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Productivity and water-use efficiency of rainfed pearlmillet *(Pennisetum glaucum)* as influenced by planting patterns and integrated nutrient management

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ABSTRACT

A field experiment was conducted during the rainy *(kharif)* seasons of 2001 and 2002 a the Indian Agricultural Research Institute, New Delhi, to study the effect of planting patterns and nutrient management on growth, yield attributes, yield, nutrient uptake and water-use efficiency of rainfed pearmillet [*Pennisetum glaucum* (L.) R. Br. Emend. Stuntz.]. Modified planting patterns, viz. ridge and furrow (RF), paired row (PR) and paired rows + intercrop (PR+1 system), recorded significantly higher growth, yield, nutrient uptake and water-use efficiency of pearlmillet than uniform row (UR) system of planting. The maximum grain yield and water-use efficiency (WUE) were recorded with PR system of planting. Nutrient management caused remarkable improvement in growth, yield attributes, yield, nutrient uptake and water-use efficiency of pearlmillet. The performance of nutrient management treatments in term of grain yield and WUE followed the order of recommended dose of fertilizer (RDF)>1/2 RDF + *Azospirillum* + phosphorus-solubilizing bacteria (PSB) > 1/2 RDF + *Azospirillum* >1/2 RDF + PSB > 1/2 RDF > control.

Key words : Pearlmillet, Planting patterns, INM, Productivity, Water-use efficiency

Research priorities need to focus on how to increase and sustain the crop productivity in rainfed areas. Pearlmillet is most preferred crop of dryland and rainfed area owing to its drought-escaping mechanism coupled with comparatively higher production ability under low soil fertility, soil-moisture deficit, intense heat and minimum managerial inputs. Despite its higher production potential, soil-moisture deficit, often coinciding with critical growth stages of crop is the most important reason of low productivity of pearlmillet.

Among agronomic management practices, selection of suitable planting method (Kaushik and Gautam, 1994) and nutrient management comprising INM approach (Bellaki *et al.,* 1999) are essential to make best use of limited available water. At present productivity level, pearlmillet removes about 72 kg of N + P_2O_5+K_2O/ha, whereas only 10–12 kg/ha of these nutrients are applied. Low cost nutrient source or INM approach involving biofertilizers in conjunction with chemical fertilizers can be affordable by the resource poor farmers. Since information on planting pattern and nutrient management in relation to moisture conservation in term of water-use efficiency and productivity of pearlmillet is meagre, the present investigation was carried out on these aspects.

MATERIALS AND METHODS

The field experiment was carried out during the rainy *(kharif)* seasons of 2001 and 2002 at Indian Agricultural Research Institute, New Delhi. The soil was sandy loam, having bulk density 1.47 Mg/m^3, field capacity 14.1% and permanent wilting point 4.75% in surface soil layer (0–15 cm). The pH of soil was 7.3 with 0.28% organic C, having available N, P, K, 105.8, 10.25 and 235 kg/ha respectively. The experiment involving hybrid 'Pusa 322' was laid out in split-plot design replicated thrice, comprising 4 planting patterns (URS, uniform row system at 50 cm; R and FS, ridge and furrow system at 50 cm; PRS, paired row system at 30/70 cm; and PRI, paired row + intercrop (1 row of cowpea) as main plot and 6 nutrient-management practices [control, recommended dose of fertilizer (RDF), ½ RDF, ½ RDF + *Azospirillum,* ½ RDF + phosphorus solubilizing bacteria (PSB), ½ RDF + *Azospirillum* + (PSB)] as sub-plot treatments. The respective species of *Azospirillum* and PSB employed in the present investigation were *Azospirillum brasilence* and *Pseudomonas striata.* The recommended dose of fertilizer (RDF) includes 60 kg N and 40 kg P_2O_5/ha under Delhi situations. Seasonal consumptive use of water by the crop for the entire growing season was estimated from total soil-mois-

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ture depletion by soil-moisture determination (Dastane, 1974).

