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Better Forage and Grain Yield Quality of Pearl Millet *(Pennisetum glaucum* L.*)* under Different Irrigation Water Supplies and Plant Densities

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Abstract: Water shortage is a global problem reducing plant growth and productivity worldwide. Much effort is being made to reduce water consumption by crops and produce 'more crop per drop'. Field experiment included 12 treatments was conducted in split-split plot design at Agriculture Research Station, College of Food and Agriculture Sciences, King Saud University, to evaluate the effect of some agronomic practices viz., three irrigation water intervals (every 5, 7 and 9 days), two varieties [Indian cv. (exotic) and Gizani (local)] and two plant densities (280 x 10^3 and 400 x 10^3) on increasing yield and quality of Pearl millet. In both seasons of the study, results showed that a sharp increase in forage yield was achieved with irrigation every 5 days due to the increase in leaf area and leaf area index. Similar trend was also observed in forage quality viz., fat%, digestibility % and soluble carbohydrate contents as well as crude protein percentage. The two varieties were considerably different in most of growth parameter traits and the local variety (Gizani) has surpassed the introduced one. Plant density was also significant on most of growth parameters. Decreased plant density produced the highest leaf area and leaf area index, whereas fresh and dry weights were increased at high plant density. Grain yield and yield component were influenced through the highly responsive yield fraction of grain yield per hectare, grain weight per panicle (g), 1000 grains weight (g) and number of panicles per m^2. High leaf area and leaf area index were obtained with irrigation water supplies every 5 days, while the lowest value were recorded at irrigation water supplies every 9 days.

Key words: Pearl millet · *Pennisetum glaucum* L. · Fodder yield · Forage quality

INTRODUCTION

Pearl millet *Pennisetum glaucum* L. is the fourth most important grain crop next to rice, wheat and sorghum. It is becoming an increasingly important forage crop in many regions of the world [1]. Also, it is a suitable crop for semi-arid areas, due to its high resistance to drought stress [2]. Millet is cultivated for grain as a staple food for million of people and its grains in most likely to be used for animal feed and as forage crop in different countries, especially in areas of limited rainfall, unavailable irrigation, high evapotranspiration and high temperature and also in dry land areas where rainfall is too unreliable to grow maize and/or other crops.

Pearl millet is a potential alternative grain crop for areas of nutrient-poor soil, low rainfall and a short growing season since dwarf hybrids with good yield potential have been developed [3]. It is now being considered as a substitute for corn and sorghum in certain region of the world [4]. Pearl millet is a high protein content which is about 8-60 % higher than feed corn and is also 40 % higher in lysine and in the same time is much lower in tannins than sorghum [5]. Pearl millet is an important food and forage crop in Africa and Asia and as an important forage crop in Americas. It has great potential to the extreme limits of agriculture because of its high yield potential and resistance to biotic and abiotic stresses. Adoption rates of new cultivars/varieties and improved the selected cultivars are one important task to develop high yielding pearl millet genotypes that maintain a stable yield across the drought stressed environments, especially in desert areas where pearl millet is the principal grain crop for human consumption and an indispensable fodder plant for livestock production [6]. Yield stability of a variety is influenced partly by its genetic structure, whereas the most effective factor is the interaction occurs between the genotype and the environment (G x E), according to quantitative genetics theory [7].

