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Evaluation Effect of Different level of Nitrogen and Cutting Height on Morphological Traits, Seed Protein Content and Prussic Acid Concentration of Sorghum (*Sorghum bicolor* L., cv. Speed feed)

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ABSTRACT

BACKGROUND: Nitrogen is a crucial component of plant nutrition, and its deficiency limits productivity of crops more than any other element. To manage the sorghum crop for achievement of maximum forage production, the farmer should be concerned about nitrogen requirement and plant height.

OBJECTIVES: This research was carried out to evaluate response of morphological traits, seed protein content and prussic acid concentration of Sorghum to different level of urea fertilizer and cutting height.

METHODS: Current study was conducted via split plot experiment based on randomized complete blocks design with three replications along 2012 year. The main factor included three level of urea fertilizer (200, 300 and 400 $kg.ha^{-1}$) and three level of cutting height (7, 12 and 14 cm) belonged to subfactor.

RESULT: Result of analysis of variance revealed effect of different level of urea fertilizer, cutting height and interaction effect of treatments on all studied characteristics was significant at 5% probability level. Assessment mean comparison result of interaction effect of treatments on all measured traits indicated the maximum amount of seed yield (693 $gr.m^{-2}$), panicle length (15.43 cm), stem diameter (15.90 cm), plant height (174.73 cm), prussic acid concentration (276.96 ppm) and seed protein concentration (10.90%) were noted for 400 $kg.ha^{-1}$ urea and 7cm of cutting height and lowest amount of mentioned traits belonged to 200 $kg.ha^{-1}$ urea and 17cm of cutting height treatment.

CONCLUSION: Generally result of studied research revealed 400 $kg.ha^{-1}$ urea fertilizer and 7cm cutting height had the highest amount of studied characteristics and it can be advice to farmers.

KEYWORDS: *Fertilizer, Forage, Nutrition, Qualitative traits, Urea.*

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1. BACKGROUND

Nitrogen element is an important nutrient for optimum crop growth and optimum production. Although its effect on the growth and yield of sorghum has been demonstrated to be dependent on the factors of climate, soil type and genotype which also vary across seasons and locations, the application nitrogen generally results in increase in the biomass and yield of sweet sorghum until an optimum rate is reached. This optimum rate varies from one location to another and from one season to another. However, from this, the optimum rate can be said to lie within the range of 60 and 120 kg N ha^{-1} depending on the location, the soil type and the native nitrogen of the soil determined through soil test (Olugbemi, 2017). Although sorghum is a C4 crop and uses nitrogen in a more efficient way compared to most C3 crops, nitrogen is the most essential nutrient for sorghum growth, which is still one of the major factors limiting its yield (Young and Long, 2000). The rate of nitrogen fertilization to optimize sorghum growth and yield varies with cultivars. Genetic diversity of nitrogen use has been demonstrated in sorghum with some of the most efficient types being cultivars that evolved from low-fertility environments (Gardner *et al*., 1994). Mansouri-Far *et al*. (2011) showed that increase in nitrogen fertilizer level improves maize growth and yield. They also found that the responses of different hybrids to nitrogen supply were different. Mahmud *et al*. (2003) reported that N fertilization increases crude protein, fodder and dry matter yield in forage sorghum. Under nitrogen deficit conditions, photosynthesis is not used fully in the synthesis of organic nitrogen compounds and hence sugars are accumulated (Karic *et al*., 2005). There is a positive relationship between nitrogen fertilization and forage yield (Almodares *et al*., 2009) and as Marsalis *et al*. (2010) reported dry matter is decreased by N fertilization. Results of Hammad *et al*. (2011) revealed that maximum amount of plant growth, number of kernels per ear and grain yield of maize was found in apply 250 kg N ha^{-1} treatment and the highest days to maturity time and biological yield were recorded from 300 kg N ha^{-1} application. It has been clearly shown in the literature that applying optimum rate of nitrogen element at proper time is crucial in improving crop productivity. Farmers usually apply high rates of nitrogen fertilizer to ensure the fulfillment of the crop needs, while they are using both water and nitrogen element in an inefficient way by increasing leaching potential of nutrients into the ground water (Ramos *et al*., 2012). Depending on soil nitrogen fertility, farmers apply between 45 and 224 kg N ha^{-1} in sorghum crop production (Zhao *et al*., 2005).

