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RESPONSE OF MULTI-CUT SUMMER FORAGE PEARL MILLET (*PENNISETUM GLAUCUM*) TO VARYING LEVELS OF IRRIGATION AND NITROGEN UNDER SEMI-ARID CONDITION OF NORTH GUJARAT

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SUMMARY

A field experiment was conducted during summer seasons of 2011and 2012 on sandy loam soil at S. D. Agricultural University, Sardarkrushinagar to study the response of multi-cut summer forage pearl millet (*Pennisetum glaucum*) to varying levels of irrigation and nitrogen under semi-arid condition of Gujarat. Twelve treatment combinations comprised four levels of irrigation scheduling (0.6, 0.8, 1.0 and 1.2 IW : CPE) and three levels of nitrogen (100, 150 and 200 kg N/ha). The pooled results showed that irrigation levels at 1.2 IW : CPE ratio showed significant influence on growth attributes viz., plant height, number of tillers and leaf : stem ratio. The irrigation at 1.2 IW : CPE ratio resulted significantly in higher green fodder (1192.34 q/ha) and dry matter yield (288.37 q/ha) over other levels of irrigation. However, maximum water use efficiency (86.07 kg/ha) was recorded with irrigation at 0.8 IW : CPE ratio. The net realization (Rs. 93963/ha) and B : C ratio (3.71) were recorded highest with irrigation at 1.2 IW : CPE ratio. The N levels had significant effects on all the growth parameters like the plant height, number of tillers and leaf : stem ratio. Application of 200 kg N/ha gave significantly higher green forage yield (1145.19 q/ha), dry matter yield (249.74 q/ha), WUE (87.66 kg/ha), net realization (Rs. 83015/ha) and B : C ratio (3.86) over 150 and 100 kg N/ha. Consequently for higher productivity and profibility of multi-cut summer forage pearl millet, it should be grown with irrigation given at 1.2 IW : CPE ratio and fertilized with 200 kg N/ha.

Key words : Dry matter, forage yield, irrigation, nitrogen, pearl millet

Forage pearl millet (*Pennisetum glaucum* (L.) R. BR.) is a good risk cover crop for sustained forage production under irrigated condition. The importance of cultivation of pearl millet is being emphasized due to its profuse tillering habit, multi-cut nature, drought tolerance, resistance to insect-pests and diseases, absence of poisonous prussic acid, good performance even in poor soil, good per day productivity and leafiness. Pearl millet is one of the major summer crops grown for feed and forage in the semi-arid and arid regions with low inputs. It needs relatively less water than other crops and can grow in the regions which are too hot and dry for other crops such as sorghum (Singh and Singh, 1995). However, it readily responds to high fertility and moisture. Also, studies showed that nitrogen (N) application could increase millet production efficiently (Beyaert and Roy, 2005; Maman *et al.,* 2006; Ketterings *et al*., 2007).

Forage pearl millet is an excellent choice for warm season pasture. Multi-cut nature of the crop ensures the forage supply over a long period of time. Balanced cattle feed and nutritious green fodders are pivotal for enhancing the milk production. Forage pearl millet is an important green fodder crop in the areas of light textured soils that can provide 2-3 cuttings to meet the green fodder requirement of milch animals in **kharif** season.The forage pearl millet locally known as "*Rajka Bajri*" in Gujarat state is widely grown as multi-cuting crop system in Gujarat. It is a heavy feeder of total nutrients due to good tillering capacity, rationing and fast growth rate. Its fresh green fodder yield ranges from 500 to 600 q/ha with 3 to 4 cuttings (Purushotham *et al.,* 2001). In view of the high investment costs of developing irrigation facilities and limited availability of irrigation water, it should be used most efficiently. It

