

Impact of cropping system, fertility level and moisture-conservation practice on productivity, nutrient uptake, water use and profitability of pearl millet (*Pennisetum glaucum*) under rainfed conditions

J.P. TETARWAL AND K.S. RANA

Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012

Received : March 2006

ABSTRACT

A field experiment was conducted on a sandy loam soil at Indian Agricultural Research Institute, New Delhi during rainy (*kharif*) season of 2003 and 2004. The treatment combinations comprised two cropping systems [pearlmillet sole (50 cm row spacing) and pearl millet paired row (30/70 cm row spacing) + one row of mothbean] and three fertility levels (control, 40 kg N + 20 kg P_2O_5 /ha and 80 kg N + 40 kg P_2O_5 /ha) in main plots; and four moisture-conservation practices (no mulch, dust mulch + straw mulch, kaolin + straw mulch and farmyard manure (FYM) @ 5 t/ha + dust mulch + straw mulch) in subplots. Split-plot design was followed with three replications. The planting of one row of mothbean between paired rows of pearl millet proved superior to sole pearl millet in respect of pearl millet-equivalent yield (29.60 q/ha), water use and economics. Application of 80 kg N + 40 kg P_2O_5 /ha as also FYM @ 5 t/ha + dust mulch + straw mulch recorded significantly higher pearl millet-equivalent yield, nutrient uptake, water use and economics compared with the rest of the treatments.

Key words : Economics, Fertility levels, Intercropping, Mulch, Nutrient uptake, Pearl millet, Water-use efficiency

Indian agriculture is dominated by farming. Rainfed agriculture contributes to 42 per cent of the national foodgrain production, mainly through sorghum, millets and pulses. Therefore dryland areas are important for the economy of the country and will continue to be so in future. Agricultural land area is inelastic and hence enhancement of productivity is the only alternative. Hence special attention is needed to achieve the goal of increasing and stabilizing agricultural production in moisture deficit areas.

Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] is the fourth most important cereal after rice, wheat and maize in India. It is the staple food for millions of people in the semi-arid tropics. Pearl millet survives in rainfed areas because of its drought escaping mechanism but still responds well to all inputs including fertilizers. Soil moisture is the most important factor for successful crop production in drylands. Use of organic manure as well as mid-season corrections through mulches, anti-transpirants and planting methods are effective in increasing the productivity and water use by pearl millet.

A good deal of research work has been done on mulches as well as anti-transpirants. Yet sufficient information is lacking regarding their efficiency in pearl millet production under north Indian conditions. Therefore it was deemed desirable to investigate the effect of nutrient

management and moisture-conservation practices on rainfed pearl millet.

MATERIALS AND METHODS

The field experiment was conducted on a sandy loam soil at the research farm of the Division of Agronomy, Indian Agricultural Research Institute, New Delhi in two consecutive rainy (*kharif*) seasons (2003 and 2004). This location has a typical semi-arid and subtropical climate, characterized by hot, dry summer and cool winter. The soil was sandy loam (61.48% sand, 12.6% silt and 25.8% clay) with adequate internal drainage and was poor in organic matter (0.40% organic carbon), medium in available nitrogen (251.0 kg/ha), phosphorus (16.4 kg/ha) and potassium (316 kg/ha), and neutral in soil reaction (pH 7.7). The rainfall received during the growing period (June to October) was 810.3 mm in 2003 and 425.4 mm in 2004. Split-plot design was adopted with three replications. The treatment combinations comprised two cropping systems [pearlmillet sole (50 cm row spacing) and pearl millet paired row (30/70 cm row spacing) + one row of mothbean] and three fertility levels (control, 40 kg N + 20 kg P_2O_5 /ha and 80 kg N + 40 kg P_2O_5 /ha) in main plots; and four moisture-conservation practices (no mulch, dust mulch + straw mulch, kaolin + straw mulch and FYM @

5 t/ha +dust mulch+straw mulch) in subplots.

