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Summer Forage Sorghum Yield, Protein and Prussic Acid Contents as Affected by Plant Density and Nitrogen Topdressing

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ABSTRACT

Two similar field experiments were carried out at Kushkak and Fars Agricultural Experimental Staties to determine the effects of plant densities and nitrogen topdressing (NT) rates on forage yield, some agronomic traits, protein and prussic acid contents of forage sorghum (*Sorghum bicolor* L. Moench var. Sudenense). Both experiments were conducted as spilt plots arranged in randomized complete block design with four replications. Plant density consisted of 25, 33 and 50 plants m^{-2} in the main plots and nitrogen topdressing rates were 0, 100, 200 and 300 kg N ha^{-1} as urea in the sub-plots. Increasing plant density increased main stem height (MSH), leaf area index (LAI), total tiller number m^{-2} (TTN), total fresh forage (TFF), total dry matter (TDM), leaf dry matter (LDM), and stem dry matter (SDM) yields. However, it decreased crude protein percentages (CPP) and had no effects on leaf-stem ratio at both locations. Increasing nitrogen rates increased MSH, LAI, TTN, TFF, TDM, CPP, forage prussic acid percentage (FPAP) and decreased leaf-stem ratio. Optimum plant densities and NT rates for these experiments were 50 plants m^{-2} and 200 kg N ha^{-1}, respectively at both locations. Nitrogen applications had more effects on the second than the first out. The reaction of forage yields and most agronomic traits to the treatments were extremely similar at both locations.

Keywords: Crude protein, Dry forage, Fresh forage, Plant density, Prussic acid, Total tillers number.

INTRODUCTION

Forage sorghum (*Sorghum bicolor* L. Moench var. Sudenence) is an important forage crop in tropical, semitropical and even warm-temperate regions and is cultivated over about 30,000 ha, mainly in the southern provinces of Iran (28). Comprehensive information on the effects of plant density and nitrogen topdressing (NT) on forage yield and quality of this crop is scanty, particularly as a summer cropping in Fars province.

Generally, high plant densities and narrow row spacing are effective means of increasing dry matter production, but forage quality often declines with higher plant densities. Naghshgar (23), and Taleb-nejat (26) found the highest dry forage yield of the Speedfeed cultivar at a 30 cm row spacing. The dry matter yield (DMY) of sorghum-sudangrass hybrids and Atlas sorgo also increased with high plant densities (20, 25). Caravetta *et al*. (9) showed lower DMY but higher forage digestibility with lower densities. Halasz (11) noted the highest forage DMY of MV 301 cultivar at a 20cm row spacing. Ailoie (2) reported a doubling of protein yield as seeding rates increased from 10 to 30 kgha^{-1}.

Forage sorghum is a highly responsive crop to N fertilizers (16, 17). Nitrogen topdressing is more efficient for regrowth during growing the season. Kashani and Bah-

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rani (17) found increased dry forage yield for Vidan cultivar with NT. Haskins *et al*. (13) observed that 120 kg N ha^{-1} (1/3 on planting, 1/3 after the first cut and 1/3 after the second cut) increased DMY of Sordan 3 cultivar. Bowman *et al*. (6) reported that N fertilizer increased DMY and protein contents of Sordan cultivar. Lee and Seo (19), and Singh *et al*. (24) obtained the highest dry matter and protein yields by increasing N. However, high N rates may increase prussic acid contents of forage sorghum, ultimately poisoning animals (16, 21). The purpose of this experiment was to determine the effects of plant density and NT rates on forage sorghum yields, crude protein percentage (CPP) and forage prussic acid percentage (FPAP) when sorghum is planted as a summer crop at two locations in Fars province.

MATERIALS AND METHODS

Two similar experiments were carried out to determine the effects of plant densities and NT rates on the forage yields, protein and prussic acid contents of forage sorghum as a summer cropping at Kushkak (52°, 46′E, 29°, 50′N, altitude: 1650 m) (Shiraz University Agricultural Research Experimental station.), 75 km northwest of Shiraz and at Zargan (52°, 43′E, 29°, 48′N, altitude: 1603 m) (Fars Agricultural. Experimental Station), 30 km north of Shiraz. Mean temperatures and rainfall of the growing season and annual means of both locations are given in Table 1.