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Plant density is one of the most important factors affecting plant productivity [8]. The optimum plant density varies depending on genotypes or environmental factors such soil fertility, moisture supply and planting date. Berenguer and Faci [9] reported that an increase in plant density can reduce water availability to the individual plant and lead to water deficiency, followed by yield decrease. Generally, previous results worthy cleared that yield per single plant decreases as the plant density per unit area increase. Also plant density can affect plant morphology and dry matter content [10, 11]. Almass *et al.* [4] found that pearl millet grain yield at 0.4 m row spacing was greater than at 0.9 m spacing due to increases in number of plant per unit area not increases in yield per plant. Ali [12] showed that sowing pearl millet at the medium plant density (250 thousand plant/ha) gave the highest values of most studied traits. Numerous experiments showed that plant density and planting pattern differently affected yield and morphological traits [13-17]. Caraveta *et al.* [18] declared that the reduction of sorghum tillering with the increase in plant density was caused by the reduction of light penetrance into the canopy. Duncan [19] showed that forage dry weight increased with the increasing of plant density. Bullock *et al.* [20] found that the dry weight of plant in the arrangement of square cultivation was greater than that in the arrangement of rectangular cultivation.

Under Saudi Arabia condition, traditionally water is an indispensable component for crop production especially in fodder crops where the maximum vegetative growth is desired within a short period of time. Therefore, the objective of the present study was to study the effects of varietal differences and plant density on forage yield and quality traits of pearl millet under different moisture soil conditions.

MATERIALS AND METHODS

The present experiments were laid out in split-split plot design with 4 replications, included three factors viz., irrigation intervals every 5, 7 and 9 days which were arranged in main plots, whereas pearl millet varieties [local variety (Gizani) and introduced one (Indian)] occupied in the subplots and two plant densities 10 cm and 15 cm between hills were assigned to the sub-sub plots. Prior to the field experiment, soil sample from 0-30 cm depth from eight sites was taken for physical and chemical analyses by the methods described by Cottenie *et al.* [21] and But [22]. Results are presented in Tables 1 and 2. During soil preparation 150 kg/ha phosphate fertilizer in the form of super phosphate (15.5% P_2O_5) and 50 kg/ha potassium fertilizer in the form of potassium sulphate (48 % K_2O) were applied. Nitrogen fertilizer at the rate of (150 Kg N/ha.) was applied as nitrogen sulphate (20.6 % N) in two split equal doses (at sowing and after the first cut). All cultural practices were followed as recommended. Sowing was done on 10 and 8 of April in the first and second seasons, respectively. Seeds were sown by hand drilled in hills 10 cm and 15 cm apart (one side) on the upper third of the ridges. Each subplot units consisted of 6 ridges (3.5 meters in length and 50 cm in width). Total plot area was 10.5 m^2. Seeding rate was 35 kg/ha. Two weeks after sowing, the plants were thinned and 2 plants per hill were left till harvest. During growing season, two representative cuts after 45 days from complete emergence followed by a second cut 60 days later were taken. Sample from one square meter for each sub-sub plot was taken to determine leaf area per plant into the main axis and fresh forage yield (ton/ha) was calculated, sub sample was dried in an oven at 70°C to constant weight and dry yield (ton/ha) was calculated.

Table 1: Chemical properties of the irrigation water during the two growing seasons

Chemical properties	First season	Second season
pH	7.10	7.17
EC(dS/m)	1.45	1.73
O.M %	0.02	0.02
Soluble cations (meq/l)		
Ca+	6.30	5.50
Mg+	1.75	1.87
Na+	7.35	7.65
K+	0.44	0.46
Soluble anions (meq/l)		
HCO_3^-	2.40	2.60
Cl^-	4.85	4.80
SO_4^{--}	9.14	8.56
Total N ppm	10.50	11.01
Total P ppm	9.23	9.42
Total K ppm	17.00	17.12

Table 2: Physical and chemical properties of the experimental soil site during the two growing seasons

Properties	First season	Second season
Saturation percentage (%)	29.70	28.12
pH (soil paste 1:5)	7.86	7.81
EC (dS/m)	3.88	3.91
Organic matter (%)	0.46	0.47
$CaCO_3$ (%)	29.42	29.63
Field capacity (%)	16.30	16.42
Wilting point (%)	7.67	7.71
Sand (%)	57.92	57.82
Silt(%)	27.20	27.25
Clay (%)	14.88	14.90
Soil texture (%)	Sandy loam	Sandy loam
Available macro. and micro nutrients (ppm)		
N	35.40	35.80
P	14.80	12.76
K	243.50	251.42
Fe	3.27	3.24
Mn	2.44	2.61
Zn	6.07	6.13
Cu	0.70	0.74

