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GROWTH AND QUALITY OF FORAGE PEARL MILLET (*PENNISETUM AMERICANUM* L.) AS INFLUENCED BY NITROGEN AND ZINC LEVELS IN HYPER ARID REGION OF RAJASTHAN

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SUMMARY

A field experiment was conducted on sandy loam soils of Agronomy Farm at College of Agriculture, SKRAU, Bikaner during **kharif** season of 2014 to study the effect of nitrogen and zinc on growth, nutrient content and uptake and quality of fodder pearl millet (*Pennisetum americanum* L.), with 20 treatment combinations viz., five nitrogen levels (0, 30, 60, 90 and 120 kg/ha), and four zinc sulphate doses (no zinc, 15, 30 and 45 kg/ha). The experimental results indicated that application of nitrogen @ 90 kg/ha being at par with higher N dose (120 kg/ha) significantly increased all growth characters *viz*., plant height, number of leaves/plant, tillers/plant, leaf : stem ratio and chlorophyll content of leaves. Whereas, number of leaves/ plant increased up to the highest N level of 120 kg/ha during both cutting stages in fodder pearl millet. The quality parameters, namely, crude protein and ether extract increased significantly with increasing nitrogen dose up to 120 kg/ha, but nitrogen fee extract (NFE) and total digestible nutrient (TDN) content in fodder showed reverse trend and recorded the maximum values under control treatment at both the cuttings. Application of zinc sulphate ($ZnSO_4$) up to 30 kg/ha significantly improved growth characters at both the cutting stages. Moreover, the quality parameters also improved with doses of $ZnSO_4$ up to 45 kg/ha.

Key words : Ash, crude protein, crude fiber, ether extract, NFE,TDN, growth, nutrient uptake

Pearl millet (*Pennisetum americanum* L.) as fodder crop has some additional advantages over sorghum and maize because of firstly, the green fodder of pearl millet has high crude protein content and secondly, its green fodder can be safely fed to cattle at all stages of growth because of absence of hydrocyanic acid. It is nutritious and palatable and can be fed as green, dry or as conserved fodder in the form of silage or hay. The more tillers production capacity, rapid growth rate and higher crude protein (CP) contents and short growth period make the pearl millet as strong cereal for fodder purpose. The nutritional quality of livestock feeds stuff is assessed by its dry matter, CP, fat, ash contents and crude fibre (CF) contents. The required concentration of these quality attributes in plant can be achieved with harvesting at optimal time (Cecelia *et al.*, 2007) and optimum plant nutrition factors such as nitrogen rates and other micronutrients especially zinc application (Alloway, 2008).

Nitrogen is an essential nutrient for plant growth and development. Nitrogen is a very important constituent of cellular components. Alkaloids, amides, amino acids, proteins, DNA, RNA, enzymes, vitamins, hormones and many other cellular compounds contain nitrogen as one of the elements. An adequate supply of nitrogen is associated with vigorous vegetative growth and deep green colour. Also nitrogen is an integral part of chlorophyll ($C_{35}H_{72}O_5N_4Mg$) and to improve the yield and quality of forage pearl millet. Judicious and appropriate use of fertilizer not only increases yield but also improves quality of forage especially protein contents (Ayub *et al.*, 2007). Generally, pearl millet has been known for growing under low N management but, several studies showed that N application can increase millet production efficiency (Singh *et al.*, 2010). Further, zinc is an imperative micronutrient. It is needed in small quantity, but plays indispensable role in various plant physiological processes such as photosynthesis, protein and sugar synthesis, fertility and production of seeds, growth regulation and disease immune system. It is the constituent of several enzyme systems which regulate various metabolic reactions in the plant. Singh (2009) reported that 49% soils in India are deficient in available Zn and the application of Zn is reported to increase cereals yield by 6.3-9.3 per cent. Thus, a field experiment " Effect of nitrogen and zinc on growth and quality of fodder pearl millet under hyper arid region of Rajasthan" was planned.