Both experiments were organized as split plot design with four complete blocks on a Ramjerd, fine mixed mesic, Typic Calcixerepts and Zargan fine, loamy carbonatic, thermic, Typic Calcixerepts soils were used, respectively. The total N contents of the soils were 0.11 and 0.13%, before conducting the experiment, respectively. Both experimental sites were under wheat (*Triticum aestivum* L.) cultivation and were harvested in early June. Forage sorghum (Speedfeed cultivar) was planted on June 20 and 26, 1995, at Kushkak and Zargan, respectively.

The treatments were plant densities with 20, 30 and 40 cm row spacings and 10 cm between plants in each row (25, 33 and 50 plants m^{-2}, respectively) in the main plots and 0, 100, 200 and 300 kg N ha^{-1} as urea applied to the sub-plots twice- half at tiller initiation (15-20 cm plant height) of the first cut and the rest after the first cut, in irrigation water at both locations. Three hundred kg ammonium phosphate ha^{-1} was also applied to all plots before planting.

Each plot had eight rows 6 m in length. The plants were thinned or replanted to give the desired density on July 6th and 8th at both locations, respectively and they were irrigated at 10 day intervals throughout the experiment. Weeds were controlled with a

Table 1. Monthly means of temperature and rainfall of the growing period during the experiment in 1995 and annual means of Kushkak and Zargan locations.

		Temperature (°C)		Rainfall (mm)	
Location	Month	1995	1976-1996	1995	1976-1996
Kushkak	May-June	21.0	21.6	6	1.9
	June-July	25.0	25.0	0	0.2
	July-Aug.	24.9	24.9	0	1.3
	Aug.-Sept.	23.8	22.3	0	0
	Sept.-Oct	17.4	17.0	33	22
		(1982 – 1995)		(1982 - 1995)	
Zargan	May-June	27.1	26.0	7.1	0.16
	June-July	27.2	28.2	0	0
	July-Aug.	27.1	26.7	0	0.085
	Aug.-Sept.	24.1	23.1	0	0.046
	Sept.-Oct	18.2	17.9	27.8	2.7

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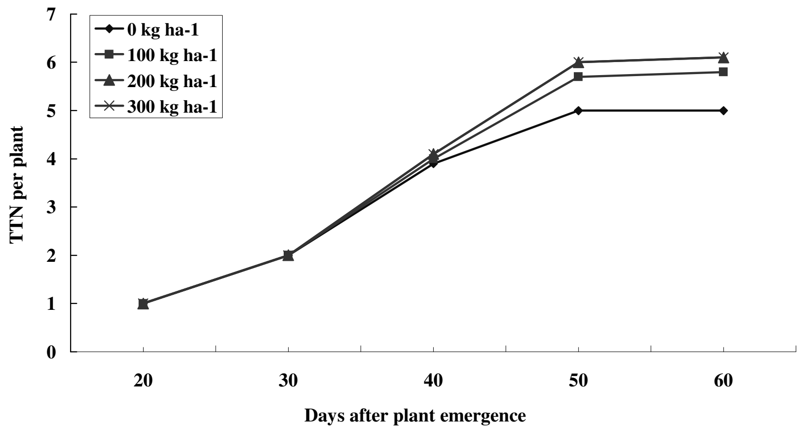

Figure 1. Effect on nitrogen rates on TTN per plant in 1st cut at Zarghan.

mixture of atrazine (6-chloro-*N*-ethyl-*N*-(1-methylethyl-1, 3, 5-triazine-2, 4-diamine) (1.6 kg ai ha^{-1}) and 2, 4-D (2, 4-Dichlorophenoxy acteic acid) (1 kg ai ha^{-1}) applied on July 12th and 17th at both locations. The same herbicides were applied at the same rates at the 2-leaf stage of the regrowth period.

The plants were harvested at 10 to 20% heading in each cut at about 7 cm above the ground at both locations. At each cut agronomic traits such as main stem height (MSH) (from crown to last leaf sheath), leaf area index (LAI) and total tillers number (TTN) per plant and per m^2 were determined from a minimum of five randomly sampled plants from the 2nd and 7th rows of each plot. The leaf area was calculated by multiplying maximum length × width × 0.74 (25). The mean total leaf area $plant^{-1}$ was multiplied by the number of plants m^{-2} to obtain leaf area index. Total fresh forage yield was also determined immediately after harvest in the field from the two central rows of each plot in each cut. Then the plant materials were separated into leaves and stems, dried at 75°C for 48 h and weighed. Crude protein was determined according to the microkjeldel (3) and prussic acid (only at Kushkak site) according to the AOAC (4) methods.