Fertilizers were drilled 8-10 cm below the surface in bands. All the fertilizers were applied as per treatment through urea and single super-phosphate, just before sowing. FYM was incorporated in the plots after preparing lay-out as per treatment in both the years. Hybrid 'Pusa 605' pearl millet and 'RMO 40' variety of mothbean were used. The crops were sown on 15 July 2003 and 31 July 2004. The pearl millet seeds were sown @ 5 kg/ha by *kera* (dropping the seeds in furrow behind the plough). The spacing between row to row in sole pearl millet was maintained at 50 cm, whereas in paired row sowing 30 cm apart, maintaining a distance of 70 cm between two pairs of rows. One row of mothbean was sown between two paired rows of pearl millet.

The first dust mulch was created at 25 days after sowing (DAS) and second at 40 DAS in both the years. Wheat straw @ 5 t/ha was spread over the soil surface at 42 DAS according to treatment. Kaolin (6 per cent suspension) was sprayed as per treatment over the crop foliage at 50 DAS in both the years.

RESULTS AND DISCUSSION

Crop yield

The cropping system did not influence the grain and stover yields of pearl millet (Table 1), perhaps due to the effect of constant level of plant population. Goswami *et al.* (2002) also reported similar results.

Application of fertilizers (Table 1) significantly improved the grain and stover yields of pearl millet as well as seed yield of mothbean compared with no fertilization. A dose of 80 kg N + 40 kg P₂O₅/ha recorded significantly higher grain (28.81 q/ha) and stover (82.78 q/ha) yields over the control (21.80 and 54.97 q/ha respectively) and was on a par with that of 40 kg N + 20 kg P₂O₅/ha. Similarly, this treatment also gave significantly higher grain yield of mothbean (1.67 q/ha) than the control. It could be attributed to the availability of more amounts of N and P for better growth and development, which ultimately resulted in higher yield. Sharma and Gupta (2002) reported linear increase in the yield of millet with increase in the dose of N and P over the control.

Grain and stover yields of pearl millet as well as grain yield of mothbean were influenced re-

Table 1. Effect of cropping system, nutrient level and moisture-conservation practice on yield, nutrient uptake, consumptive use, water-use efficiency, moisture extraction pattern and economics (average data of 2 years) of pearl millet cultivation

Treatment	Yield (q/ha)			Nutrient uptake (kg/ha)	Consumptive use (mm)	WUE (kg/ha-mm)	Moisture-extraction pattern (%)			Net return (Rs/ha)	B:C ratio	
	Pearlmillet		Mothbean				PEY	0-30 cm	30-60 cm			60-90 cm
	Grain	Stover										
Cropping system												
Pearlmillet sole (50 cm row spacing)	26.60	73.74		92.18	34.86	8.07	43.14	32.66	24.20	7,477	0.83	
Pearlmillet paired row (30/70 cm)+ 1 row of mothbean	25.39	69.72	1.35	84.69	32.00	8.34	41.46	33.30	25.21	8,375	0.87	
CD (P=0.05)	NS	NS		6.23	NS							
Fertility level												
Control (no nutrition)	21.80	54.97	0.85	64.23	22.54	7.19	42.72	32.76	24.51	5,812	0.71	
40 kg N+20 kg P ₂ O ₅ /ha	27.37	77.45	1.54	95.83	36.93	8.52	42.36	32.98	24.66	8,988	0.95	
80 kg N+40 kg P ₂ O ₅ /ha	28.81	82.78	1.67	105.25	41.12	8.90	41.83	33.22	24.95	9,126	0.88	
CD (P=0.05)	2.00	6.34	0.20	7.63	2.41					1,059		
Moisture-conservation practice												
No mulch	20.76	55.93	0.85	68.70	25.16	6.95	42.96	32.80	24.20	5,918	0.78	
Dust mulch + straw mulch	25.94	69.77	1.38	91.75	35.05	8.29	42.31	32.94	24.76	7,873	0.84	
Kaolin + straw mulch	27.11	74.69	1.44	91.75	35.05	8.38	42.12	33.04	24.84	8,058	0.80	
FYM @ 5 t/ha + dust mulch + straw mulch	30.17	86.51	1.74	106.59	41.06	9.20	41.83	33.16	25.01	10,051	0.97	
CD (P=0.05)	2.35	7.11	0.29	6.54	3.13							

