Journal of Crop Nutrition Science
ISSN: 2423-7353 (Print) 2538-2470 (Online)
Vol. 5, No. 4, 2019
http://JCNS.iauahvaz.ac.ir
OPEN ACCESS

Assessment Effect of Different level of Nitrogen Fertilizer (Urea Source) and Interval between Irrigation Round on Crop Production of Sorghum (*Sorghum bicolor* L., cv. Speed feed)

Bahareh Jahangiri[1,2], Mojtaba Alavifazel[2]*, Mohamad Reza Dadnia[2]

1- MSc. Graduated, Department of Agronomy, Khuzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran.

2- Department of Agronomy, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.

RESEARCH ARTICLE

ARTICLE INFO.
Received Date: *24 Sep. 2019*
Received in revised form: *22 Oct. 2019*
Accepted Date: *26 Nov. 2019*
Available online: *30 Dec. 2019*

To Cite This Article: Bahareh Jahangiri, Mojtaba Alavifazel, Mohamad Reza Dadnia. Assessment Effect of Different level of Nitrogen Fertilizer (Urea Source) and Interval between Irrigation Round on Crop Production of Sorghum (*Sorghum bicolor* L., cv. Speed feed). ***J. Crop. Nutr. Sci.,*** 5(4): 1-11, 2019.

ABSTRACT

BACKGROUND: Nutrients play a very important role in chemical, biochemical, physiological, metabolic, geochemical, biogeochemical, and enzymatic processes. Innovations for saving water in irrigated agriculture and thereby improving water use efficiency are of paramount importance in water-scarce regions. Conventional deficit irrigation is one approach that can reduce water use without causing significant yield reduction.

OBJECTIVES: This study is aimed to examine the changes of crop production of sorghum in response to apply different interval irrigation round and urea fertilizer.

METHODS: A farm research was arranged via split plot experiment based on the randomized complete block design with three replications in 2012. Main plots were included apply three levels of interval between irrigation (I_1: 8 day; I_2: 12 day; I_3: 16 day) and the sub plots consisted three level of urea fertilizer (N_1: 200, N_2: 300, N_3: 400 kg.ha^{-1}).

RESULT: According result of analysis of variance effect of different level of urea fertilizer, irrigation regime and interaction effect of treatments on all studied traits (instead harvest index) were significant. Evaluation mean comparison result of interaction effect of treatments on all measured traits revealed the highest amount of seed yield (817 gr.m^{-2}), 1000-Seed weight (33.38 gr), Fresh forage yield (11829 gr.m^{-2}) and total dry weight (3071 gr.m^{-2}) were noted for 8 day interval between irrigation round and 400 kg.ha^{-1} urea fertilizer and lowest amount of mentioned traits belonged to 16 day interval between irrigation round and 200 kg.ha^{-1} urea fertilizer treatment.

CONCLUSION: Finally according result of current research application 8 day interval between irrigation round and 400 kg.ha^{-1} urea fertilizer had the highest amount of studied traits and it can be advice to producers in studied region.