RESULTS AND DISCUSSION

Plant densities and nitrogen topdressing significantly increased MSH, LAI and TTN at both locations (Table 2). The profound effect of increasing plant densities and N was to shade and increase competition for light which led to increased LAI and plant height in both cuts at both locations. Similar results have been obtained by others (13, 22, 24). High plant densities occasionally cause lodging plants, but no lodging was observed even by tillers in this experiment at either locations. There was a significant interaction between plant density and N fertilizer rates for MSH, LAI and TTN m^{-2} at both locations (Table 2). As plant density increased higher N rates had more effects on MSH, LAI, and TTN m^{-2}, which showed higher efficiency of N applications at higher plant density. However, there was no significant difference between 100 and 300 kg N ha^{-1} at both locations which agrees with the results of Agabawi and Jupines (1).

Tillering started after the third leaf expansion or about 30 days after emergence and increased considerably from 30 to 50 days at the first cut (Figure 1). High rates of tillering at the nearly final parts of plant growth were

Table 2. Effect of plant density and N fertilizer rates on some agronomic traits of forage sorghum at Kushkak and Zargan.

		Plant density (per m^2)											
		25				33				50			
		N (kg ha^{-1})											
Location	Agronomic traits	0	100	200	300	0	100	200	300	0	100	200	300
Kushkak	Main stem height (cm)	157 e	165 d	173 c	174 c	154 e	176 c	179 c	180 bc	156 e	180 bc	185 a	185 a
	Leaf area index	4.4 i	5.8 f	6.3 e	6.5 d	4.9 h	6.4 d	6.9 b	6.9 b	5.4 g	6.7 c	7.3 a	7.3 a
	Total tillers number m^{-2}	175 g	210 f	220 f	225 ef	190 g	240ed	254cd	261 c	257 c	319 b	352 a	356 a
Zargan	Main stem height (cm)	153 c	171 b	171 b	170 b	150 c	172 b	175ab	176ab	152 c	176 ab	181 a	182 a
	Leaf area index	4.3 i	5.8 e	6.2 e	6.4 d	4.8 h	6.4 d	6.7 c	6.8 b	5.3 g	6.8 b	7.2 a	7.3 a
	Total tillers number m^{-2}	165 h	197 f	201 f	216 f	184 g	235 d	218 e	252 c	250 c	311 b	344 a	341 a

Means of each row followed by the same letter are not significantly different (Duncan 1%).

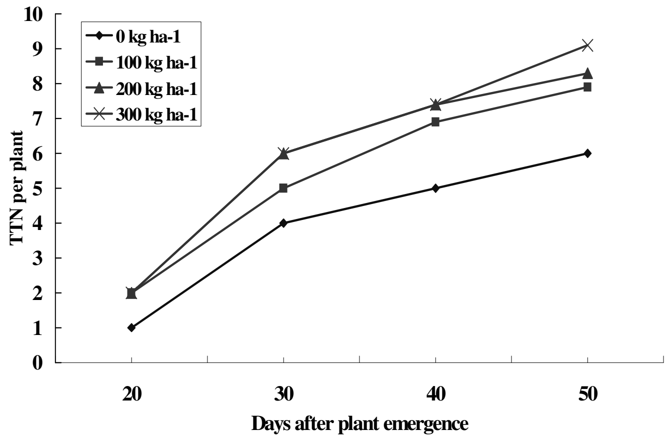

Figure 2. Effect of nitrogen rates on TTN per plant in 2nd cut at Zarghan.

due to higher plant growth rates and higher available spaces. Nitrogen topdressing increased tillering and tiller survival (Table 2) which confirms the results of Muldoon (22) who found an increase in TTN with N application. The number of tillers per plant was not significantly different among N fertilizer treatments at 40 days after planting in the first cut and 30 days after the first cut, but it became different later at the Zargan site (Figures 1 and 2). Tillering started earlier in the second cut (25 days after the first cut) and continued to increase until 20 to 40 days after the first cut. Total tillers number were higher in the second than first cut which can be attributed to better plant establishment and probably higher growth rate due to more favorable climatic conditions (Table 1).