Two inner ridges were left till harvest for determining grain yield and yield component characters. Samples of whole plant at each cut were taken at random and prepared for chemical analysis (washed with 0.001 M hydrochloric acid followed by redistilled water to remove contamination, then dried and grounded in stainless steel mill through 0.5 mm). The powdered samples were ashed according to the method of Chapman and Pratt [23]. Content of Fe, Zn and Mn in the first and second cuts were determined using a Zeiss PMO atomic absorption spectrophotometer. Forage quality was also determined viz., crude protein percentage by determining total nitrogen by using the modified micro-kjeldahl methods as followed by Peach and Tracey [24]. Crude protein percentage was calculated by multiplying the N percent by 6.25. Crude fiber and total ash were determined by using the methods described in A.O.A.C. [25]. Forage quality parameters viz., fat %, digestibility % and soluble carbohydrate content were also determined. Grain yield of two inner ridges was determined and grain yield per hectare was calculated. Yield component characters viz., grain weight per panicle (g), 1000 grains weight (g) and number of panicles per m^2.

Statistical Analysis: Data obtained during the growth period and at harvest were subjected to proper statistical analysis of variance according to the methods suggested by Gomez and Gomez [26] and wherever the treatment differences were found significant (F test), critical differences will be compared by the Least Significant Differences Test at (0.05) level of significance.

RESULTS AND DISCUSSION

Growth and Forage Yield Traits: Responses of pearl millet growth to irrigation water intervals, varietal differences and plant density as well as their interactions are shown in Table 3. Generally, leaf area and leaf area index (LAI) were most responsive to all factors studied herein and their interactions. Both parameters were significantly affected by irrigation intervals. High leaf area and leaf area index were obtained with irrigation water supplies every 5 days, whereas the lowest value of both parameters were recorded at irrigation water supplies every 9 days. Irrigation water supplies every 5 days contributed 24.71 % and 46.42 % of leaf area and leaf area index, respectively as compared to irrigation ever 9 days. This is turn favorably influenced above-ground biomass. Thus, total fresh and dry weights of the above underground biomass per hectare for the three irrigation intervals, followed a similar trend of the leaf area and leaf area index. The sharp increase in forage yield achieved with irrigation every 5 days compared to the other two irrigation treatments. Such increment may be due to high soil moisture content which reflected the solubility and availability of soil nutrients, which in turn increased nutrients absorption and thereby resulted in higher growth rate from early stage in terms of leaf area, leaf area index and fresh and dry forage yield. Similar finding was reported by Ben-Ghedalia *et al.* [27] when they confirmed that pearl millet grown under a wide range of conditions and their high resistance to drought makes it a classical crop of semi-arid areas.

Table 3: Fresh and dry forage yield (ton /ha) as well as either leaf area or leaf area index of pearl millet as affected by water irrigation intervals, varieties and plant densities as well as their interactions (combined analyses of two years)