2. OBJECTIVES

The current research was carried out to evaluate response of morphological characteristics, seed protein content and prussic acid concentration of Sorghum crop to apply different level of nitrogen fertilizer (urea source) and cutting height.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

Current study was conducted according split plot experiment based on randomized complete blocks design with three replications along 2012 year. Place of research was located in Ahvaz city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (Southwest of Iran). The main factor included three level of urea fertilizer (200, 300 and 400 kg.ha^{-1}) and three level of cutting height (7, 12 and 14 cm) were for subfactor. This experiment had 27 plots. Physical and chemical properties of the studied soil were mentioned in table 1.

Table 1. Physical and chemical properties of studied field

Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture	ρb (gr.cm^{-3})	Potassium (mg.kg^{-1})
0-30	12.5	41	46.5	Siltyclay	1.34	181
30-60	11.8	40	48.4	Siltyclay	1.36	125

Continue Table 1.

Soil depth (cm)	Phosphorus (mg.kg^{-1})	Nitrogen (mg.kg^{-1})	pH	Organic carbon (%)	EC (ds.m^{-1})
0-30	9.1	7	7.8	0.65	2.6
30-60	6.8	3	7.6	0.36	2.2

3.2. Farm Management

The required nitrogen was provided by the urea source. In order to prevent horizontal movement of urea fertilizer during the fertilization, some furrows were made in irrigation streams and the fertilizer was evenly placed in the furrows. Then they were covered by soil and immediately irrigated. While planting at the first stage, urea fertilizer was distributed to the experiment land as the basic fertilizer. Potassium fertilizer was not used due to high level of absorbable potassium. The required amounts of nitrogen fertilizers were identified after the soil analysis and the needed fertilizer for each plot was calculated with regard to the plot size and the levels of studied treatments and 25% of pure nitrogen as the base fertilizer was added to the land before planting and 75% was added at 8-leaf stage. There were 8 plots in each block. The space between each sub plot from the other one was as one non-planting line and the space between every two main plots was as two non-planting lines. There were 6 planting rows in each plot and the space between the rows was 75 cm and over the rows was 12 cm. Cultivar seeds were used. The seeds were planted at the end of July month as ridge and furrows at the depth of 3-4 cm. in seed mixing method, after blending the seeds they were dried in shadow and immediately planted. After sowing the seeds, the field was irrigated. During the growth stage, growing operations such as irrigation, thinning and controlling the weeds (at the 4-leaf stage) were done.

3.3. Measured Traits

To measure the seed nitrogen content and straw nitrogen content the Kjeldahl method was used. So, to calculate the seed protein content the following formula was used (Bremner *et al*., 1983): **Equ.1.** Seed protein content (%)= Nitrogen percentage × 5.8. Prussic acid was determined according to the AOAC (1990) methods.

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.8) software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Seed yield