Tillering was largely completed at the final period of stem growth, about 50 days after plant emergence in the first cut and 40 days after the first cut at Zargan which was due to canopy shading. Muldoon (22) also observed reduced tillering of forage sorghum

Table 3. Effect of plant densities on some agronomic traits of forage sorghum during the growing season at Kushkak and Zargan.

		Plant density (m^{-2})		
Location	Agronomic trait	25	33	50
Kushkak	Total tillers number (m^{-2})	208c	236b	321a
	Total fresh forage (t ha^{-1})	40.3c	44.3b	49.1a
	Total forage dry matter (t ha^{-1})	6.8c	8.3b	10.5a
	Leaf dry matter (t ha^{-1})	3.4c	3.8b	4.2a
	Stem dry matter (t ha^{-1})	3.4c	4.5 b	6.3a
	Leaf-stem ratio	0.67a	0.69a	0.69a
Zargan	Total tillers number (m^{-2})	195c	230b	313 a
	Total fresh forage (t ha^{-1})	36.3c	43.3b	48.3a
	Total forage dry matter (t ha^{-1})	8.2c	9.3b	10.3a
	Leaf dry matter (t ha^{-1})	3.3c	3.8b	4.2a
	Stem dry matter (t ha^{-1})	4.9c	5.5b	6.1a
	Leaf-stem ratio	0.67a	0.68a	0.69a

Means of each row followed by the same letter are not significantly different (Duncan 1%).

Table 4. Effect of N fertilizer topdressing on some agronomic traits of forage sorghum during the growing season at Kushkak and Zargan.

		N (kg ha^{-1})			
Location	Agronomic trait	0	100	200	300
Kushkak	Total fresh forage (t ha^{-1})	34.8c	45.5b	48.8 a	48.7a
	Total forage dry matter (t ha^{-1})	7.4c	9.7b	10.5 a	10.4a
	Leaf dry matter (t ha^{-1})	3.3b	4.0a	4.0 a	3.9a
	Stem dry matter (t ha^{-1})	4.1c	5.7b	6.5 a	6.5a
	Leaf-stem ratio	0.8a	0.70b	0.62c	0.59d
Zargan	Total fresh forage (t ha^{-1})	34.1c	44.b	48.0a	48.2a
	Total forage dry matter (t ha^{-1})	7.3 c	9.3b	10.3a	10.3a
	Leaf dry matter (t ha^{-1})	3.3 b	3.8a	3.9a	3.8 a
	Stem dry matter (t ha^{-1})	4.0 b	5.5b	6.4a	6.5 a
	Leaf-stem ratio	0.82a	0.70 b	0.6 c	0.60d

Means of each row followed by the same letter are not significantly different (Duncan 1%).

plants 35 days after emergence. Although TTN per plant was higher in less populated plants, TTN per m^2 was higher in plants grown in a higher population Therefore, TTN per m^2 increased with increasing plant density which is similar to the findings of Bugger and Campbell (7) who measured an increase of TTN m^{-2} by increasing plant density. Apparently, there was a marked difference between the growth of main stems and tillers, particularly in higher populated plants which could be due to higher growth rates of plants at the first cut. At the second cut there was no main stem, TTN were higher, and tillers grew more uniformly than in the first cut.

Forage yields generally increased with increased plant density in both cuts at both locations (Table 3) which was similar to other reports (9, 14, 20). The highest total fresh forage (TFF) (49.1 t ha^{-1}), total dry matter (TDM) (10.5 t ha^{-1}), leaf dry matter (LDM) (4.2 t ha^{-1}), and stem dry matter (SDM) (6.3 t ha^{-1}) yields were obtained at 50 plants m^{-2} with a significant difference with other plant densities at Kushkak. The forage yields probably could respond to higher plant densities at both locations.

Nitrogen fertilizer rates also increased TFF, TDM, LDM, and SDM yields at both locations and the highest TFF (48.7 t ha^{-1}) and TDM (10.4 t ha^{-1}) were obtained at Kushkak (Table 4). The percentage of stem dry matter increased with increased N fertilizer which was similar to other results (17, 23, 26). The rate of dry matter production was higher in 2nd cut due to the decrease of soil N in 1st cut (absorption by plants, leaching and volatilization), accompanied by better plant establishment allowing for better water and mineral uptake. Similar results were shown by Bahrani (5) and Harm and Tucker (12) who showed a higher rate of dry matter production of forage sorghum at the second cut. Leaf-stem ratios increased with increasing plant density at both locations (Table 5), however, they significantly decreased with N application, (Table 4). In another words, N applications mainly increased stem weight which agrees with the results of Kashani and Bahrani (17).