has transported to the site of use and applied to the fields efficiently at appropriate timing and in adequate amounts. Irrigation scheduling i. e. the timing and amount of irrigation to crops play significant role in optimizing crop production with a given amount of water and avoiding the adverse effects of either over-irrigation or under-irrigation on soil environment. These objectives are achieved through optimum scheduling of irrigation based on sound scientific principles of soil-water-plant atmosphere relationships. Among the different approaches to schedule irrigation, climatological approaches based on irrigation water (IW)/cumulative pan evaporation (CPE) ratio are found to be the most appropriate as these integrate all the weather parameters giving their natural weightage in a given soil-water plant continuum. Scheduling irrigation, based on the date of the pan evaporation, is likely to increase agricultural production at least by 15-20 per cent (Dastane, 1972). Nitrogen is another production factor being an important constituent of protein and chlorophyll. It imparts dark green colour to plant, promotes vegetative growth and rapid early growth. It improves the quality by increasing the protein content of fodder and governs to considerable degree, the utilization of potassium, phosphorus and other element. Therefore, the present investigation was carried out to find out appropriate schedule of irrigation and optimum dose of nitrogen for summer forage pearl millet under semi-arid condition of north Gujarat.

MATERIALS AND METHODS

Field experiment was conducted at Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar geographically situated at 24^{0}19′ North latitude and 72^{0}19′ East longitude of North Gujarat agro-climatic region, during summer between 2011 and 2012.The soil of the experimental field was loamy sand having field capacity of 7.09 and 7.14 per cent and permanent wilting point 2.40 and 2.42 per cent and soil moisture before sowing was 5.5 and 5.7 per cent, pH 7.75 and 7.73 and electrical conductivity (EC) 0.12 and 0.11 dS/m, respectively during 2011 and 2012. The soil was low in organic carbon (0.17 and 0.22%), available nitrogen (152.8 and 165.3 kg/ha), medium in available P (18.0 and 21.0 kg/ha) and high in available K (216.9 and 220.6 kg/ha). The experiment was laid out in split-plot design with three replications, keeping four levels of irrigation (0.6, 0.8, 1.0 and 1.2 irrigation water (IW) cumulative pan evaporation (CPE) ratio in main plot and three levels of nitrogen (100, 150 and 200 kg N/ha) in sub-plots. The crop was fertilized as per respective treatments i. e. 100, 150 and 200 kg N/ha in the form of urea, common application of phosphorus was given @ 50 kg P_2O_5/ha as a basal dose for all the treatments. The full dose of phosphorus (SSP) and one-fourth of nitrogen in the form of urea were applied as basal dose at the time of land preparation and remaining 75 per cent quantity of nitrogen was applied as 25 per cent after first cutting, 25 per cent after second cutting and 25 per cent after third cutting as per treatment.The seeds of forage pearl millet (GFB 1) variety were drilled manually in previously opened furrows at a distance of 30 cm between the rows with the seed rate of 12 kg/ha. The irrigation treatments were imposed after establishment of crop and common irrigation was given immediately after sowing. The cumulative pan evaporation values were calculated from daily pan evaporation measured with the help of USWB class 'A' open pan evaporimetre installed at meteorological observatory, which was in the proximity of the experimental plot.The quantity of irrigation water applied in surface flooding was measured by 7.5 cm head parshall flume. A fixed depth of 50 mm irrigation water was applied to each treatment based on IW : CPE ratio of 0.60, 0.80, 1.00 and 1.20. Four cuts were taken for green forage. The first cut was taken at 45-50 DAS, while the second cut at 30 days after first cut, third cut at 30 days after second cut and fourth cut at 30 days after third cut. The growth attributing parameters were recorded at the time of harvesting under each treatment. Ten plants were selected randomly from each treatment and recorded the observation on growth parameters. Fresh weight of green forage was recorded at each cut and the dry matter was worked out. The plant samples were first air-dried and then heated in oven at 75°C to constant weight at atmospheric pressure. The loss of weight is considered as moisture and the residue as dry matter. Water use efficiency was calculated by using formula as suggested by Michael (1978). The economics were calculated on the basis of prevailing market prices of green forage and dry forage. The statistical analysis of data, fitting of non-linear quadratic model and plotting of graphs were done using SAS 9.3 (SAS Institute Inc. 2012, Cary, NC, USA).