KEYWORDS: *Dry matter, Forage, Fresh yield, Harvest index, Seed weight.*

***Corresponding Author:** Mojtaba Alavifazel ✉ Mojtaba_alavifazel@yahoo.com

1. BACKGROUND

Forage crops play an important role in supplying energy and protein to livestock (Eskandari *et al*., 2009). Sorghum has potential uses such as: food (grain), feed (grain and biomass), fuel (ethanol production), fiber (paper), fermentation (methane production) and fertilizer (utilization of organic byproducts) (Roy *et al*., 2018). Sorghum speed feed is a crop of world-wide importance and is unique in its ability to produce under a wide array of harsh environmental condition (Sadeghzade *et al*., 2012). Sorghum is grown as fodder crop due to the poor pollination and seed set during the extremely hot dry season (April-August) in the south provinces of Iran (Karimi *et al*., 2009). The productivity of grain sorghum could be increased by improving the cultural practices, such as irrigation regime, nitrogen fertilizer and plant density. Sorghum is an important cereal grain due to its drought resistance and relatively low input costs. Worldwide, sorghum is ranked fifth among cereal grains in terms of quantity and importance (Rooney and Awika, 2005). Drought and water shortage are considered an objective reality. In the past, water crisis was not as significant as today, since the population was less, but with the population increase by about six times and the need for more food during the last 100 years, the incidence of this crisis has become more evident than the past (Chimenti *et al*., 2002). Tolk *et al.* (2013) also reported that under drought conditions, the persistent green hybrid maintained yield by retaining greater seed numbers. In many regions of the world like Iran, drought stress is one of the most important factors that decrease agricultural crop production. Flowering, pollination and seed filling are sensitive stages to drought stress in plants (Thomas *et al*., 2004). Improving the efficiency of water use in agriculture is associated with increasing the fraction of the available water resources that is transpired because of the unavoidable association between yield and water use (Jaleel *et al*., 2007). Fertilizer management plays an important role for obtaining satisfactory yields and to increase crop productivity. Nutrient management may be achieved by the involvement of organic sources, bio fertilizers, and micro-nutrients (Singh *et al*., 2002). Among the macro nutrients essential for crop growth, nitrogen (N) is a very mobile element in the soil, due to its susceptibility to leaching, de nitrification, and volatilization losses. Excessive use of N fertilizer can lead to pollution of water bodies and may lead to soil acidification. Balanced and efficient use of applied N is of paramount importance in the overall nutrient management system than any other plant nutrient in order to reduce its negative impact on the environment. Besides, even under the best management practices, 30%-50% of the applied nitrogen is lost through different routes and hence more fertilizer needs to be applied than actually needed by the crop to compensate for the loss. The transitory loss of N not only causes loss to the farmer but also causes irreversible damage to the environment. High rates of chemical fertilizer cause environmental pollution (Shamme *et al.,* 2016).

Nitrogen is generally a limiting nutrient in crop production, and especially in sorghum, as it has been said to be the most responsive nutrient for its production (Singh *et al*., 1972). To achieve economically viable returns, efficient use of available resources, like nitrogen, is necessary to maximize yields in all seasons. Variable responses to the application of nitrogen fertilizer have been observed in sorghum owing to differences in climatic, soil and genotypic factors across seasons and locations (Muchow, 1988). After the industrial revolution widespread introduction of inorganic fertilizers led to a decline in the use of organic material in the cropping systems (Hasanuzzaman *et al*., 2010). One of limitation factor in agricultural plants production in dry areas in the water tension at growth step negative effect of water tension on corn growth depends on the time of tension occurrence, the intensity, plant growth and genotype step. Low irrigation in one of strategies to expert agricultural plant tillage and scrounge in water use which is a proper method to produce harvest in water shortage, generally in this method water performance is reduced cognizant to be compensated by enter tillage surface expansion and in many areas of America, India, Africa and many other lands which have water shortage, this method is prevalent (English and James, 1990). The limitation of water resources in arid and semi-arid areas was the main reason that we considered water as the most important material in the production lines, although people often do not obey the irrigation water consumption rules and regulations (Cakir, 2004). Innovations for saving water in irrigated agriculture and thereby improving water use efficiency are of paramount importance in water-scarce regions. Conventional deficit irrigation is one approach that can reduce water use without causing significant yield reduction (Kirda *et al*., 2005).

2. OBJECTIVES

This research is aimed to examine the changes of crop production of sorghum in response to apply different interval irrigation round and urea fertilizer.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

To evaluate the effect of different level of Nitrogen fertilizer and irrigation method on crop production of Sorghum (Speed feed cultivar) a farm research was arranged via split plot experiment based on the randomized complete block design with three replications in 2012. Place of research was located in Ahvaz city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (Southwest of Iran). Main plots were included apply three levels of interval between irrigation (I_1: 8 day; I_2: 12 day; I_3: 16 day) and the sub plots consisted three level of urea fertilizer (N_1: 200, N_2: 300, N_3: 400 $kg.ha^{-1}$). Physical and chemical properties of studied field 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	11.5	40	48.4	Siltyclay	1.36	125

Continue Table 1.

Soil depth (cm)	Phosphorus ($mg.kg^{-1}$)	Nitrogen (%)	pH	Organic carbon (%)	EC ($ds.m^{-1}$)
0-30	9.1	0.07	8	0.65	1.6
30-60	6.8	0.03	7.8	0.36	1

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 as ridge and furrows at the depth of 3-4 cm. In seed mixing method, after blending seeds they were dried in shadow and planted. After sowing seeds, field was irrigated. During the growth stage, growing operations such as irrigation, thinning and controlling the weeds (at 4-leaf stage) were done.