There was a significant interaction between plant density and N rates for TFF, TDM, SDM and LDM at both locations which again showed higher efficiency of N applications at higher plant density (Table 5). The highest TFFY (55.2 t ha^{-1}) and TDM (11.8 t ha^{-1}) were obtained with 50 plants m^{-2} and 300 kg N ha^{-1} at Kushkak (Table 5). However, there was no significant difference between 200 and 300 kg N ha^{-1} and between the two locations for TFF, TDM, SDM and LDM. Therefore, applications of 200 kg of N ha^{-1} are recommended for both locations.

Table 5. Effect of plant density and N fertilizer rates on some agronomic traits of forage sorghum during the growing season.

		Plant density (m^{-2})											
		25				33				50			
		N (kg ha^{-1})											
Location	Agronomy trait	0	100	200	300	0	100	200	300	0	100	200	300
Kushkak	Total fresh forage (t ha^{-1})	33.8 g	41.9 e	42.5 de	44 de	35 fg	45 cd	48.9 d	47.1 bc	36.7 f	49.5 b	55.1 a	55.2 a
	Total forage dry matter (t ha^{-1})	6.9 g	8.9 e	9.1 de	9.3 de	7.5 fg	9.6cd	10.5 b	10.1 bc	7.8 f	10.6 b	11.8 a	11.8 a
	Leaf dry matter (t ha^{-1})	3.1 h	3.6 g	3.4 gh	3.4 gh	3.3 g	4.0 e	3.8 e	3.0 e	3.5 e	4.4 b	4.5 a	4.5 a
	Stem dry matter (t ha^{-1})	3.8 g	5.3 e	5.6 c	5.9 c	4.1 d	5.6 c	6.5 b	6.3 b	4.3 d	6.2 b	7.3 a	7.3 a
	Leaf-stem ratio	0.81	0.69	0.63	0.56	0.81	0.71	0.61	0.61	0.82	0.71	0.61	0.61
Zargan	Total fresh forage (t ha^{-1})	32.1 g	39.4 e	42.3 de	43.3 d	34.2 fg	44.2cd	47.7 b	46.9 bc	30.6 f	48.8 d	54.3 a	54.4 a
	Total forage dry matter (t ha^{-1})	6.8 f	8.1 e	9.0 d	9.2 d	7.3 ef	9.4 cd	10.2bc	10.0 bc	7.7 f	10.3 b	11.6 a	11.6 a
	Leaf dry matter (t ha^{-1})	3.1 e	3.3 cd	3.4 cd	3.3 cd	3.3 cd	3.9 b	3.8 b	3.8 b	3.5 c	4.3 a	4.4 a	4.4 a
	Stem dry matter (t ha^{-1})	3.8 f	3.8 f	5.6 d	5.9 cd	7.5 f	5.6 d	6.4 b	6.2 bc	4.7 f	6.1 cd	7.2 a	7.2 a
	Leaf-stem ratio	0.81	0.69	0.62	0.57	0.81	0.70	0.61	0.61	0.82	0.70	0.61	0.61

Means of each row followed by the same letter are not significantly different (Duncan 1%).

Table 6. Effect of plant density and N fertilizer rates on crude protein content (%) of forage sorghum at Kushkak and Zargan.

Location	N rates (kg ha^{-1})	Plant density (m $^{-2}$)			
		25	33	50	Mean
Kushkak	0	6.7 e	6.5 f	6.4 f	6.6 C
	100	8.4 bc	8.2 c	7.9 d	8.2 A
	200	8.9 a	8.5 bc	8.3 bc	8.6 A
	300	9.1 a	8.6 b	8.4 bc	8.7 A
	Mean	8.3 A	7.9 B	7.8 C	
Zargan	0	6.6 h	6.5 i	6.3 j	6.5 D
	100	8.3 d	8.0 f	7.8 g	8.0 C
	200	8.8 b	8.4 c	8.3 d	8.5 B
	300	8.9 a	8.5 c	8.4 c	8.7 A
	Mean	8.2 A	7.9 B	7.7 C	

Means of interaction of plant density and N rate in each location that are followed by small letters and main effects that are followed by capital letters are not significantly different (Duncan 1%).