RESULTS AND DISCUSSION

Effect of Irrigation Levels

The results of 2011, 2012 and its pooled showed

that the increase in levels of irrigation had significant influence on growth parameters like plant height, number of tillers, leaf stem ratio and fodder yields of multi-cut forage pearl millet as compared to other levels of irrigation (Tables 1 and 2). On the basis of pooled data, irrigation scheduled at 1.2 IW : CPE ratio gave significantly higher plant height (160.02 cm), number of tillers (71.24) and leaf : stem ratio (1.78), green forage yield (1192.34 q/ha), dry matter yield (288.37 q/ha) and per day productivity (9.23 q/ha) over the other levels of irrigation. However, maximum WUE (86.07 kg/ha) was realized under 0.8 IW : CPE ratio of irrigation. Green forage and dry matter yield was increased significantly with increase in level of irrigation up to 1.2 IW : CPE ratio showing an increase of 75.45 and 121.55 per cent, respectively, over the irrigation at 0.6 IW : CPE ratio. Moreover, maintenance of adequate available soil moisture in root zone would be conducive for proper uptake as well as utilization of nutrients, this had a variable impact on growth components and yield attributes for better yield. The increase in green forage yield with increased level of irrigation was observed by Purushotham *et al.* (2001), Gangaiah (2005), Chaurasia *et al.* (2006), and Tiwana *et al*. (2012).

Effect of Nitrogen Levels

The N application significantly influenced growth parameters and yields of multi-cut forage pearl millet during both the years as well as in pooled data (Tables 1 and 2). The maximum plant height (150.22 cm), number of tillers (69.43), leaf : stem ratio (1.71), green forage yield (1045.19 q/ha), dry matter yield (249.74 q/ha), WUE (87.66 kg/ha) and per day productivity (9.49 q/ha) were recorded highest under application of 200 kg N/ha compared to other levels of N (100 and 150 kg/ha). Nitrogen applied at 200 kg N/ha increased the green forage and dry matter yield to the tune of 15.64 and 34.08 per cent, respectively, over the 100 kg N/ha. The remarkable increase in yields with higher levels of nitrogen might be attributed to favourable effect on yield attributes viz., plant height, number of tillers per metre row and leaf : stem ratio. The increase in leafy part due to nitrogen application might have ultimately resulted in higher photosynthetic activities and also in production of more photosynthates. This readily supplied food growing parts might have helped in improvement of growth and yield attributes. As a result of which, nitrogen yielded better response on forage

TABLE 1

Effect of irrigation and nitrogen levels on growth attributes of summer multi-cut forage pearl millet (Average of four cuts)

Treatment	Plant height (cm)			No. of tillers			Leaf : stem ratio		
	2011	2012	Pooled	2011	2012	Pooled	2011	2012	Pooled
Irrigation (IW : CPE ratio) (I)									
I_1–0.6	127.69	129.99	1 28.75	57.24	58.99	58.12	1.48	1.50	1.49
I_2–0.8	137.46	139.10	138.28	59.00	61.00	60.00	1.51	1.54	1.53
I_3–1.0	147.03	149.29	148.16	64.83	66.34	65.59	1.62	1.64	1.63
I_4–1.2	159.14	160.91	160.02	70.16	72.33	71.24	1.77	1.79	1.78
S. Em±	3.456	3.108	2.324	1.534	1.390	1.035	0.020	0.035	0.020
C. D. (P=0.05)	11.06	9.94	6.90	4.91	4.45	3.07	0.07	0.11	0.06
C. V. (%)	8.38	7.54	7.92	8.46	7.66	7.95	4.44	7.55	6.15
Nitrogen (kg/ha)									
100	136.78	138.61	136.70	57.81	59.37	58.59	1.49	1.52	1.51
150	142.38	144.60	143.50	62.25	64.12	63.19	1.59	1.61	1.60
200	149.18	151.25	150.22	68.36	70.50	69.43	1.69	1.72	1.71
S. Em±	4.118	4.010	2.874	1.810	1.798	1.276	0.039	0.045	0.030
C. D. (P=0.05)	12.02	11.70	8.17	5.28	5.25	3.63	0.11	0.13	0.08
Interaction									
I × N	NS	NS	NS	NS	NS	NS	NS	NS	NS
C. V. (%)	11.37	11.07	11.31	11.20	11.12	11.32	9.50	11.09	10.40

NS–Not Significant.