MATERIALS AND METHODS

A field experiment was conducted during **Kharif** season 2014 on sandy loam soil at Agronomy Farm, College of Agriculture SK Rajasthan Agricultural University, Bikaner situated in arid western hyper arid zone of Rajasthan using fodder pearl millet variety AVKB-19. Total 20 treatment combinations comprising five nitrogen levels (0, 30, 60, 90 and 120 kg N/ha), and four zinc levels (0,15, 30, 45 kg $ZnSO_4$/ha) was evaluated in factorial randomized block design with three replications. The experimental soil was saline in reaction having pH 8.4, EC 0.20 dS/m (1 : 2 solution), organic carbon 0.11 per cent, and available N, P, K were 93.85, 21.91 and 234.0 kg/ha, respectively. Mean weekly meteorological data for the period of the experimentation are presented in Fig. 1. Sowing was done manually with kera method on 24 July 2014 at onset of monsoon rain at row spacing of 25 cm using seed rate of 10 kg/ha. During the crop period nitrogen fertilizer was applied in three splits i.e, one-third dose (as per treatment) and full dose of $ZnSO_4$ at sowing. The remaining two-third dose of nitrogen was top dressed in two splits equally i. e. first at 25 DAS and rest dose after about one week of first cutting (50 DAS) with sprinkler irrigation. The crop was harvested for green fodder at 45 DAS (first cut) and at 90 DAS for second cut. Growth characters viz., plant height, leaf : stem ratio and number of leaves/ plant were recorded in each plot from second inner row both sides leaving the boarder row at both cutting stages adopting standard procedures. Chlorophyll content of leaves was worked out at 45 and 90 DAS by the method of Hiscox and Israelstem (1979). The forage nutritive value was analyzed in term of CP, CF, fat, ash, NFE and TDN contents of dry matter using standard method (A.O.A.C, 1990). The sub sample of dry matter was well grind and passed through 0.5 mm sieve and was preserved for chemical analysis. The ash contents were calculated by incineration the well ground samples at 550°C for three hours. For CP, the nitrogen contents of feed sample was determined by Kjeldahl method and the value recorded for nitrogen was then multiplied with 6.25 (Jones, 1931) to determine CP of the sample. The ether extract contents were recorded by using Soxelt Method. Total 417 mm rainfall was received in

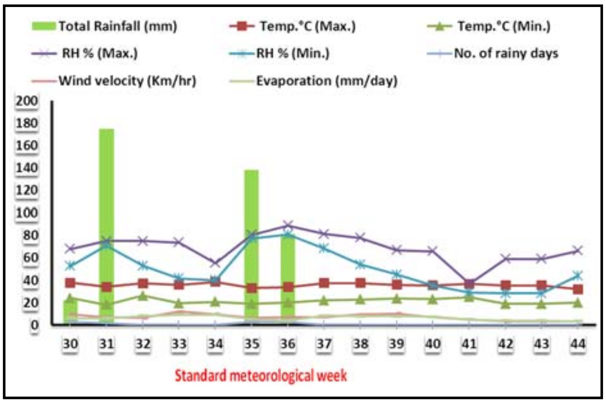

Fig. 1. Mean weekly meteorological data during crop season (**Kharif** 2014).

11 number of rainy days and four irrigations were given by sprinkler system operating three hours spaced at 6.0 m apart continuous nozzle arrangement with depth of 4.0 cm each.

The data were analyzed using standard method of analysis for variance (ANOVA) for factorial randomized block design for field experiment as per Gomez and Gomez (1976).

RESULTS AND DISCUSSION

Nitrogen Levels

Growth : Plant height, number of leaves/plant, number tillers/plant, leaf : stem ratio and chlorophyll content of leaves of fodder pearl millet were significantly influenced with application of increasing doses of nitrogen. The highest plant height (182.39 cm), number of tillers/ plant (4.79), leaf : stem ratio (0.37) and chlorophyll content of leaves (1.49 mg/g) were recorded with maximum nitrogen level of 120 kg/ha being at par to lower level i.e. 90 kg/ha and registered statistically superior to preceding lower N doses at both cutting stages (Table 1). While, number of leaves/plant (14.32) recorded maximum at 120 kg N/ha, showed significantly higher over all lower N levels and control. Nitrogen has essential functions in plant life *viz.*, its role in rapid multiplication of tissues and increase in amount of growth substances such as naturally occurring phytohormones, photosynthesis rate, increase level of auxin supply with higher level of nitrogen might have brought about a significant increase in plant height, and number of tillers per plant, number of leaves per plant, leaf : stem ratio and chlorophyll content of leaves in the present investigation. Gasim (2001) also indicated that increase in plant height with nitrogen fertilizer is due to the fact that nitrogen promotes number of