Result of analysis of variance revealed effect of different level of urea, cutting height and interaction effect of treatments on seed yield was significant at 5% probability level (Table 2). According result of mean comparison maximum of seed yield (594 $gr.m^{-2}$) was obtained for 400 $kg.ha^{-1}$ urea and minimum of that (510 $gr.m^{-2}$) was for 200 $kg.ha^{-1}$ (Table 3). Evaluation mean comparison result indicated in different level of cutting height the maximum seed yield (641 $gr.m^{-2}$) was noted for 7cm and minimum of that (495 $gr.m^{-2}$) belonged to 17cm treatment (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum seed yield (693 $gr.m^{-2}$) was noted for 400 $kg.ha^{-1}$ urea and 7cm of cutting height and lowest one (480 $gr.m^{-2}$) belonged to 200 $kg.ha^{-1}$ urea and 17cm of cutting height treatment (Table 5). It seems like that the increase of seed yield is due to the positive effect of nitrogen and receiving light and the increase of photosynthesis, crop growth rate, leaf area index, and leaf area duration. The results are consistent with the findings of (Nawas-Nazanat *et al.,* 2005). In another study conducted by Garg *et al.* (2005) increasing nitrogen to soil increased the plant photosynthetic efficiency and ultimately increased the seed yield and growth rate. On the other hand, since the rate of light absorption by leaves and converting it into photosynthetic materials are the other factors affecting the plant growth and production, the increase of leaf area in the farm leads to the increase of light absorption and ultimately leads to the increase of seed yield. Marsalis *et al*. (2010) also noted that responses of biological yield to nitrogen in sorghum cultivars were different and showed a positive reaction to nitrogen fertilization rate. However, Cox and Cherney (2001) reported no benefit on yield or silage quality when nitrogen was applied at levels higher than 150 kg N ha^{-1}. Positive effect of nitrogen rate on sorghum biological yield has also been reported by other researchers (Borrell and Hammer, 2000; Cox and Cherney, 2001; Zhao *et al*., 2005; Marsalis *et al*., 2010).

4.2. Panicle length

According the result of analysis of variance effect of different level of urea fertilizer, cutting height and interaction effect of treatments on panicle length was significant at 5% probability level (Table 2).

Table 2. Result analysis of variance of measured traits

S.O.V	df	Seed yield	Panicle length	Stem diameter
Replication	2	550.8^{ns}	0.08^{ns}	1.07^{ns}
Urea (U)	2	4979.2*	9.54*	14.80*
Error I	4	315.4	1.03	0.43
Cutting height (C)	2	2762.2*	20.05*	11.45*
U × C	4	1821.3*	14.10*	0.47*
Error II	12	141.4	1.36	3.72
CV (%)	-	3.81	4.44	6.14

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

Continue Table 2.

S.O.V	df	Plant height	Prussic acid concentration	Seed protein concentration
Replication	2	5.32^{ns}	2557.9^{ns}	0.95^{ns}
Urea (U)	2	151.70*	4649.5*	94.8**
Error I	4	8.19	63.9	0.4
Cutting height (C)	2	153.83*	4450.6*	88.4**
U × C	4	94.69*	250.3*	72.5**
Error II	12	4.09	9.5	0.7
CV (%)	-	3.57	6.68	9.63

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

Assessment mean comparison result indicated in different level of urea the maximum panicle length (14.32 cm) was noted for 400 kg.ha^{-1} and minimum of that (12.42 cm) belonged to 200 kg.ha^{-1} (Table 3). Compare different level of cutting height showed that the maximum and the minimum amount of panicle length belonged to 7cm kg.ha^{-1} (14.52 cm) and 17cm (11.87 cm) treatments (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum panicle length (15.43 cm) was noted for 400 kg.ha^{-1} urea and 7cm of cutting height and lowest one (10.59 cm) belonged to 200 kg.ha^{-1} urea and 17cm of cutting height treatment (Table 5). Adesoji *et al*. (2018) reported application of 60 kg N ha^{-1} produced significantly longest panicle which was at par with application of 90 kg N ha^{-1}. In combined means, application of 30, 60 and 90 kg N ha^{-1} increased length of sorghum panicle by 2.0, 5.9 and 4.7% when compared with the control treatment, respectively.

4.3. Stem diameter

According the result of analysis of variance effect of different level of urea fertilizer, cutting height and interaction effect of treatments on the stem diameter was significant at 5% probability level (Table 2).

Table 3. Mean comparison effect of different level of urea on measured traits

Urea ($kg.ha^{-1}$)	Seed yield ($gr.m^{-2}$)	Panicle length (cm)	Stem diameter (cm)
200	510^{c}	12.42^{b}	12.32^{b}
300	549^{b}	14.04^{a}	14.50^{ab}
400	594^{a}	14.32^{a}	15^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Continue Table 3.