TABLE 2
Effect of irrigation and nitrogen levels on yield of summer multi-cut forage pearl millet (Average of four cuts)

Treatment	Green fodder yield (q/ha)			Dry matter yield (q/ha)		
	2011	2012	Pooled	2011	2012	Pooled
Irrigation (IW : CPE ratio) (I)						
I_1–0.6	664.74	702.25	683.50	122.15	138.16	130.16
I_2–0.8	910.50	938.31	924.41	189.61	206.01	197.82
I_3–1.0	1091.69	1124.73	1108.21	249.18	247.60	248.39
I_4–1.2	1171.86	1212.80	1192.34	280.07	296.67	288.37
C. D. (P=0.05)	62.58	64.99	41.90	13.14	14.27	9.01
Nitrogen (kg/ha)						
100	886.58	921.04	903.80	183.65	188.85	186.26
150	965.02	999.69	982.35	207.52	217.60	212.56
200	1027.50	1062.85	1045.19	239.60	259.89	249.74
C. D. (P=0.05)	79.41	82.15	55.65	17.95	18.94	12.71
Interaction						
I × N	NS	NS	NS	NS	NS	NS

NS–Not Significant.

yield in the present study. DM yield of pearl millet was significantly affected by N levels and irrigation regimes. DM in pearl millet increased with increasing N rates in all cuts across the irrigation treatments. DM increased quadratically with increased N rates (Fig. 1). Increase in DM caused by amount of N was also found by Ayub et al. (2002), Beyaert and Roy (2005) and Ketterings *et al.* (2007). Beyaert and Roy (2005) found a quadratic response in all cuts by applying 50 kg to 250 kg N/ha in sorghum-Sudangrass. Al-Suhaibani (2006) reported that greatest forage yield of sorghum was obtained at 200 kg/ha. These observations are similar to our results. Total