3.3. Measured Traits

In order to determine the yield and its components two planting lines from each plot and after the removal of marginal effect were carried to the laboratory and were placed in the oven at 75°C for 48 hours and after ensuring that the samples were completely dry, they were weighed and finally the total yield was measured. 1000-seed weight was measured after accurate sifting and cleaning of seeds and drying them in open air. Harvest index (HI) was calculated according to formula of Gardner *et al*. (1985) as follows: **Equ.1.** HI= (Seed yield/Biologic yield) ×100.

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 irrigation regime, urea fertilizer and interaction effect of treatments on seed yield was significant at 5% probability level (Table 2). According result of mean comparison of interval between irrigation round the maximum amount of seed yield (671 $gr.m^{-2}$) was obtained for 8 day and minimum of that (530 $gr.m^{-2}$) was for 16 day treatment (Table 3). Evaluation mean comparison result of different level of urea fertilizer indicated the maximum seed yield (706 $gr.m^{-2}$) was noted for 400 $kg.ha^{-1}$ and minimum of that (514 $gr.m^{-2}$) belonged to 200 $kg.ha^{-1}$ (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum seed yield (817 $gr.m^{-2}$) was noted for 8 day interval between irrigation round and 400 $kg.ha^{-1}$ urea fertilizer and lowest one (447 $gr.m^{-2}$) belonged to 16 day interval between irrigation round and 200 $kg.ha^{-1}$ urea fertilizer (Table 5). Several reports showed that sorghum crop had severed reaction to the nitrogen fertility. Beyart *et al.* (2005) studied nitrogen fertility on sorghum Sudan grass and reported that the highest seed yield was produced by application 125 kg nitrogen per hectare. It seems like that the increase of seed yield is due to the positive effect of nitrogen fertilizer and receiving light and the improve of photosynthesis process, crop growth rate, leaf area index, and leaf area duration. The mentioned 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 and crop production.

Table 2. Result analysis of variance of measured traits

S.O.V	df	Seed yield	1000-Seed weight	Fresh forage yield	Total dry weight	Harvest index
Replication	2	489^{ns}	3.91^{ns}	24102^{ns}	5971^{ns}	11.82^{ns}
Interval irrigation round (I)	2	54971^{*}	63.85^{*}	169516^{*}	44649^{**}	134.78^{ns}
Error I	4	6012	4.58	23951	4242	79.85
Urea fertilizer (U)	2	8557^{*}	66.43^{*}	112384^{*}	23712^{**}	23.49^{ns}
I×U	4	3741^{*}	7.68^{*}	48979^{*}	12697^{*}	16.03^{ns}
Error II	12	1143	1.49	14842	3082	14.50
CV (%)	-	6.15	4.32	1.21	2.22	16.38

$^{ns, *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

4.2. 1000-Seed weight

According result of analysis of variance effect of irrigation regime, urea fertilizer and interaction effect of treatments on 1000-Seed weight was significant at 5% probability level (Table 2). Mean comparison result of different level of interval between irrigation round indicated that maximum 1000-Seed weight (30.10 gr) was noted for 8 day and minimum of that (25.32 gr) belonged to 16 day treatment (Table 3). As for Duncan classification made with respect to different level of urea fertilizer the maximum and minimum amount of 1000-Seed weight belonged to 400 $kg.ha^{-1}$ (31.74 gr) and 200 $kg.ha^{-1}$ (26.74 gr) (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum 1000-Seed weight (33.38 gr) was noted for 8 interval between irrigation round and 400 $kg.ha^{-1}$ urea fertilizer and lowest one (23.99 gr) belonged to 16 day interval between irrigation round and 200 $kg.ha^{-1}$ urea fertilizer (Table 5). Biari *et al.* (2008) reported that in case of consumption of chemical and bio-fertilizers the weight of 1000-seed would increase which is consistent with the present results. Sepaskhah and Khajehabdollahi (2005) reported that decrease in corn yield due to water stress in AFI was mainly due to the decrease in the number of kernels per cob and to a lesser extent to the decrease in1000-kernel weight. Babaogli *et al*. (2012) Also suggested that, drought stress raising could led to dehydration stages faced with grain filling period and resulted in less transmission of photosynthetic compounds to the grains, that it decreased 100 grain weight. As the drought stress increases, the amount of photosynthesis, assimilates and transfers to the seed decreases, and causes wrinkling and weight loss seeds. The seed weight is determined during pollination, and the inadequacy of photosynthetic materials for the growth of embryonic cells has a negative effect on the seed weight. Also Drought stress reduced seed yield by reducing the number of seed per ear and 1000-seed weight (Karimi and Naderi, 2007).