Increasing plant densities significantly decreased crude protein percentage (CPP) at both locations (Table 6). Higher CPP in plants grown at low densities may have been due to luxury consumption of N and / or less competition among plants for nutrient uptake. These results agree with Caravetta (9), Koller and Clark (18) and Worker (27) who found that protein percentage was highest in plants grown at low densities. However, they contradict the findings of Jeon *et al.* (15) who reported an increase in CPP with increasing sowing rate of Sordan 79 cultivar. Nitrogen fertilizer rates significantly increased CPP at both locations (Table 6), which confirms the results of Harms and Tucker (12) and Jung *et al.* (16). There were nitrogen and plant density rate interactions for CPP at both locations (Table 6). The highest CPPs (9.1 and 8.9%) were obtained at 25 plants m^{-2} and 300 kg N ha^{-1} at Kushkak and Zargan, respectively.

Plant density had no significant effects on FPAP at Kushkak (Table 7) which was similar to other results (7, 11, 15). However, higher N rates significantly increased FPAP which confirmed the results of Harms and Tucker (12) and Ghorashi *et al.* (10) at the

Table 7. Effect of plant density and N rates on prussic acid content (mg per 100 g dry matter) of forage sorghum at Kushkak.

Cut	N rates (kg ha^{-1})	Plant density (m^{-2})			
		25	33	50	Mean
1st	0	12.2	12	12.2	12.2 c
	100	12.0	12.5	12.7	12.4 c
	200	16.2	16.7	16.7	16.5 b
	300	18.5	19.0	19.2	18.9 a
	Mean	14.7	15.1	15.2	
2nd	0	2.5	2.5	2.5	2.5
	100	2.5	2.5	2.5	2.5
	200	3.0	2.5	2.5	2.7
	300	3.0	2.5	2.5	2.7
	Mean	2.8	2.5	2.5	

Means in each column followed by the same letters are not significantly different (Duncan 1%).

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Table 8. Effect of N rates on prussic acid content (mg per 100 g dry matter) of the two cuts of forage sorghum at Kushkak.

N rates (kg ha^{-1})	Prussic acid 1st cut	2nd cut
0	12.2 c	2.5
100	12.7 c	2.5
200	16.6 b	3.0
300	18.9 a	2.0
Mean	15.1 A	2.5 B

Means of each column (small) and row (capital) followed by the same letters are not significantly different (Duncan 1%).

first cut (Table 8). The forage prussic acid percentage of the second cut was significantly lower than the first cut, probably due to degradation of the acid and a higher metabolic activity of the plant due to higher temperatures during growth processes which can reduce the prussic acid accumulation (Tables 1, 7 and 8). These low amounts of FPAP are not toxic to animals (21).

In summary, increasing plant densities increased MSH, LAI, TTN, TFF, TDM, LDM and SDM, decreased CPP, and had no significant effects on leaf-stem ratio and FPAP at both locations. Nitrogen topdressing also significantly increased MSH, LAI, TTN m^{-2}, TDM, LDM, SDM, CPP and FPAC, but decreased leaf-stem ratio at both locations. Forage yields were higher at the second than the first cut at both locations. Optimum plant density and N rates for these experiments were 50 plants m^{-2} and 200 kg N ha^{-1} at both locations. The two locations, Kushkak and Zargan, had relatively similar climate and soil conditions (Table 1), and there were no significant differences between them for forage yields and most agronomic traits (Table 9). Summer planting of forage sorghum can produce high forage yields in many parts of Fars province.

Table 9. Effect of location on some agronomic traits of forage sorghum.

Location	Main stem height (cm)	Leaf area index	Total tillers number m^{-2}	Total fresh forages (t ha^{-1})	Total dry matters (t ha^{-1})	Leaf dry matter (t ha^{-1})	Stem dry matter (t ha^{-1})	Leaf stem ratio	Crude protein content (%)
Kushkak	172a	6.0a	254.9a	44.4a	9.5a	3.8a	5.7a	0.68a	8.0a
Zargan	169a	6.1a	244.3b	43.6a	9.3a	3.7a	5.6a	0.68a	7.9a

Means of each column followed by the same letters are not significantly different (Duncan 1%).

