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Influence of pearlmillet (*Pennisetum glaucum* (L.) R. Br.) Crop geometry on growth and yield attributes under Dryland conditions

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Abstract
The field experiment was conducted at College of agriculture, Bijapur, to know the effect of crop geometry on pearl millet under dryland conditions during Kharif 2013-2014. The experiment was laid out with eight treatments replicated three times in randomized block design. Row spacing of 120 cm x 5 cm recorded significantly higher pearlmillet grain yield as compared to recommended spacing 60 cm x 10 cm (1203 kg ha^{-1}). The increase in grain yield was to the tune of 60 percent higher with 120 cm x 5.0 cm. Row spacing 135 cm x 10 cm recorded significantly higher absolute growth rate and relative growth rate 0.94, 2.96 and 16.73, 50.21 at 30 to 60 DAS and at 60 DAS to harvest respectively. As the row spacing increases net assimilation rate was also increased, highest net assimilation rate was found in the treatment 135 cm x 10 cm (0.25 g dm^{-2}day^{-1} and 11.07 g dm^{-2}day^{-1}) at 30 to 60 DAS and 60 DAS to harvest respectively.

Keywords: crop geometry, dryland, pearlmillet, growth and yield attributes

1. Introduction
Pearl millet (*Pennisetum glaucum* (L.) R. Br.) belongs to family Poaceae (section Paniceae), is one of the most important among the millets or nutritious coarse grain cereals, the crop is grown as a nutrient rich food source for humans as well as a fodder crop for livestock and feed for poultry. Pearl millet is the most drought and heat tolerant among cereals or millets and it has the highest water use efficiency under drought stress, also this plant species has unique tolerance to high temperature and moisture stress even at flowering, seed setting and grain filling stages. Yield of a crop depends on the final plant density. The density depends on the germination percentage and the survival rate in the field. Establishment of required plant density is essential to get maximum yield. Whereas, low density will leave soil moisture unutilized. Hence, optimum density will lead to effective utilization of soil moisture, nutrients, sunlight etc. When the density is more, individual plant gets narrow space leading to competition for growth factors between plants resulting in reduction of yield per plant. However the yield per unit area is increased up to a certain level of plant density due to utilization of growth factors. Maximum yield per unit area can, therefore, be obtained when the plant density is optimum. Hence, optimum density will lead to effective utilization of soil moisture, nutrients, sunlight etc. Northern Dry Zone (zone three) of Karnataka is a biggest zone having an area of 50.8 lakh.ha, out of this 35.5 lakh. ha is under cultivation. This area receives an annual rainfall of 594.3 mm in 30 rainy days. The rainfall is not sufficient for profitable crop production due to uneven distribution of rainfall. The problems such as erratic rainfall, undulating topography, poor adoption of soil and moisture conservation practices by the farmers, hence crop management practices play an important role in overcoming the drought situations. Keeping this in view a present investigation on Influence of Pearlmillet (*Pennisetum glaucum* (L.) R. Br.) Crop Geometry on Growth and yield attributes under Dryland Conditions was conducted.

Material and Methods
The experiment was conducted at the farm of College of Agriculture, Bijapur in the Northern Dry Zone of Karnataka (Zone 3) and is situated at 16^0 49' North latitude, 75^0 43' and East longitude and at an altitude of 593.8 m above the mean sea level. The experiment consisted of eight treatments Viz., T_1: 60 cm x 10 cm, $T_{2:}$ 75 cm x 8 cm T_3: 90 cm x 7 cm, T4:90 cm x 10 cm, T_5: 120 cm x 5 cm, T_6:120 cm x 10 cm T_7:135 cm x 5 cm T_8:135 cm x 10 cm. The experiment was laid out in RBD with three replications. The soil of the experimental sight was medium deep black soils.