Table 3. Mean comparison effect of different level of interval irrigation round on measured traits

Interval irrigation round (day)	Seed yield ($gr.m^{-2}$)	1000-Seed weight (gr)	Fresh forage yield ($gr.m^{-2}$)	Total dry weight ($gr.m^{-2}$)	Harvest index (%)
8	671a	30.10a	11203a	2767a	24.25a
12	581ab	29.69a	10733ab	2619b	22.18a
16	530b	25.32b	10403b	2287c	23.17a

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

4.3. Fresh forage yield

Result of analysis of variance revealed effect of irrigation regime, urea fertilizer and interaction effect of treatments on fresh forage yield was significant at 5% probability level (Table 2). According result of mean comparison maximum of fresh forage yield (11203 $gr.m^{-2}$) was obtained for 8 day interval between irrigation round and minimum of that (10403 gr.m^{-2}) was for 16 day treatment (Table 3). Evaluation mean comparison result indicated in different level of urea fertilizer the maximum fresh forage yield (11463 gr.m^{-2}) was noted for 400 kg.ha^{-1} and minimum of that (10441 gr.m^{-2}) belonged to 200 kg.ha^{-1} treatment (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum fresh forage yield (11829 gr.m^{-2}) was noted for 8 day interval between irrigation round and 400 kg.ha^{-1} urea fertilizer and lowest one (9893 gr.m^{-2}) belonged to 16 day interval between irrigation round and 200 kg.ha^{-1} urea fertilizer (Table 5). 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. Moghimi and Emam (2015) in order to evaluate the impact of different amounts of nitrogen fertilizer on yield of sorghum cultivars reported Pegah cultivar and application of 205 kg N ha^{-1} might be offered for producers (in similar climate). Nitrogen is an important nutrient for optimum crop growth and yield performance. Although its effect on the growth and yield of sweet 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).

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

Urea fertilizer(kg.ha^{-1})	**Seed yield (gr.m^{-2})**	**1000-Seed weight (gr)**	**Fresh forage yield (gr.m^{-2})**	**Total dry weight (gr.m^{-2})**	**Harvest index (%)**
200	514b	26.74b	10441b	2406b	21.36a
300	562ab	26.91b	10462b	2414b	23.28a
400	706a	31.74a	11463a	2853a	24.75a

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

4.4. Total dry weight

According result of analysis of variance effect of irrigation regime and urea fertilizer on total dry weight was significant at 1% probability level but interaction effect of treatments was significant at 5% probability level (Table 2). Assessment mean comparison result indicated in different level of interval between irrigation round the maximum total dry weight (2767 gr.m^{-2}) was noted for 8 day and minimum of that (2287 gr.m^{-2}) belonged to 16 day treatment (Table 3). Compare different level of urea fertilizer showed that the maximum and the minimum amount of total dry weight belonged to 400 kg.ha^{-1} (2853 gr.m^{-2}) and 200 kg.ha^{-1} (2406 gr.m^{-2}) treatments (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum total dry weight (3071 gr.m^{-2}) was noted for 8 interval between irrigation round and 400 kg.ha^{-1} urea fertilizer and lowest one (2123 gr.m^{-2}) belonged to 16 day interval between irrigation round and 200 kg.ha^{-1} urea fertilizer (Table 5). Joorabi *et al*. (2015) reported that nitrogen fertilizer (150 kg.ha^{-1}) could increase qualitative and quantitative traits such as seed yield (9.82 t.ha^{-1}) of sorghum forage in Speed feed variety. Tarang *et al*. (2013) reported applications of Nitroxin biofertilizer and chemical fertilizer (400 kg.ha^{-1} urea with 300 kg.ha^{-1} ammonium phosphate) had a significant effect on traits of root dry weight, number of seed per row (36.5), number of seeds per ear (458.56), 1000-grain weight, seed (13.23 t.ha^{-1}) and biological yield (26.4 t.ha^{-1}) , and the harvest index (53.88%).