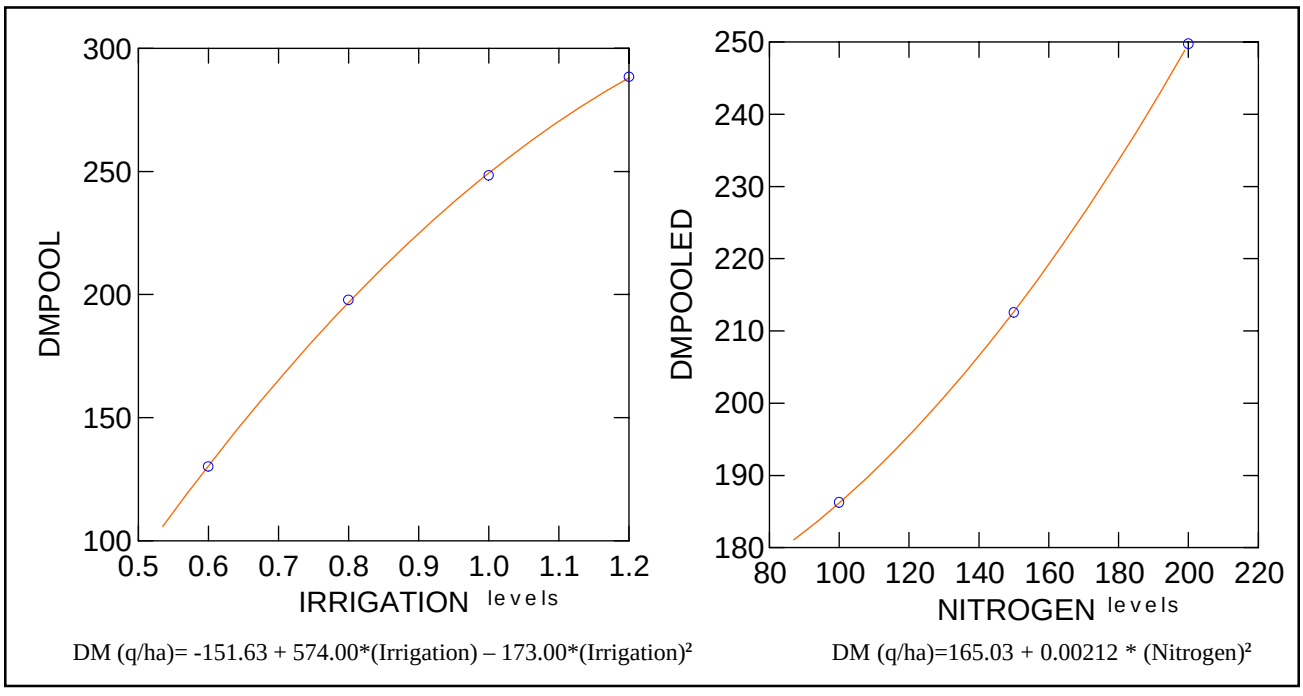

Fig. 1. Relationship of pearl millet dry matter yield (q/ha) with nitrogen fertilizer levels and irrigation levels (fitting of non-linear quadratic equation).

DM, averaged over three cuts, increased with more N application. Beyaert and Roy (2005) found a quadratic response to N rates in sorghum–Sudangrass. However, Maman *et al.* (2006) reported both linear and quadratic responses in above ground yield of pearl millet with N rate. In case of forage pearl millet, linear response to nitrogen was reported by Tiwana and Puri (2005), Chaurasia *et al*. (2006), Joshi and Kumar (2007) and Tiwana *et al*. (2012).

Economics

The data on economics (Table 3) revealed that application of 1.2 IW : CPE ratio recorded the highest net realization (Rs. 93963/ha) and BCR (3.71). This shows that for securing higher returns and benefits, we need to apply irrigation with 1.2 IW : CPE ratio. Among the different nitrogen levels, application of 200 kg N/ha recorded the highest net realization (Rs. 83015/ha) and BCR (3.86) values. This indicates that application of more nitrogen is required for higher net returns from forage production.

TABLE 3

Effect of irrigation and nitrogen levels on per day productivity, WUE and economics of summer multi-cut forage pearl millet (Average of 2011 and 2012)

Treatment	Per day productivity (q/ha)			WUE (kg/ha)			Net realization (Rs./ha)	B : C ratio
	2011	2012	Pooled	2011	2012	Pooled		
Irrigation (IW : CPE ratio) (I)								
I_1–0.6	5.03	5.49	5.26	78.20	87.78	82.99	46280	2.09
I_2–0.8	7.02	7.51	7.27	82.77	89.36	86.07	69371	3.00
I_3–1.0	7.97	8.48	8.23	80.87	86.52	83.70	86751	3.60
I_4–1.2	9.00	9.46	9.23	71.02	78.25	74.64	93963	3.71
C. D. (P=0.05)	0.66	0.52	0.39	5.72	6.26	3.94	-	-
Nitrogen (kg/ha)								
100	5.25	5.73	5.49	72.03	79.03	75.53	70067	3.44
150	7.27	7.74	7.51	78.73	85.98	82.36	77322	3.69
200	9.25	9.73	9.49	83.90	91.42	87.66	83015	3.86
C. D. (P=0.05)	0.63	0.66	0.44	6.24	6.82	4.50	-	-
Interaction								
I × N	NS	NS	NS	NS	NS	NS	-	-

WUE–Water use efficiency. NS–Not Significant.
Selling price of green forage–Re. 1.0/kg.

CONCLUSION

In the light of the results obtained from this investigation, it is concluded that for securing maximum summer forage pearl millet production and for getting higher net monetary realization, summer forage pearl millet crop should be irrigated at 1.2 IW : CPE ratio with application of 200 kg N/ha for taking four cuts in loamy sand soils under semi-arid condition of north Gujarat.

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