Treatments					Fresh forage yield			Dry forage yield		
Water irrigation	Varieties	Plant densities	Leaf area / plant, cm^2	LAI	1st cut	2nd cut	Total	1st cut	2nd cut	Total
Irrigation every 5 days	Gizani	15 cm 280x10^3)	898	1.79	46.67	39.85	86.52	34.49	29.33	63.82
		10 cm (400x10^3)	674	0.99	66.67	48.45	115.12	48.82	35.18	84.00
	Indian	15 cm (280x10^3)	678	1.36	40.00	36.88	76.88	28.97	27.23	56.20
		10 cm (400x10^3)	590	0.79	52.00	44.45	96.45	37.46	33.34	70.80
General mean of irrigation every 5 days			710	1.23	51.34	42.40	93.74	37.08	31.20	68.28
Irrigation every 7 days	Gizani	15 cm (280x10^3)	770	1.54	40.82	36.95	77.77	30.02	27.20	57.22
		10 cm (400x10^3)	655	0.87	45.87	38.17	84.04	34.78	25.42	60.20
	Indian	15 cm (280x10^3)	629	1.26	39.57	35.54	75.11	27.92	26.66	54.58
		10 cm (400x10^3)	567	0.77	44.89	37.28	82.17	33.17	27.47	60.64
General mean of irrigation every 7 days			655.25	1.11	42.79	36.99	79.77	31.47	26.69	58.16
Irrigation every 9 days	Gizani	15 cm (280x10^3)	672	0.90	39.56	34.80	74.36	28.79	25.64	54.43
		10 cm (400x10^3)	603	0.80	44.43	34.63	79.06	32.83	25.49	58.32
	Indian	15 cm (280x10^3)	511	0.98	34.66	31.96	66.62	26.00	23.97	49.97
		10 cm (400x10^3)	491	0.68	36.32	31.05	67.37	26.76	23.29	50.05
General mean of irrigation every 9 days			569.25	0.84	38.74	33.11	71.86	28.60	24.60	53.19
LSD for: Irrigation intervals (A)			50.42	0.22	3.54	3.13	6.66	2.20	3.17	3.32
Varieties (B)			44.46	0.12	4.62	1.77	5.46	3.77	0.95	4.24
Plant density ©			67.53	0.34	5.76	2.12	4.42	4.26	1.43	1.98
Ax B			22.41	0.47	3.44	1.98	7.82	3.43	2.10	4.82
B x C			31.54	0.62	2.27	2.25	5.44	2.35	1.18	1.58
AxC			22.14	0.14	2.20	1.87	4.22	3.24	2.24	1.97
AxBxC			18.24	0.27	3.23	2.22	6.74	2.15	1.95	1.54

Table 4: Fresh and dry forage yield (ton /ha) and leaf area of pearl millet as affected by varieties and plant densities (combined analyses of two years)

				Fresh forage yield			Dry forage yield		
Treatments		Leaf area /plant, cm^2	LAI	1st cut	2nd cut	Total	1st cut	2nd cut	Total
General mean of varieties	Gizani	712.33	1.15	47.34	38.81	86.15	34.96	28.05	63.01
	Indian	577.67	0.98	41.24	36.20	77.44	30.15	27.00	57.15
General mean of plant densities	15 cm (280x10^3)	689.67	1.31	40.21	36.00	76.21	29.37	26.67	56.04
	10 cm (400x10^3)	600.00	0.85	48.36	39.01	87.37	35.64	28.37	66.80
LSD for:									
Varieties (B)		44.46	0.12	4.62	1.77	5.46	3.77	0.95	4.24
Plant density (C)		67.53	0.34	5.76	2.12	4.42	4.26	1.43	1.98

Results presented in Table 4 also showed that the two varieties were considerably different in most of growth parameter traits viz., leaf area and leaf area index (LAI); fresh and dry forage yield traits. Local variety Gizani surpassed the introduced one Indian. Such effect may be due to the genetic variability between the two varieties. Gizani had favorable gene action against stress condition. The significance of genetic variability among genotypes for different crops was also reported by Perkins and Jinks [28], Mano and Takeda [29] and Dudley and Moll [30].

Regarding, the responses of the pearl millet to plant density are shown in Table 4. Results indicated that decreased plant density produced the highest leaf area and leaf area index. The decrement in both traits at high plant density may be due to the competition between plants on light, water and nutrients which led to lower accumulation. In contrast, fresh and dry weights were increased at high plant density, due to the increases in number of plant per unit area. These findings are in a good line with those obtained by Almass *et al.* [4] and Ali [12]. The interactions between water irrigation supply treatments, varietal differences and plant densities had significant influences on growth and forage yield traits; more or less values were obtained as factors changes (Table 3).