Price of pearl millet : Rs 505/q; mothbean: Rs 1,500/q

markably due to moisture-conservation practices (Table 1). Among these, FYM @ 5 t/ha + dust mulch + straw mulch recorded significantly higher grain (30.17 q/ha) and stover (86.51 q/ha) yields, followed by Kaolin + straw mulch (27.11 and 74.69 q/ha), dust mulch + straw mulch (25.94 and 69.77 q/ha), and (minimum) no mulch (20.76 and 55.93 q/ha) respectively. Similar results were also observed in seed yield of mothbean. The increased productivity of grain and stover with moisture-conservation practices was owing to the use of dust mulch and straw mulch, which helped extend the period of storage of water in soil profile due to reduction in evaporation; as Kaolin reduces transpirational loss of water and FYM increases water-holding capacity of soil. Jat and Gautam (2001) reported similar results in pearl millet.

Nutrient uptake

Cropping system had no marked influence on N and P uptake by grain as well as stover of pearl millet, but the total uptake of N and P was significantly higher with sole crop compared with that of pearl millet + mothbean intercropping system (Table 1).

Application of 80 kg N + 40 kg P_2O_5 /ha recorded significantly higher uptake of N and P by grain and stover as well as by total dry matter over the control and 40 kg N + 20 kg P_2O_5 /ha, except in N uptake by grain, in which 80 kg N + 40 kg P_2O_5 /ha and 40 kg N + 20 kg P_2O_5 /ha remained on a par with each other. This could be attributed to the fact that added nutrients increased the N and P content in grain and stover of pearl millet, by providing balanced nutritional environment inside the plant and higher photosynthetic efficiency, which favoured better growth and crop yield. Application of fertilizers significantly improved the protein content in grain compared with the control.

Moisture-conservation practice markedly influenced the nitrogen and phosphorus uptake by grain and stover as well as total uptake and protein content in grain of pearl millet (Table 1). The maximum uptake was recorded under FYM @ 5/ha + dust mulch + straw mulch, followed by Kaolin + straw mulch, dust mulch + straw mulch and no mulch. This could be attributed to higher grain and stover yields, apparently due to increased availability of water to the plants, as also reported by Yadav (2000).

Pearlmillet-equivalent yield

Cropping system owed measurable improvement in pearl millet-equivalent yield (Table 1). Pearl millet intercropped with mothbean recorded significantly higher equivalent yield (29.60 q/ha) than sole pearl millet (26.60 q/ha). This was due to additional yield of mothbean and its

higher price. Tetarwal and Nanwal (2002) also recorded similar observations.

Application of 80 kg N + 40 kg P_2O_5 /ha recorded significantly higher pearl millet-equivalent yield (31.40 q/ha) over the control (23.14 q/ha), which was on a par with that of 40 kg N + 20 kg P_2O_5 /ha (Table 1), probably due to increase in economic yields of both the components on nitrogen and phosphorus application.

Various moisture-conservation practices showed remarkable improvement in pearl millet-equivalent yield (Table 1), the maximum being with FYM @ 5 t/ha + dust mulch + straw mulch (32.89 q/ha), followed by Kaolin + straw mulch (29.36 q/ha) and dust mulch + straw mulch (28.09 q/ha), and minimum with no mulch (22.08 q/ha). It might be due to significant increase in the yield of pearl millet and mothbean.

Soil-moisture use

Water-use efficiency (WUE) in terms of pearl millet-equivalent yield showed marked variation due to all the practices (Table 2). Pearl millet paired row + one row of mothbean recorded higher WUE over sole crop. This might be due to higher grain yields of both the crops than the amount of water used for biomass production. Consumptive use and rate of moisture use were higher in the intercropping system than sole crop because both the crops absorbed more moisture during the crop period. Goswami *et al.* (2002) reported similar findings. In general, soil-moisture utilization by crops was maximum from the top soil layer (0-30 cm) than from 30-60 and 60-90 cm layers. The intercropping system depleted more moisture from deeper layers than pearl millet sole. The moisture stress in upper (0-30 cm) soil profile might have compelled roots to go deeper in search of moisture.