RESULTS AND DISCUSSION

Effect of planting patterns

Growth characters: Growth parameters of pearlmillet, viz. plant height, dry matter/plant and tillers/m row length, were influenced by different planting patterns. Paired row (PR) system of planting recorded the maximum improvement in growth parameters, which was significantly superior to UR and RF system of planting. This improvement in growth attributes could be assigned to higher moisture availability for crop owing to better moisture conservation under these modified planting patterns.

Yield attributes and yield: All the yield attributes except weight varied significantly due to planting patterns. Significantly higher number of ears/m^2, were observed with modified planting patterns (RF, PR and PR+I system) compared to UR system of planting. The PR system of planting proved to be most effective followed by PR+I and RF system of planting. Further, 1 row of cowpea as an intercrop in PR+I system of planting had no adverse effects.

Modified planting paterns (RF, PR and PR+I system) brought about a significant improvement in grain and stover yields of pearlmillet over UR system of planting. Maximum grain yields of 31.7 and 25.9 q/ha were recorded with PR system, being 39 and 48.8% more over UR system of planting in 2001 and 2002 respectively. The higher yield obtained under these planting patterns might be owing to cumulative effect of higher ears/m^2 due to improved soil-moisture availability. These results corroborate the findings of Jadhav *et al.* (1996) on pearlmillet.

Nutrient uptake: Nutrients (N and P) uptake by pearlmillet was notably higher due to modified planting patterns (RF; PR+I system) compared to UR system of planting. Higher uptake of N and P by pearlmillet was recorded with PR system followed by PR+I and RF system of planting. There is direct relationship between the average crop yield and nutrient uptake which are governed by moisture availability in soil (Potts *et al.*, 1991).

Water-use efficiency: Planting patterns resulted in considerable variation in water-use efficiency (WUE) in term of grain yield of pearlmillet during both the years. Significantly higher WUE of pearlmillet was recorded under PR and PR+I system of planting. The PR system of planting increased the WUE of pearlmillet by 32% and 38% over UR system of planting in 2001 and 2002 respectively. Higher moisture availability and increased grain yield might be responsible for increased WUE under these planting patterns. Kaushik and Gautum (1994) reported similar findings.

Effect of nutrient management

Growth characters: Growth attributes, viz. plant height, dry matter and tillers/m row length, increased significantly with the increased N levels up to 60 kg/ha and P levels up to 40 kg/ha. Poor status of N and P in the soil might be responsible for good response to applied N and P. Seed inoculation with *Azspirillum* and PSB along with 1/2 RDF remarkably improved height of pearlmillet over their respective N and P levels alone. This might be attributed to increased availability of N due to N fixation by *Azospirillum* and increased solubilization of native and

Table 1. Growth and yield attributes of pearlmillet as influenced by planting patterns and nutrient management

Treatment	Plant height (cm)		Dry matter/ plant (g)		Tillers/m row		Ears/m^2		Grain weight/ ear (g)		1,000-grain weight (g)	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Planting pattern												
Uniform row system	171.3	154.6	64.9	45.5	31.0	37.4	33.9	23.6	14.8	10.7	6.5	5.6
Ridge and furrow system	196.6	164.4	70.2	51.6	40.8	40.2	38.5	25.8	15.81	10.0	6.6	5.6
Paired row system	214.0	175.6	76.1	55.9	48.6	43.0	42.3	28.7	17.5	11.9	6.6	5.7
Paired row+intercrop system	213.0	171.6	75.9	55.5	47.1	42.4	41.9	28.3	17.3	11.7	6.6	5.6
CD (P=0.05)	11.5	7.2	3.8	2.2	3.0	1.9	2.2	1.2	0.9	0.5	NS	NS
Nutrient management												
Control	172.9	152.8	55.4	45.9	27.9	30.3	28.7	23.0	8.1	9.8	6.2	5.2
RDF	217.9	177.4	82.2	55.8	50.1	46.3	46.7	29.0	20.8	12.5	6.8	5.8
½ RDF	186.5	160.2	64.4	49.4	35.6	38.0	33.8	24.6	13.0	10.6	6.5	5.4
½ RDF + *Azospirillum*	200.6	170.1	73.2	52.8	44.6	41.8	40.1	27.1	17.9	11.2	6.6	5.7
½ RDF + PSB	200.1	167.5	72.9	51.7	44.0	40.8	39.8	26.8	18.1	11.6	6.6	5.7
½ RDF+*Azospirillum* + PSB	217.3	176.1	82.7	57.2	49.2	45.9	45.9	28.9	20.2	12.3	6.7	5.8
CD (P=0.05)	121.1	7.3	4.1	2.3	3.2	2.0	2.4	1.3	1.0	0.5	0.2	0.2