TABLE 1
Effect of nitrogen and zinc levels on growth of forage pearl millet

Treatment	Plant height (cm)		Tillers/plant		Leaves/plant		Leaf : stem ratio		Chlorophyll content of leaves (mg/g)	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Nitrogen levels (kg/ha)										
N_0	111.84	58.98	3.91	2.29	7.44	4.07	0.21	0.15	1.88	1.76
N_{30}	128.11	73.05	4.25	2.65	9.75	5.08	0.27	0.20	2.14	1.97
N_{60}	143.88	81.36	4.45	2.84	10.95	5.62	0.31	0.23	2.27	2.07
N_{90}	175.41	92.43	4.76	3.08	13.35	6.71	0.35	0.26	2.40	2.20
N_{120}	182.39	97.05	4.79	3.13	14.32	7.26	0.37	0.28	2.48	2.26
S. Em±	2.77	1.86	0.05	0.03	0.21	0.08	0.01	0.01	0.03	0.03
C. D. (P=0.05)	7.94	5.32	0.13	0.10	0.59	0.22	0.03	0.03	0.09	0.10
$ZnSO_4$ levels (kg/ha)										
Zn_0	138.72	77.38	4.34	2.71	10.27	5.16	0.26	0.19	2.08	1.91
Zn_{15}	145.11	78.21	4.36	2.76	10.75	5.37	0.29	0.21	2.19	2.02
Zn_{30}	154.26	82.66	4.47	2.86	11.73	5.80	0.32	0.24	2.31	2.13
Zn_{45}	155.21	84.05	4.56	2.88	11.89	6.67	0.33	0.25	2.36	2.15
S. Em±	2.48	1.66	0.04	0.03	0.18	0.07	0.01	0.01	0.03	0.03
C. D. (P=0.05)	7.10	4.76	0.12	0.09	0.53	0.20	0.03	0.02	0.08	0.09

NS–Not Significant.

internodes and increase length of the internodes which results in progressive increase in plant height. Further, he reported that the increase in leaf to stem ratio with nitrogen application is probably due to the increase in number of leaves and leaf area under nitrogen treatments, producing more and heavy leaves. These results are close conformity with the findings of Singh and Sumeriya (2010), Meena *et al.* (2012), Midha *et al.* (2015) and Sheoran *et al.* (2016) in fodder pearl millet.

Quality : Nitrogen free extract and total digestible nutrient were noted maximum with no nitrogen (0 kg/ha) and deceased significantly at higher N levels (120 kg/ha) in pearl millet. On the contrarily, ether extract, crude fiber and ash content recorded higher with increasing nitrogen levels up to 120 kg/ha which was at par with 90 kg/ha, though statistically proved non-significant at all cutting stages except ether extract at first cut stage which improved significantly with higher N levels (Table-2). Further, increasing N fertilization in fodder pearl millet increased the availability of nitrogen in the rhizosphere and since nitrogen is main constituent of amino acids, it ultimately increased crude protein contents of plants. These results are in cognizance with the findings of Saini (2012) in forage sorgham and Shivran and Pareek (2001)in fodder pearl millet. The higher percentage of crude fat in plant receiving higher dose of nitrogen might be due to more chlorophyll of leaves. The higher amount of chloroplast and other pigments at early age of the plant might have also attributed to higher crude fat content at early stage. Deposition of structural carbohydrates in plant during later stages may also be one of the other reasons. Meena *et al.* (2012) also reported similar findings and are in close conformity with the present study. Nitrogen free extract was recorded maximum in control treatment which was significantly higher over 120, 90 and 60 kg N ha^{-1} but was found at par with 30 kg N/ha at the both cutting stage (Table-2).This might be attributed to the fact that nitrogen application at higher doses had significant positive effect on crude protein content thereby reducing the proportion of carbohydrates. These results collaborate with findings of Saini (2012), Midha *et al.* (2015) and Sheoran *et al.* (2016).