REFERENCES

1. Agabawi, K. A., and Jupins, A. E. 1985. Effect of Nitrogen Application on Growth and Nitrogen Content of Striga hermonthic Benth and *Sorghum Vulgare* Grown for forage. *Plant Soil.*, **3**: 295-304.
2. Ailoie, G. 1993. Influence of Sowing Form on the Yield and Quality of Sudangrass Sorghum Hybrids. *Herb. Abst.* **63(1)**: 1.
3. AOAC, 1975. *Official Methods of Analysis*. Association of Official Analytical Chemists, 12th Ed. Washington, D. C. USA.
4. AOAC, 1990. *Official Methods of Analysis*, Association of Official Analytical Chemists, 15th ed. Arilingtion, Virgina, USA.
5. Bahrani, J. 1990. Forage Yield and Protein Content of five Sudangrass Cultivars in Ahvaz. *Iran Agric. Res.* **9**: 153-160.
6. Bowman, J. P., Henderlong, H. R. and Garica, G. S. 1993. Effect of Nitrogen Fertilization on Forage Quality of Summer Annual Forages. *Herb. Abst.* **63(2)**: 60.
7. Bugger, A.W., and Campbell, W. F. 1961. Effects of Rates and Methods of Seeding on the Original Stand, Tillering, Stem Diameter, Leaf-stem Ratio, and Yield of Sudangrass. *Agron. J.* **53**: 289-291.
8. Bugger, A.W. and Hitlle, C. N. 1965. Yield, Protein, Nitrate and Prussic Acid Content of

[DOR: 20.1001.1.16807073.2004.6.1.5.9]

Sudangrass Hybrids and Pearl Millet Harvested at Two Cutting Frequencies and Two Stubble Heights. *Agron. J*. **59**: 295-265.
9. Caravetta, G. J., Cherney, J. H. and Johnson, K. D. 1990. Within-row Spacing Influences on Diverse Sorghum Genotypes. 2. Dry Matter Yield and Forage Quality. *Agron. J*. **82**: 210-215.
10. Ghorashi., A. M., Dorolsom, P. N. and Schol, J. M. 1980. Effect of Stage of Growth, Temperature and N and P Levels on the Hydrocyanic Acid Potential of Sorghum in the Field and Growth Room. *Crop. Sci*. **20**: 45-47.
11. Halasz, K. 1976. Sowing Rate Trials on Sandy Soil with Hybrid Sudangrass. *Herb. Abst*. **49(12)**: 491.
12. Harms, C. L. and Tucker, B. B. 1973. Influence of Nitrogen Fertilization and other Factors on Yield, Prussic Acid, Nitrate and Total Nitrogen Concentrations of Sudangrass Cultivars. *Agron. J*. **65**: 21-26.
13. Haskins, F. A., Gorz, H.G. and Clark, R. B. 1982. Influence of Radiation on Apparent Hydrocyanic Acid Potentials of Sorghum Seedlings. *Herb. Abst*. **52(9)**: 440.
14. Huda, A. K. S. 1988. Simulating Growth and Yield Responses of Sorghum to Changes in Plant Density. *Agron. J*. **80**: 541-547.
15. Jeon, B. J., Lee, S. M., Shin, D. U., Moon, S. H. and Kim, U. S. 1992. Effect of Plant Density and Planting Pattern on the Growth Characteristics, Dry Matter and Feeding Value of Sorghum Sudangrass Hybrids. *Herb. Abst*. **62(10)**: 416.
16. Jung, G. A., Lilly, S. C., Shine, S. S. and Raid, R. L. 1964. Studies with Sudangrass. 1. Effects of Growth Stage and Level of Nitrogen Fertilization upon Yield of Dry Matter, Estimated Digestibility of Energy, Dry Matter and Digestibility Protein, Amino Acid Composition and Prussic Acid Potential. *Agron. J*. **56**: 533-537.
17. Kashani, A. and Bahrani, J. 1985. Effect of Nitrogen Levels and Clipping Intervals on Forage Yields of Sudangrass. *Iran J. Sci. Agric*. **10**: 28-39 (In Farsi with Eng. summary).
18. Koller, R. N., and Clark, N. A. 1965. Effect of Plant Density and Moisture Supply on the Forage Quality of Sudangrass. *Agron. J*. **57**: 591-593.
19. Lee, J. K., and Seo, S.1989. Effect of N Fertilization Levels on the Regrowth, Carbohydrate Reserves and Dry Matter Yield of Sorghum Sudangrass. *Herb. Abst*. **60(4)**: 123.
20. Masoaka, Y., and Tanako, N. T. 1980. Studies on the Digestibility of Forage Crops. 1. Effect of Plant Density on the Feeding Value of Sorghum-Sudangrass Hybrids. *J. Jap. Grassl. Soc*. **26**: 179-184.
21. Morrison, F. B. 1961. Feeds and Feeding. 9th Ed., Morrison Publ. Co., N.Y. PP.254.
22. Muldoon, P. K. 1985. Summer Forage under Irrigation. 1. Growth and Dvelopment. *Aust. J. Exp. Agric. Anim. Husb*. **25**: 392-40.
23. Naghshgar, A. 1994. Determining the Optimum Row Spacing for Forage Sorghum Speedfeed Cultivar. *Fars Agric. Exp. Stn*. (Zargan), Iran (In Farsi).
24. Singh, V., Singh, A. K., Verma, S. S. and Yoshi, Y. P. 1989. Effect of Nitrogen Fertilization on Yield and Quality of Multicut Tropical Forage. *Herb. Abst*. **59(10)**: 392.
25. Stickler, F. C. and Laude, H. H. 1960. Effect of Row Spacing and Plant Population on Preformance of Corn, Grain Sorghum and Forage Sorghum. *Agron. J*. **52**: 275-277.
26. Taleb-nejat, A. 1995. Determining the Optimum Row Spacing and Seeding Rate of Speedfeed Forage Sorghum. *Central Province Exp. Stn., Iran* (In Farsi).
27. Worker, G. F. 1973. Sudangrass and Sudangrass Hybrids Responses to Row Spacing and Plant Maturity on Yield and Chemical Composition. *Agron. J*. **65**: 975-977.
28. Yearly Bulletin of Statistics. 1994. Iran Statisical Center, Tehran.