Table 5: Grain yield and yield component characters of pearl millet as affected by varieties and plant densities (combined analyses of two years)

Treatments		1000 grains weight (g)	No. of panicles/m^2	Grain weight per panicle (g)	Grain yield (kg/ha)	Protein content (%)
General mean of varieties:	Gizani	8.27	79.37	15.62	1605.33	10.19
	Indian	7.78	77.45	15.92	1547.83	9.83
General mean of plant densities	15cm	9.86	74.42	17.05	1429.00	10.18
	10cm	7.38	82.40	14.48	1724.20	9.83
LSD for:						
Varieties (B)		n.s	1.33	n.s	19.57	0.24
Plant density ©		1.24	3.57	2.10	98.64	0.16

Table 6: Grain yield and yield component characters of pearl millet as affected by water irrigation

Treatments --- Water irrigation	Varieties	Plant densities	1000 grain weight (g)	No. of panicles/ m^2	Grain weight per panicles, (g)	Grain yield (kg/ha)	Grain protein content (%)
Irrigation every 5 days	Gizani	15 cm (280x10^3)	10.8	84.2	14.3	1801	10.8
		10 cm (400x10^3)	9.6	77.0	17.9	2098	10.2
	Indian	15 cm (280x10^3)	9.6	89.5	14.5	1469	10.4
		10 cm (400x10^3)	6.9	74.6	18.8	1442	10.0
General mean of irrigation every 5 days			9.23	81.33	16.38	1703	10.35
Irrigation every 7 days	Gizani	15 cm (280x10^3)	8.4	82.7	15.2	1487	10.29
		10 cm (400x10^3)	7.0	77.5	16.9	1602	9.98
	Indian	15 cm. (280x10^3)	9.0	83.9	16.3	1569	9.59
		10 cm (400x10^3)	7.8	72.8	17.5	1724	9.24
General mean of irrigation every 7 days			8.05	79.23	16.48	1596	9.78
Irrigation every 9 days	Gizani	15 cm. (280x10^3)	7.2	81.4	13.6	1388	10.0
		10 cm. (400x10^3)	6.6	73.4	15.8	1567	9.83
	Indian	15 cm. (280x10^3)	7.0	78.7	13.0	1219	9.96
		10 cm. (400x10^3)	6.4	71.2	15.4	1553	9.75
General mean of irrigation every 9 days			6.80	76.18	14.45	1432	9.89
LSD for:							
Irrigation intervals (A)			0.49	1.90	1.38	95.23	0.28
AxB			n.s	1.45	n.s	42.62	0.14
BxC			n.s	0.84	n.s	22.14	0.11
AxC			1.12	1.57	0.82	16.72	0.27
AxBxC			0.57	0.44	0.56	18.99	0.34

intervals, varieties and plant densities as well as their interactions (combined analyses of two years)

Grain Yield, Yield Component Characters and Yield Quality: Data manifested in Tables 5 and 6 showed that grain yield per hectare and yield component characters as well as grain quality estimated as protein content significantly affected by water irrigation supplies. Water irrigation supply every 5 days recorded the maximum values of 9.23, 81.33, 16.38, 1703 and 10.35 for 1000 grains weight, number of panicles /m^2, grain weight per panicle, final grain yield (kg/ha) and protein content (%), respectively. The increment in grain yield was 14.65 and 35.73% as compared to irrigation every 7 and 9 days, respectively. The superiority of such trait may be due to the exist of soil moisture content which led to favorable nutritional environment in root zone which led to higher uptake of soluble nutrients and this might have increased the rate of photosynthates translocation from stems and leaves to the sink. The present results are in agreement with those obtained by Zerbini and Thomas [1], Tabosa *et al.* [2] and Maiti and Bidinger [3]. Data presented in Table 5 showed that a significant differences between the two genotypes in grain yield per hectare, yield component characters and protein content. The highest values of all these traits were beside the local cultivar variety (Gizani) as compared to the introduced one (Indian). Such effect was true in both seasons and followed a similar trend of leaf area and leaf area index, fresh and dry matter yield. Furthermore, local variety was more adapted to the environment of the present study.