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

Interval irrigation round (day)	Urea fertilizer (kg.ha^{-1})	Seed yield (kg.ha^{-1})	1000-Seed weight (gr)	Fresh forage yield (gr.m^{-2})	Total dry weight (gr.m^{-2})	Harvest index (%)
8	200	612ab	27.91b	10974bc	2669bc	22.93a
	300	584ab	29.03b	10807bcd	2561c	22.80a
	400	817a	33.38a	11829a	3071a	26.60a
12	200	482b	28.31b	10454cde	2408cd	20.02a
	300	574ab	27.81b	10429cde	2534c	22.65a
	400	688ab	32.96a	11315ab	2914ab	23.61a
16	200	447c	23.99c	9893e	2123e	20.63a
	300	529ab	23.89bc	10149de	2167de	24.92a
	400	614ab	28.06b	11166abc	2573c	23.68a

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

4.5. Harvest index (*HI*)

Harvest index shows the way of dividing the nutritional materials between growing structures of seed and plant. As one of the components for calculating the HI is grain yield, the changes in HI depend very much on the changes of grain yield. Based on the formula of HI, every factor can change the harvest index when the grain yield is influenced more than total dry weight (Sinclair *et al*., 1990). Result of ANOVA revealed effect of irrigation regime, urea fertilizer and interaction effect of treatments on HI was not significant (Table 2).

5. CONCLUSION

Finally according result of current research application 8 day interval between irrigation round and 400 kg.ha^{-1} urea fertilizer had the highest amount of studied traits and it can be advice to producers in studied region.

ACKNOWLEDGMENT

The authors thank all participants, who took part in the study.

FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.
FUNDING/SUPPORT: This study was done by scientific support of Department of Agronomy, Islamic Azad University, Khuzestan Science and Research Branch.

REFRENCES

Almodares, A., M. Jafarinia. and M. R. Hadi. 2009. The effects of nitrogen fertilizer on chemical compositions in corn and sweet Sorghum. American-Eurasian J. Agric. Environ. Sci. 6(4): 441-446.

Babaogli, F., F. Rahimzadeh Khoeai. and M. Yarnia. 2012. Effect of biological fertilizer on yield and yield components of corn (*Zea mays* L.) CV. S.C. 504 in drought condition. J. Appl. Environ. Biol. Sci. 2(3): 117-122.

Beyaert, R. P. and R. C. Roy. 2005. Influence of nitrogen fertilization on multi-cut forage sorghum, Sudan grass yield and nitrogen use. Agron. J. 97: 1493-1501.

Biari, A., A. Gholami. and H. A. Rahmani. 2008. Growth promotion and enhanced nutrient uptake of maize by application of plant growth promoting rhizobacteria in arid region of Iran. J. Biol. Sci. Biotech. Adv. 19: 135-138.

Cakir, R. 2004. Effect of water stress at different development stages on vegetative and reproductive growth of corn. Field Crops. J. 89: 1-16.

Chimenti, C. A., J. Pearson. and A. J. Hall. 2002. Osmotic adjustment and yield maintenance under drought in sunflower. Field Crop Res. 75: 235-246.

English, M. J. and L. James. 1990. Deficit irrigation. II: Observation on colombia basin. ASCE, J. Irrigation Drain. Eng. 116: 413-426.

Eskandari, H., A. Ghanbari. and A. Javanmard. 2009. Intercropping of cereals and legumes for forage production. Notulae Sci. Biol. 1: 7-13. http://dx.doi.org/10.15835/nsb.1.1.3479.

Gardner, F., R. Pearce. and R. L. Mitchell. 1985. Physiology of crop plants. Iowa State Univ. Press. Ames. USA.

Garg, B. K., S. Kathju. and S. P. Vyas .2005. Salinity-fertility interaction on growth. Photosynthesis and nitrate reductase activity in sesame. Indian J. Plant Physiol. 10: 162-167.

Hasanuzzaman, M., K. U. Ahamed, K. Nahar. and N. Akhter. 2010. Plant growth pattern, tiller dynamics and dry matter accumulation of wetland rice (*Oryza sativa* L.) as influenced by application of different manures. Nature and Sci. J. 8(4): 1-10. *In*: Rosegrant, M. W. and J. A. Roumasset. Economic feasibility of green manure in rice-based cropping systems. Proc. Sym. Sustainable Agriculture. The Role Green Manures Crops in Rice Farming Systems. IRRI. Manila. Philippines. May 25-29. 1987-1988. pp. 11-27.

Jaleel, C. A., P. Manivannan, A. Kishorekumar, B. Sankar, R. Gopi, R. Somasundaram. and R. Panneerselvam . 2007. Alterations in osmoregulation, antioxidant enzymes and indole alkaloid levels in *Catharanthus roseus* exposed to drought. Colloids and Surfaces B: Biointerfaces. 59(2): 150-157.