Nitrogen content and uptake : Application of increasing levels of nitrogen up to 120 kg/ha significantly increased the nitrogen content as well as total nitrogen uptake by pearl millet fodder (Table 3). Though, non–significant difference was noted between 60-90 and 90-120 kg/ha. This might be due to the fact that increased availability of nitrogen to plants resulted in vigorous vegetative and root growth leading to improved absorption of other nutrient from soil and hence, more concentration in plant. Moreover, nitrogen fertilization may increase the cation exchange capacity of roots and thus makes more efficient in absorbing other nutrients ions. The results obtained here are in close conformity with findings of Yadav *et al.* (1988) who also found increased Zn content of pearlmillet fodder due to application of nitrogen. Also, improvement in photosynthetic efficiency of plants as evidence from higher dry matter production by ground parts might have supplied adequate metabolites for root growth and its functional activity. Another reason for higher nitrogen content in plant might be due to increased activities of nitrate reductase enzyme (Singh *et al.,* 2014).

TABLE 2
Effect of nitrogen and zinc levels on quality of forage pearlmillet

Treatment	Crude fiber (%)		Exther extract (%)		Ash (%)		Nitrogen free extract (%)		Total digestible nutrient (%)	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Nitrogen levels (kg/ha)										
N_0	27.99	28.75	2.06	1.99	10.79	10.12	52.56	53.02	60.26	60.63
N_{30}	28.13	28.89	2.13	2.03	11.00	10.32	50.86	51.41	60.07	60.42
N_{60}	29.18	29.97	2.16	2.10	11.42	10.71	48.55	49.11	59.65	60.06
N_{90}	30.33	31.14	2.18	2.11	11.62	10.91	46.80	47.39	59.40	59.80
N_{120}	30.28	31.08	2.20	2.13	11.68	10.95	46.59	47.20	59.37	59.78
S. Em±	0.88	0.90	0.04	0.07	0.35	0.37	0.78	0.81	0.23	0.26
C. D. (P=0.05)	NS	NS	0.10	NS	NS	NS	2.22	2.33	0.66	0.73
$ZnSO_4$ levels (kg/ha)										
Zn_0	28.40	29.17	2.10	2.00	10.90	10.30	50.65	51.15	60.08	60.39
Zn_{15}	29.05	29.83	2.14	2.04	11.10	10.45	49.72	50.22	59.92	60.25
Zn_{30}	29.31	30.10	2.16	2.11	11.40	10.75	48.87	49.33	59.68	60.06
Zn_{45}	29.97	30.77	2.18	2.12	11.80	10.90	47.04	47.80	59.31	59.85
S. Em±	0.79	0.80	0.03	0.07	0.32	0.33	0.69	0.73	0.21	0.23
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	1.99	2.08	0.59	NS

$ZnSO_4$ Levels

Growth : Increasing dose of $ZnSO_4$ from 0 to 45 kg/ha improved plant height, number of tillers/ plant number of leaves/plant leaf: stem ratio, chlorophyll content of leaves at both cutting stages. Zinc sulphate @ 45 kg/ha was founded at par with 30 kg/ha recorded the maximum values of above mentioned growth parameters and showed statistically superiority over 15 kg zinc sulphate/ha dose and control (Table 1). The beneficial effect of zinc in plant was due to increased auxin concentration and its stimulating effect on most of the physiological and metabolic process together with more available nitrogen, augmented the production of photosynthetes and their translocation to different parts including leaves of fodder pearl millet, which increased the chlorophyll content in the leaves. The result of present investigation are in close conformity with finding of Satpal *et al.* (2017).