Urea ($kg.ha^{-1}$)	Plant height (cm)	Prussic acid concentration (ppm)	Seed protein concentration (%)
200	160.84^{c}	213.40^{b}	7.32^{b}
300	168.56^{b}	245.46^{ab}	9.50^{a}
400	171.58^{a}	257.34^{a}	9.57^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Mean comparison result of different level of urea indicated that maximum stem diameter (15 cm) was noted for 400 $kg.ha^{-1}$ urea and minimum of that (12.32 cm) belonged to 200 $kg.ha^{-1}$ (Table 3). As for Duncan classification made with respect to different level of cutting height maximum and minimum amount of stem diameter belonged to 7cm (14.51 cm) and 17cm (12.62 cm) (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum stem diameter (15.90 cm) was noted for 400 $kg.ha^{-1}$ urea and 7cm of cutting height and lowest one (11.17 cm) belonged to 200 $kg.ha^{-1}$ urea and 17cm of cutting height treatment (Table 5). Sebetha and Modisapudi (2019) reported nitrogen fertilizer source had significant effect ($p<0.001$) on sorghum stem diameter. Stem diameter of sorghum fertilized with ammonium sulphate, LAN and urea had significantly larger stem diameter of 1.07 cm than control. The interaction of nitrogen fertilizer source × cultivar × soil type had significant effect ($p<0.001$) sorghum stem diameter.

4.4. Plant height

According result of analysis of variance effect of different level of urea, cutting height and interaction effect of treatments on plant height was significant at 5% probability level (Table 2). Mean comparison result of different level of urea indicated the maximum and the minimum amount of plant height belonged to 400 $kg.ha^{-1}$ (171.58 cm) and 200 $kg.ha^{-1}$ (160.84 cm) (Table 3). Among different level of cutting height maximum plant height (173.72 cm) was obtained for 7cm and minimum of that (161.07 cm) was for 17cm treatment (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum plant height (174.73 cm) was noted for 400 $kg.ha^{-1}$ urea and 7cm of cutting height and lowest one (163.20 cm) belonged to 200 $kg.ha^{-1}$ urea and 17cm of cutting height treatment (Table 5).

Amanullah *et al*. (2009) who showed that the maize plant height responded positively to higher nitrogen rate. Turgut (2000), also, indicated that plant height in maize could be increased up to 280 kg N ha^{-1}.

4.5. Prussic acid concentration

According the result of analysis of variance effect of different level of urea fertilizer, cutting height and interaction effect of treatments on prussic acid concentration was significant at 5% probability level (Table 2). Mean comparison result of different level of urea fertilizer indicated the maximum prussic acid concentration (257.34 ppm) was obtained for 400 $kg.ha^{-1}$ and minimum of amount of mentioned trait (213.40 ppm) belonged to 200 $kg.ha^{-1}$ urea treatment (Table 3).

Table 4. Mean comparison effect of different level of cutting height on measured traits

Cutting height (cm)	Seed yield ($gr.m^{-2}$)	Panicle length (cm)	Stem diameter (cm)
17	495^{c}	11.87^{b}	12.62^{b}
12	516^{b}	14.39^{a}	14.25^{a}
7	641^{a}	14.52^{a}	14.51^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Continue Table 4.

Cutting height (cm)	Plant height (cm)	Prussic acid concentration (ppm)	Seed protein Concentration (%)
17	161.07^{c}	225.07^{b}	7.62^{b}
12	169.19^{b}	226.73^{b}	9.25^{a}
7	173.72^{a}	264.39^{a}	9.51^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Compare different level of cutting height showed that the maximum and the minimum amount of prussic acid concentration belonged to the 7cm (264.39 ppm) and 17cm (225.07 ppm) treatments (Table 4). Assessment the mean comparison result of interaction effect of treatments indicated the maximum amount of prussic acid concentration (276.96 ppm) was belonged to the 400 $kg.ha^{-1}$ urea fertilizer with 7cm of cutting height and lowest amount of mentioned trait (197.83 ppm) belonged to the apply 200 $kg.ha^{-1}$ urea fertilizer and 17cm of cutting height treatment (Table 5).