RDF, Recommended dose of fertilizers (60 kg N + 40 kg P_2O_5/ha); PSB, phosphorus-solubilizing bacteria

Table 2. Effect of planting patterns and nutrient management on yield, nutrient uptake, consumptive use and water-use efficiency of pearlmillet

Treatment	Grain yield (q/ha)		Stover yield (q/ha)		Total N uptake (kg/ha)		Total P uptake (kg/ha)		Consumptive use (mm)		Water-use efficiency (kg/ha-mm)	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Planting pattern												
Uniform row system	22.8	17.4	67.7	52.4	71.9	53.3	6.6	5.0	277.1	243.4	8.2	7.1
Ridge and furrow system	26.9	20.9	71.6	57.7	80.8	64.3	7.6	6.1	285.6	250.4	9.4	8.3
Paired row system	31.7	25.9	76.2	62.4	94.0	74.4	8.9	7.0	292.2	263.2	10.8	9.8
Paired row+intercrop	30.5	25.4	75.0	61.1	90.2	73.5	8.6	6.9	292.8	263.8	10.4	9.6
CD (P=0.05)	1.4	1.4		2.6	8.7	8.2	0.4	0.3			0.5	0.5
Nutrient management												
Control	21.3	18.7	63.1	51.8	65.2	55.5	5.8	5.1	276.4	249.4	7.7	7.5
RDF	32.1	24.9	82.5	62.9	100.1	76.9	9.8	7.2	299.3	258.2	10.7	9.6
½ RDF	25.9	20.6	66.9	55.8	77.4	60.0	7.1	5.8	283.6	253.7	9.1	8.1
½ RDF+*Azospirillum*	29.7	23.1	75.7	59.0	87.5	68.9	8.3	6.1	286.0	255.5	10.4	9.0
½ RDF+PSB	28.4	22.5	70.7	58.4	80.6	68.0	8.1	6.4	286.7	256.7	9.5	8.8
½ RDF+*Azospirillum* + PSB	21.7	24.6	80.1	62.2	97.2	73.9	9.5	7.3	289.5	257.8	10.9	9.5
CD (P=0.05)	1.4	1.3	3.4	3.2	12.5	9.6	1.4	0.7			0.5	0.5

applied P by PSB.

Yield attributes and yield: Significant higher values of yield attributes, viz. ears/m^2 and test weight, were recorded by application of nutrients. Maximum improvements in yield attributes was observed with application of RDF which was significantly superior to all other treatments except inoculation of *Azospirillum* and PSB along with application of 1/2 RDF.

Substitution of 50% RDF by *Azospirillum* and PSB resulted in 48.8 and 31.5% more grain yield over the control and was at par with RDF in 2001 and 2002 respectively. Balanced nutrition due to combined use of biofertilizers and fertilizers throughout the crop period probably resulted in better growth, enhanced yield attributes and finally yield. The results are in agreement with the findings of Ranghuwanshi *et al.* (1997).

Nutrient uptake: The uptake of N and P by pearlmillet varied phenomenally with the nutrient management treatments and indicated statistical significance. Maximum N and P uptake was recorded with application of RDF, which remained at par with 1/2 RDF + *Azospirillum* + PSB.

Water-use efficiency: Maximum WUE was realized with application of RDF, closely followed by application of 1/2 RDF along with dual inoculation of *Azospirillum* and PSB. This increased value of WUE might be ascribed to higher grain yield coupled with more proportionate increase in grain yield compared to consumptive use of water due to higher availability of N and P to crop under aforesaid treatments. Further, increase in WUE having combined application of fertilizer and biofertilizer might be due to relatively rapid plant growth during crop-growing period with low vapour pressure deficit, which decreased evaporation–transpiration and improved transpiration efficiency (Bellaki *et al.*, 1999). These results are in conformity with those of Badanur *et al.* (1998).

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