Concerning the effect of plant density, data presented in Table 5 indicated that increasing the distance between hills to 15 cm increased seed index (1000 grains weight in g) from 7.38 to 9.86 g, whereas number of panicles per square meter 74.42 at the same distance between hills was decreased as compared to 10 cm between hills 82.40. This is may be due, in the case of increasing seed index, to the lowest competition between plants on growth factors such as light, nutrients and water under low plant density which led to increase plant metabolites and in turn reflected on translocation of photosynthates from stem and leaves to sink, whereas increasing number of panicles per square meter promoted higher number of plant. As shown in the same Table, although, the superiority of sowing pearl millet at 15 cm between hills in most of yield component characters as compared to sowing at 10 cm between hills could not compensate the decrease in grain yield per hectare due to the decreasing in number of panicles per square meter. Similar results were recorded by Almass *et al.* [4] and Ali [12]. The same trend was also observed in protein percentage, sowing millet at 15 cm between hills recorded higher value of protein percentage 10.18 % as compared to sowing millet at 10 cm between hills 9.83%. The increment in protein content might be due to higher utilization of environmental factors by the crop along with the less competition between plants at wide distances between hills. The interactions between the three factors under the present study had a significant influence on most of yield and yield component characters. The maximum values of these traits were registered from sowing local variety (Gizani) at 10 cm between hills and applied water irrigation every 5 days 2098 kg/ha, followed by sowing the same cultivar at 15 cm between hills 1801 and given the same water irrigation treatment.

Micro-Nutrients Content: Data presented in Table 7 showed that micro-nutrients content viz., Fe, Zn and Mn were increased in the first cut as compared to the second cut. Furthermore, data also in Table 7 cleared that, excise soil moisture content at irrigation every 5 days increased the uptake of micronutrients, this is true in both cuts and might be due to higher availability of these micronutrient in root zone and this resulting higher absorption, better translocation and accumulation in plant tissues. Contrary, extending irrigation interval more than 5 days decreased micronutrient content due to less soil moisture content.

Table 7: Micro-nutrients content (ppm), in dry matter of pearl millet in the first and second cuts as affected by water irrigation intervals, varieties and plant densities as well as their interactions (Means of two years)

Treatments			First cut			Second cut		
Water irrigation	Varieties	Plant densities	Fe	Zn	Mn	Fe	Zn	Mn
Irrigation every 5 days	Gizani	15 cm (280x10^3)	192	66	25	178	49	21
		10 cm (400x10^3)	148	76	23	111	45	20
	Indian	15 cm (280x10^3)	135	52	21	107	50	20
		10 cm (400x10^3)	113	92	29	87	66	21
General mean of irrigation every 5 days	147	71.5	24.5	120.75	52.50	20.5		
Irrigation every 7 days	Gizani	15 cm (280x10^3)	163	81	20	134	68	18
		10 cm (400x10^3)	132	64	25	122	52	17
	Indian	15 cm (280x10^3)	112	47	21	98	42	20
		10 cm (400x10^3)	107	52	21	93	47	22
General mean of irrigation every 7 days	128.5	61.0	21.75	111.75	52.25	19.25		
Irrigation every 9 days	Gizani	15 cm (280x10^3)	117	64	20	112	48	22
		10 cm (400x10^3)	97	43	28	99	50	21
	Indian	15 cm (280x10^3)	99	52	22	87	56	23
		10 cm (400x10^3)	89	66	24	85	46	21
General mean of irrigation every 9 days	100.5	56.3	23.5	95.75	50.00	21.75		
General mean of varieties:	Gizani	141.5	65.67	23.5	126.00	52.00	19.83	
	Indian	109.17	60.17	23.0	92.83	51.17	21.17	
General mean of plant densities	15cm	136.33	60.33	21.5	119.33	52.17	20.67	
	10cm	114.33	65.50	25.0	99.50	51.00	20.33	