تأثیر تراکم بوته و مقادیر مختلف کود نیتروژنه سرک بر عملکرد علوفه ، پروتئین و اسیدپروسیک سورگوم علوفه ای در کشت تابستانه

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چکیده

جهت تعیین اثرات تراکم بوته و مقادیر مختلف کود سرک نیتروژنه بر عملکرد علوفه، برخی ویژگی‌های زراعی و میزان پروتئین و اسید پروسیک سورگوم علوفه‌ای (*Sorghum bicolor* L. Moench var. Sudenense) در سال زراعی ۱۳۷٤ دو آزمایش مشابه در ایستگاه‌های تحقیقات کشاورزی کوشکک و استان فارس انجام گرفت . هر دو آزمایش در طرح کرتهای خرد شده بصورت بلوکهای کامل تصادفی با ٤ تکرار اجرا شدند. تراکم بوته شامل ۲۵، ۳۳ و ۵۰ بوته در مترمربع در کرتهای اصلی و مقادیر کود نیتروژنه سرک شامل ۰، ۱۰۰، ۲۰۰ و ۳۰۰ کیلوگرم نیتروژن خالص در هکتار به صورت اوره در کرتهای فرعی بودند. با افزایش تراکم بوته در هر دو محل ارتفاع ساقه اصلی، شاخص سطح برگ، تعداد کل پنجه‌ها در متر مربع ، کل عملکرد علوفه تر و ماده خشک علوفه و برگ و ساقه نیز افزایش یافت، اما درصد پروتئین خام علوفه کاهش یافت و بر نسبت برگ به ساقه و میزان اسید پروسیک تأثیری نداشت. کود نیتروژنه ارتفاع ساقه اصلی، شاخص سطح برگ، تعداد کل پنجه‌ها، کل عملکرد علوفه تر ، ماده خشک علوفه و برگ و ساقه، درصد پروتئین خام و اسید پروسیک علوفه را افزایش داد. ولی نسبت برگ به ساقه را کاهش داد. تراکم بوته و میزان کود نیتروژنه سرک بهینه در این آزمایش در هر دو محل ۵۰ بوته در متر مربع و ۲۰۰ کیلوگرم در هکتار بود. تأثیر کود سرک نیتروژنه در چین دوم در هر دو محل بیش از چین اول بود. واکنش عملکردهای علوفه و سایر صفات زراعی در هر دو محل تقریبا" مشابه بودند.