Quality : Significantly higher crude protein yield was obtained when the crop was fertilized with 45 kg $ZnSO_4$/ha in comparision to control and lower zinc application at the both cutting stage (Table 2). This might be possibly due to fact that zinc also increase the cation exchange capacity of the roots which in turn enhances the absorption of essential element especially nitrogen which was responsible for higher crude protein content in fodder pearl millet. No zinc application significantly recorded the highest nitrogen free extract (NFE) compared to control at the both cutting stage. The TDN content in fodder pearl millet was remained statistically unaffected by zinc application. The protein content and zinc concentration of pearl millet plant improved by increasing zinc fertilizer doses during both cutting stages. Also, protein yield enhanced by increasing zinc sulphate doses from 0 to 45 kg/ha (Table 3). This clearly indicate that increasing zinc level in root zone make plant to ensure more availability of nutrient particularly N and Zn which in turn increased absorption by plant and thereby increasing nutrient status at cellular level. Zinc is required as structural and catalytic components of protein or amino acids. The reason for improvement in fodder quality could be traced backs the role of zinc in plant nutrition. These results confirm the findings with Dhadich and Gupta (2005) and Midha *et al.* (2015).

Zinc content and uptake : Application of Zinc Sulphate up to 30 kg/ha had non -significant effect on Zn content and uptake of pearl millet at the both cutting stage. Further Zinc sulphate by 45 kg/ha significantly improved quality parameters compared to control. Thus the addition $ZnSO_4$ from 0 to 45 kg/ ha at sowing time seems to have enriched Zn status of the soil rhizosphere which led to its higher extraction by plants for their growth and development. This is also well evince from the nutrient analysis wherein, basal application of $ZnSO_4$ tended improvement in not only Zn status but also had synergistic effect on N content of the plant parts (Table 3). Thus greater availability of both these nutrients as per requirement for growth of individual plant parts seems to have increased accumulation of dry matter of these organs. Similar result were also reported in wheat by Jain (2004) and Satpal *et al.* (2017) in sorghum.

TABLE 3
Effect of nitrogen and zinc levels on content and uptake of forage pearlmillet

Treatment	Nitrogen content (%)		Zn content (ppm)		Crude protein (%)		Nitrogen uptake (kg/ha)			Crude protein yield (q/ha)		Zn uptake (g/ha)		
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	Total	1st cut	2nd cut	1st cut	2nd cut	Total
Nitrogen levels (kg/ha)														
N_0	1.06	0.98	31.99	29.75	6.61	6.13	21.27	15.19	36.46	1.33	0.95	68.42	73.83	142.25
N_{30}	1.26	1.18	33.58	31.23	7.88	7.36	30.30	22.72	53.02	1.89	1.42	102.08	86.30	188.38
N_{60}	1.39	1.30	34.34	31.94	8.69	8.11	38.59	30.03	68.62	2.41	1.88	133.91	90.35	224.26
N_{90}	1.45	1.35	34.93	32.49	9.07	8.46	48.05	38.49	86.54	3.00	2.41	169.80	99.98	269.79
N_{120}	1.48	1.38	35.43	32.95	9.25	8.64	49.68	40.76	90.44	3.11	2.55	177.96	104.39	282.36
S. Em±	0.03	0.02	1.03	0.96	0.19	0.12	1.71	1.09	2.15	0.11	0.07	7.48	4.11	8.93
C. D. (P=0.05)	0.07	0.06	2.96	2.75	0.54	0.36	4.89	3.12	6.15	0.31	0.19	21.42	11.75	25.58
$ZnSO_4$ levels (kg/ha)														
Zn_0	1.27	1.18	30.92	28.76	7.95	7.38	29.72	22.86	52.59	1.86	1.43	92.72	75.90	168.61
Zn_{15}	1.28	1.19	33.98	31.61	7.99	7.46	34.22	26.41	60.62	2.14	1.65	117.60	86.84	204.44
Zn_{30}	1.32	1.23	35.26	32.80	8.26	7.71	40.76	32.21	72.97	2.55	2.01	145.56	95.30	240.86
Zn_{45}	1.44	1.35	36.05	33.53	9.01	8.41	45.61	36.27	81.88	2.85	2.27	165.86	105.86	271.72
S. Em±	0.03	0.02	0.92	0.86	0.17	0.11	1.53	0.97	1.93	0.10	0.06	6.69	3.67	7.99
C. D. (P=0.05)	0.08	0.06	2.65	2.46	0.48	0.32	4.37	2.79	5.50	0.27	0.17	19.16	10.51	22.88

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