4.6. Seed protein concentration

Result of ANOVA revealed effect of different level of urea, cutting height and interaction effect of treatments on seed protein concentration was significant at 1% probability level (Table 2). Mean comparison result of different level of urea indicated that maximum seed protein concentration (9.57%) was noted for 400 $kg.ha^{-1}$ urea and minimum of that (7.32%) belonged to 200 $kg.ha^{-1}$ (Table 3). Compare different level of cutting height maximum and minimum amount of seed protein concentration belonged to 7cm (9.51%) and 17cm (7.62%) (Table 4).

Assessment mean comparison result of interaction effect of treatments indicated maximum seed protein concentration (10.90%) was noted for 400 $kg.ha^{-1}$ urea and 7cm of cutting height and lowest one (6.17%) belonged to 200 $kg.ha^{-1}$ urea and 17cm of cutting height treatment (Table 5). Application of nitrogen fertilizer affects protein accumulation and biomass production in wheat (Zorb *et al*., 2010). Almodares *et al*. (2009) suggested to apply 200 $kg.ha^{-1}$ urea because the highest biomass and protein content and the lowest fiber content will be achieved with at this amount of nitrogen fertilizer. Although, this amount of nitrogen will decreased soluble carbohydrates content but it seems this reduction dose not effect on forage palatability and digestibility considerably. Brown (2010) reported that, triticale seed protein content increased up to 54% by using 120 $kg.ha^{-1}$ nitrogen fertilizer in compare to no nitrogen application treatment. Nasseri *et al*. (2009) reported the protein yield increased with increasing in nitrogen application rates so the highest protein yield (701 $kg.ha^{-1}$) produced by nitrogen rate of 90 $kg.ha^{-1}$. The results of various experiments have proved the greater amount of protein in Durum genotypes than that of bread (Ayadi *et al*., 2014).

Table 5. Mean comparison interaction effect of treatments on measured traits

Urea ($kg.ha^{-1}$)	Cutting height (cm)	Seed yield ($gr.m^{-2}$)	Panicle length (cm)	Stem diameter (cm)
200	17	480^{cd}	10.59^{c}	11.17^{d}
	12	486^{cd}	13.67^{ab}	12.87^{c}
	7	564^{b}	13.28^{ab}	12.91^{c}
300	17	443^{d}	12.40^{b}	14.35^{b}
	12	527^{bc}	14.90^{a}	14.42^{ab}
	7	677^{a}	14.83^{a}	14.73^{b}
400	17	562^{b}	12.62^{b}	12.34^{cd}
	12	536^{bc}	14.92^{a}	15.47^{ab}
	7	693^{a}	15.43^{a}	15.90^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Continue Table 5.

Urea ($kg.ha^{-1}$)	Cutting height (cm)	Plant height (cm)	Prussic acid concentration (ppm)	Seed protein concentration (%)
200	17	163.20^{d}	197.83^{c}	6.17^{d}
	12	164.80^{cd}	201.97^{bc}	7.87^{c}
	7	172.53^{ab}	240.40^{b}	7.91^{c}
300	17	165.77^{cd}	220.62^{b}	9.35^{b}
	12	166.0^{1c}	239.91^{b}	9.42^{b}
	7	173.90^{ab}	275.85^{ab}	9.97^{ab}
400	17	169.23^{b}	252.63^{ab}	7.34^{c}
	12	170.77^{ab}	242.46^{ab}	10.47^{ab}
	7	174.73^{a}	276.96^{a}	10.90^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

5. CONCLUSION

Generally result of studied research revealed 400 kg.ha^{-1} urea fertilizer and 7cm cutting height had the highest amount of studied characteristics and it can be advice to farmers.

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FOOTNOTES

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