Table 8: Forage quality parameters of pearl millet as affected by water irrigation intervals, varieties and plant densities as well as their interactions (Means of two years)

Treatments							Digestibility %	
Water irrigation	Varieties	Plant densities	Fiber %	Ash %	Fat %	Soluble carbohydrate	1st cur	2nd cut
Irrigation every 5 days	Gizani	15 cm (280x10^3)	29.9	9.2	1.9	50.65	57.8	49.9
		10 cm (400x10^3)	29.1	9.5	1.8	50.30	57.9	49.8
	Indian	15 cm (280x10^3)	29.8	9.4	1.9	50.15	56.9	49.1
		10 cm (400x10^3)	29.0	9.2	1.8	49.80	57.8	49.6
General mean of irrigation every 5 days			29.45	9.3	1.85	50.21	57.60	49.60
Irrigation every 7 days	Gizani	15 cm (280x10^3)	30.9	10.8	1.9	51.40	57.8	49.6
		10 cm (400x10^3)	29.8	9.2	1.9	50.40	60.5	58.9
	Indian	15 cm (280x10^3)	30.4	9.8	1.8	49.80	60.1	57.6
		10 cm (400x10^3)	29.4	9.4	1.7	49.60	60.7	55.9
General mean of irrigation every 7 days			30.13	9.8	1.83	5030	59.78	55.5
Irrigation every 9 days	Gizani	15 cm (280x10^3)	31.7	10.9	1.9	47.50	63.4	57.6
		10 cm (400x10^3)	31.6	10.8	1.9	48.90	62.7	58.8
	Indian	15 cm (280x10^3)	31.1	10.7	1.7	49.92	62.4	55.8
		10 cm (400x10^3)	30.9	10.8	1.9	51.40	61.5	52.7
General mean of irrigation every 9 days			31.33	10.8	1.8	49.43	62.50	56.2
General mean of varieties:	Gizani		30.50	10.07	1.88	49.86	59.90	54.10
	Indian		30.10	9.88	1.80	50.11	59.90	53.45
General mean of plant densities	15cm		29.96	10.13	1.85	49.90	59.73	51.55
	10cm		30.63	9.8	1.83	50.07	60.18	54.28

The obtained results are well agreed to that found by Almass *et al.* [4] and Andrews *et al.* [5]. Regarding the varietal differences, data presented in Table 7 clearly showed that Gizani surpassed Indian. The superiority may be due to genetic constituencies. This is in agreement with those obtained by Abdullah *et al.* [9] who reported that the most effective factors affecting plant behaviors is that genetic structure and its interaction that occurs between the genotype and the environment. Data manifested in Table 7 showed that high distance between hills 15 cm recorded higher values of micro-nutrients content 136.33, 60.33 and 21.5 in the first cut and 119.33, 52.17 and 20.67 in the second cut for Fe, Zn and Mn, respectively. The interaction effect was significant in most of micro-nutrients content in the first and second cut.

Forage Quality: Data presented in Table 8 indicated the effect of water irrigation supplies, varietal differences and plant density as well as their interactions on forage quality of pearl millet. Good quality forage with high fat, digestibility percentage and with low fiber percentage was found herein at water irrigation supplies every 5 days as compared to irrigation either every 7 or 9 days. Both varieties recorded nearly the same values of the above mentioned forage quality traits. Results in the same Table also indicated that sowing pearl millet at 15 cm between hills was favorable for good quality forage than 10 cm between hills. More or less values were also recorded due to the interaction effect.

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