Absolute growth rate (AGR) (g day^{-1})

This was worked out by using the formula proposed by Radford (1967) and expressed in g per plant per day.

$$AGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where, W_1 = Dry weight of the plant in g at time t_1

W_2 = Dry weight of the plant in g at time t_2

Crop growth rate (CGR) (g dm^{-2}day^{-1})

It is the absolute growth rate per unit ground area per unit time and expressed as g per dm^2 per day. This was estimated by adopting formula of Watson (1952).

$$CGR = \frac{W2 - W1}{T2 - T1} \times \frac{1}{P} 11$$

Where, W_1 and W_2 = Dry matter production per plant (g) at time t_1 and t_2 respectively

P = Land area covered by plant (dm^2)

Relative growth rate (RGR) (g g^{-1} day^{-1})

The mean relative growth rate of plant at any time is defined as the rate of increase in dry weight per unit dry weight per unit time. It was calculated by the formula proposed by Radford (1967).

$$RGR = \frac{(Log_e W_2 - Log_e W_1)}{(t_2 - t_1)}$$

Where, W_1 and W_2 = Dry weight of the plant (g) at time t_1 and t_2 respectively.

Log_e = Logarithm to the base 'e' (Neperian constant)

Net assimilation rate (NAR) (g dm^{-2}day^{-1})

Net assimilation rate is the increase in dry weight per unit leaf area per unit time expressed as g per dm^2 leaf area per day. It was calculated by following the formula of Gregory (1926).

$$NAR = \frac{(W_2 - W_1)(Log_e W_2 - Log_e W_1)}{(t_2 - t_1)(L_2 - L_1)}$$

Where, L_1 and W_1 = Leaf area in dm^2 and dry weight of the plant in g at time t_1, respectively.

L_2 and W_2 = Leaf area in dm^2 and dry weight of the plant in g at time t_2, respectively.

Log_e = Logarithm to the base 'e' (Neperian constant)

Ear head length (cm)

The length of ear head was measured from base to the tip of the ear and average of five tagged plants was taken as ear head length and expressed in centimeter (cm).

Ear head circumference (cm)

Measurement at the middle of the ear was taken as the girth of the ear in cm. This was measured by placing the thread around the ear at middle portion and measured thread was placed on a scale to record girth of ear.

Grain weight (g plant-^{1})

After obtaining grains from separated ears, the mean weight of grains of the five ears was taken as the grain weight per plant and expressed in grams.

Test weight (g)

The weight of thousand grains (g) was recorded from the grain samples drawn from the procedure obtained from each of the net plant.

Grain yield (kg ha^{-1})

The ears from net plot after air dried were threshed, cleaned and weight was recorded. Grain weight per net plot was converted into grain yield per hectare.

Fodder yield (kg ha^{-1})

Fodder yield was recorded after complete sun drying of the fodder from each net plot and from this fodder yield per hectare was worked.

Results and Discussion

In the present investigation row spacing 120 cm x 5 cm recorded significantly higher pearlmillet grain yield (Table 2) as compared to recommended spacing 60 cm x 10 cm (1203 kg ha^{-1}). The increase in grain yield was to the tune of 60 percent higher with 120 cm x 5.0 cm. The increase in grain yield is attributed to the fact that the soil moisture stored in the soil profile. Earlier studies made by Khafi *et al.* (2000) [1] revealed that observed highest grain yield and fodder yield by wider row spacing.

The increase in grain yield of pearlmillet with the treatment 120 cm x 5 cm (1925 kg ha^{-1}) was due to significant increase in yield components namely test weight (15.73 g), grain weight, length of ear head (18.46 cm) and ear head circumference (9.50 cm) which all indicated due to row spacing 120 cm x 5 cm. These results are in conformity with scientist Al-Thabet (2006) [2] revealed that there was a liner increase in head diameter, 1000 seed weight and seed weight per plant with increase in plant spacing from 15 up to 25 cm. This may be due to lower number of plant that produced significantly bold grains due to less competition and more availability of light, nutrient and feeding area per plant as compared to higher plant population.

