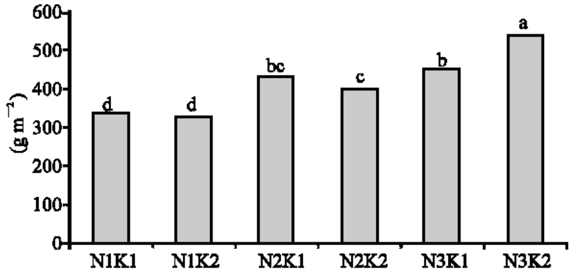

Fig. 2: Interaction between levels of nitrogen and potassium on leaf dry weight, N1, N2, N3 and K1, K2 are different rates of nitrogen fertilizer and potassium fertilizer, respectively

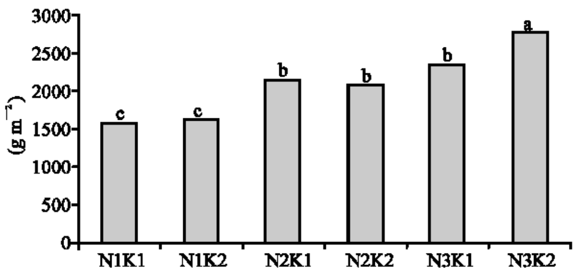

Fig. 3: Interaction between levels of nitrogen and potassium on total dry weight

Table 5. Although panicle dry weight and panicle height with the application of 90 and 180 kg urea ha^{-1} were higher than control but their differences were not significant for. This indicates that maximum grain yield could be obtained by application of 90 kg urea ha^{-1}. The effect of potassium fertilizer on panicle dry weight was significant $p<0.05$. The panicle dry weight was higher with the application 50 kg ha^{-1} than control. Potassium is required for efficient transformation of solar energy into chemical energy that could increase Carbohydrate contain (Taize and Ziger, 2000). Potassium has a significant role in the translocation of assimilates to sinks by influence electron transport in the transport chain of crops (Raja Reddy and Zhao, 2005) which increase pancile dry weight. The effect of cultivars on panicle height and number of grain in the panicle were significant at 1% level and for panicle weight at 5% level (Table 4). Cv. Keller in all the above measurements was higher than cv. Rio. Although one hundred grain weight of both cultivars were similar whilst panicle height of Rio was higher than Keller (Table 6). It may be concluded that only number of grain in the panicle contributed to the panicle dry weight. Although panicle dry weight of cv. Rio was higher than Keller but its grain number in the panicle was lower than Keller so seed compaction in Keller panicle was more than Rio. Correlation between panicle dry weight and LA at hard dough was significant $p<0.05$, $r = 0.41$ indicate relation between leaf area and photosynthetic production.

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