The highest WUE, consumptive use and rate of moisture use were recorded with 80 kg N + 40 kg P_2O_5 /ha, followed by 40 kg N + 20 kg P_2O_5 /ha and the control. It might be because that increase in pearl millet-equivalent yield was more than the corresponding increase in consumptive use of water due to fertility level. The increased activity, growth and proliferation of root system due to greater translocation of photosynthates to roots owing to balanced nutrition might have resulted in extraction of more moisture from deeper soil profile.

FYM @ 5 t/ha + dust mulch + straw mulch treatment gave the highest average values of all the three moisture characteristics and lowest with no mulch. The increase in these parameters due to moisture-conservation practices could be attributed to vigorous crop growth, resulting from increased availability of soil moisture. Our results support the finding of Das and Gautam (2003) in pearl millet. Soil-moisture depletion from 0-30 cm soil

layer was maximum with no mulch and lowest with FYM @ 5 t/ha + dust mulch + straw mulch. However, the reverse was true in 30-60 and 60-90 cm soil layers, where maximum percentage of moisture was depleted with FYM @ 5 t/ha + dust mulch + straw mulch, followed by Kaolin + straw mulch, dust mulch + straw mulch and no mulch.

Economics

Pearlmillet + mothbean intercropping system fetched higher net return (Rs 8,375/ha) as well as benefit : cost (B:C) ratio (0.87) over sole pearlmillet (Rs 7,477/ha and 0.83 respectively) on pooled mean basis (Table 2). This might be due to additional yield of mothbean and its higher price in the market. These findings are in close agreement with those of Ramulu and Gautam (1999).

An increase in dose of nitrogen and phosphorus and moisture-conservation practices, increased the net returns (Table 2). Application of 80 kg N + 40 kg P_2O_5 /ha, being at par with 40 kg N + 20 kg P_2O_5 /ha, recorded significantly higher net return (Rs 9,126/ha) and B:C ratio (0.88) than the control. This might be due to significant increase in yield under this treatment over the control and low cost of treatment.

Significantly higher net return (Rs 10,051/ha) and B:C ratio (0.97) were recorded with FYM @ 5 t/ha + dust mulch + straw mulch over the rest of the moisture-

conservation practices. This might be due to significantly higher pearlmillet-equivalent yield.

REFERENCES

- Das, G. and Gautam, R. C. 2003. Yield and water use efficiency of pearlmillet as influenced by moisture conservation methods under rainfed conditions. *Annals of Agricultural Research* **24** (1) : 78-81.
- Goswami, V. K., Kaushik, S. K. and Gautam, R.C. 2002. Effect of intercropping and weed control on nutrient uptake and water-use efficiency of pearlmillet (*Pennisetum glaucum*) under rainfed conditions. *Indian Journal of Agronomy* **47** (4) : 504-508.
- Jat, M.L. and Gautam, R.C. 2001. Productivity and water use of rainfed pearlmillet (*Pennisetum glaucum*) as influenced by summer ploughing and *in situ* moisture conservation practices under semi-arid conditions of north-west India. *Indian Journal of Agronomy* **46** (2) : 266-272.
- Ramulu, V. and Gautam, R.C. 1999. Evaluation of pearlmillet intercropping for yield and resource utilization under rainfed conditions. *Annals of Agricultural Research* **20** (2) : 240-242.
- Tetarwal, J.P. and Nanwal, R.K. 2002. Productivity of pearlmillet (*Pennisetum glaucum*) as influenced by cropping systems and fertilization under rainfed conditions. *Agronomy Digest* **2** : 8-11.
- Yadav, C.P. 2002. Effect of soil and water conservation practices and nitrogen fertilization on physical properties, yield and quality of mustard [*Brassica juncea* (L.) Czernj. & Coss]. *Indian Journal of Agronomy* **44** : 148-150.