The grain weight per plant differed significantly due to different cropping geometries. Significantly higher grain weight per plant (38.95 g) was recorded with row spacing 120 cm x 5 cm compared to recommended spacing 60 cm x 10 cm (20.61 g). The higher grain weight per plant might be the consequence of higher soil moisture content in the soil profile due to wider row spacing. Further it was observed that the row spacing 120 cm x 5 cm produced significantly higher grain weight per plant as a result of increased grain number per ear head and 1000 grain weight (test weight) (Table 2). Similar observation was also made by Zarafi and Emechebe (2006) [3]. In the present investigation, the increase in grain number per ear head and test weight might be due to higher soil moisture content in the wider row spaced plots. The increase in grain number per ear head and test weight in 120 cm x 5 cm may be attributed to higher leaf area index and consequently increased dry matter production and its accumulation in ear head.

Row spacing 135 cm x 10 cm recorded significantly higher absolute growth rate and relative growth rate 0.94, 2.96 and 16.73, 50.21 at 30 to 60 DAS and at 60 DAS to harvest respectively. As the row spacing increases net assimilation rate was also increased, highest net assimilation rate was found in the treatment 135 cm x 10 cm (0.25 g dm^{-2}day^{-1} and 11.07 g dm^{-2}day^{-1}) at 30 to 60 DAS and 60 DAS to harvest respectively. The results are in conformity with the James Lowell Fowler (1996) [4] who reported that the crop growth rate was significantly higher in high plant densities however the net assimilation rate or efficiency of the leaf surface in producing dry matter was reduced as plant population increased. This was apparently the result of less favorable light relationships or perhaps some other modification of the micro-environment of the crop as a result of the moderating effect of the leaf canopy in the closer spacing's.

Table 1: Absolute growth rate, relative growth rate, crop growth rate, net assimilation rate of pearlmillet as influenced by crop geometry

Treatments	AGR (g day^{-1})		RGR (g g^{-1} day^{-1})		CGR (g dm^{-2} day^{-1})		NAR (g dm^{-2} day^{-1})	
	30-60 DAS	60-Harvest	30-60 DAS	60-Harvest	30-60 DAS	60-Harvest	30-60 DAS	60-Harvest
T1-60 cm x 10cm	0.75	1.99	11.51	34.71	0.26	1.50	0.08	11.62
T2-75 cm x 8 cm	0.73	2.35	11.43	39.15	0.36	1.76	0.10	8.89
T3-90 cm x 7 cm	0.75	2.49	12.47	41.76	0.25	1.86	0.14	8.91
T4-90 cm x 10 cm	0.76	2.64	14.15	45.26	0.01	1.32	0.19	10.05
T5-120 cm x 5 cm	0.81	2.56	15.63	45.29	0.38	1.92	0.17	9.83
T6-120 cm x 10 cm	0.82	2.72	15.96	48.33	0.27	1.03	0.18	10.38
T7-135 cm x 5 cm	0.88	2.89	16.49	48.92	0.25	1.93	0.15	8.79
T8-135 cm x 10 cm	0.94	2.96	16.73	50.21	0.23	1.08	0.25	11.07
SEm±	0.05	0.10	0.37	1.07	0.02	0.07	0.01	0.89
CD (0.05)	0.15	0.31	1.12	3.24	0.07	0.21	0.04	NS

Table 2: Yield and yield attributes of pearlmillet as influenced by crop geometry

Treatments	Grain wt. per plant (g)	Length of ear head (cm)	Ear head circumference (cm)	Grain yield (Kg ha^{-1})	Fodder yield (kg ha^{-1})	1000 grain wt. (g)
T1-60 cm x 10 cm	20.61	16.56	8.30	1203	4089	14.39
T2-75 cm x 8 cm	24.59	16.50	8.33	1543	4220	12.27
T3-90 cm x 7 cm	22.86	17.46	8.83	1582	4182	12.50
T4-90 cm x 10 cm	29.68	18.43	8.82	1566	4460	12.67
T5-120 cm x 5 cm	38.95	18.46	9.50	1925	5246	15.73
T6-120 cm x 10 cm	35.88	18.20	9.43	1875	5177	13.74
T7-135 cm x 5 cm	21.87	17.26	9.20	1620	4730	14.49
T8-135 cm x 10 cm	22.75	17.53	8.86	1211	4530	15.66
SEm±	2.673	0.250	0.20	42	78	1.06
CD (0.05)	8.109	0.762	0.62	126	238	3.20

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