Joorabi, S., N. Akbari, M. R. Chaichi. and Kh. Azizi. 2015. Effect of sowing date and nitrogen fertilizer on sorghum forage production in a summer inter-cropping system. J. Cercetări Agron. Moldova. 3(163): 63-72.

Karimi, A., M. Noshadi. and M. Ahmadzadeh. 2009. Effects of super absorbent polymer (igeta) on crop, soil water and irrigation interval. J. Sci. Tech. Agri. Nat. Res. 12: 415-420.

Karimi, A. and M. Naderi. 2007. Yield and water use efficiency of forage corn as influenced super absorbent polymer application in soils with different textures. Agric. Res. J. 3: 187- 198. (Abstract in English)**Kirda, C., S. Topcu, H. Kaman, A. C. Ulger, A. Yazici, M. Cetin and M. R. Derici. 2005.** Grain yield response and N-fertilizer recovery of maize under deficit irrigation. J. Field Crops Research. 93: 132–141.

Moghimi, N. and Y. Emam. 2015. Growth and yield responses of two forage sorghum cultivars to different nitrogen fertilizer rates. J. Iran Agri. Res. 34(1) 39-45.

Muchow, R. C. 1998. Nitrogen utilization efficiency in maize and grain sorghum. Field Crops Res. 56: 209-216.

Nawas-Nazanat, G., M. Sawar, T. Yousaf. and A. Nasseb .2005. Yield and yield component of sunflower as affected by various NPK levels. Asian J. Plan Sci. 2(7): 561-562.

Olugbemi, O. 2017. Sweet sorghum and nitrogen fertilizer application: A review. J. Agri. Sci. 2: 28-35.

Rooney, L. W. and J. M. Awika. 2005. Specialty sorghum for healthful food and feed. *In*: Specialty grain for food and feed; Abdel- Aal, E. and P. Wood. Inc. St. Paul. MN. pp. 283-312.

Roy, R. C., A. Sagar, J. E. Tajkia, Md. A. Razzak. and A. K. M. Zakir Hossain. 2018. Effect of salt stress on growth of sorghum germ plasms at vegetative stage. J. Bangladesh Agri. Univ. 16(1): 67-72.

Sadeghzade, A., M. Tajbakhsh. and A. Jalili A. 2012. Effects of foliar application of stimurel, Force 4-L and Dulzee on yield and yield components of sorghum speedfeed. Int. Res. J. Biotech. 3(1): 018-021.

Sepaskhah, A. R. and M. H. Khajehabdollahi. 2005. Alternate furrow irrigation with different irrigation intervals for maize (*Zea mays* L.). Plant Production Science. J. 8(5): 592-600.

Shamme, S. K, C. V. Raghavaiah, T. Balemi. and I. Hamza. 2016. Sorghum growth, productivity, nitrogen removal, N-use efficiencies and economics in relation to genotypes and nitrogen nutrition in Kellem-Wollega zone of Ethiopia, East Africa. Adv. Crop Sci. Tech 4: 218-226.

Sinclair, T., R. D. M. Bennetto. and R. O. Muchow. 1990. Relative sensitivity of grain yield and biomass accumulation to drought in field grown maize. Crop Science. J. 30: 690- 693.

Singh, D. K., A. K. Pandey, U. B. Pandey. and S. R. Bhonde. 2002. Effect of farmyard manure combined with foliar application of NPK mixture and micronutrients on growth, yield and quality of Onion. Newsletter-Natl. Horti. Res. Develop. Found. 21-22: 1-7.

Singh, M., B. A. Krantz. and G. B. Baird. 1972. Agronomic production techniques in sorghum. *In*: G. P. N. Rao. and L. R. House. (Eds.). Sorghum in seventies. Oxford and IBH Publ. Co. New Delhi. India. pp: 302-333.

Tarang, E., M. Ramroudi, M. Galavi, M. Dahmardeh. and F. Mohajeri. 2013. Effects of Nitroxin bio-fertilizer with chemical fertilizer on yield and yield components of grain corn. Intl. J. Agri. Sci. 3(5): 400-405.

Thomas, M., M. J. Robertson , S. Fukai. and M. B. Peoples. 2004. The effect of timing and severity of water deficit on growth, development, yield accumulation and nitrogen fixation of mung bean. Field Crops Res. 86(1): 67-80.

Tolk, J. A., T. A. Howell. and F. R. Miller. 2013. Yield component analysis of seed sorghum grown under water stress. Field Crops Res. 145: 44-51.