



Nutrient management in pearl millet (*Pennisetum glaucum*)–mustard (*Brassica juncea*) cropping system as affected by land configuration under limited irrigation

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ABSTRACT

A field experiment was conducted during *kharif* and *rabi* seasons of 2005-06 and 2006-07 at New Delhi on a sandy-loam soil to assess the effect of two land configurations, *viz.* Flat (F) and Ridge & Furrow (R&F) sowing and five nutrient management treatments (control, 30 + 8.8 kg N +P/ha (50% recommended dose of fertilizer *i.e.* RDF), 60 + 17.6 kg N +P/ha (RDF), 50% RDF + FYM (6 t/ha) and FYM alone to pearl millet (*Pennisetum glaucum*). Residual effects of pearl millet treatments on mustard (*Brassica juncea*) were assessed at 50% RDF and RDF to mustard. Results revealed that R&F sowing and integrated nutrient management of 50% RDF + 6 t FYM to pearl millet recorded higher yield of both pearl millet and mustard over flat sowing and other fertility levels during both the years. Application of RDF to mustard improved the seed yield (1.31 t/ha) by 43.8 and 33.0% over control and 50% RDF. Ridge and furrow sowing and 50% RDF + FYM application recorded significantly higher N and P uptake by both the crops over flat sowing and other fertility levels, respectively.

Key words : Cropping system, Farmyard manure, Land configuration, Mustard, Nutrients, Nitrogen, Phosphorus and Pearlmillet

Pearlmillet [*Pennisetum glaucum* (L.) R. Br. Emend Stuntz] - mustard [*Brassica juncea* (L.) Czernj and Coss.] cropping system is one of the predominant cropping system in Rajasthan, Uttar Pradesh, Haryana and Madhya Pradesh under limited water conditions and is preferred by the farmers also because of attractive price of mustard. However, the abiotic stresses, such as moisture and soil fertility are largely responsible for low productivity of pearl millet as well as mustard. The excess moisture and water-logging conditions during monsoon creates unfavourable conditions for growth *viz.* reduced aeration, hampered root development, reduced nutrient uptake and conducive environment for disease incidence, finally leading to reduced crop stand and yield. The moisture stress in post-monsoon period adversely affects the growth and development of mustard and ultimately leads to reduced yields. Both pearl millet and mustard crops are grown under marginal and sub-marginal lands. Thus, the balanced nutrition is needed which could be achieved through

multi-nutrients application (Hegde, 2003). Since pearl millet and mustard crops respond favorably to applied N and P, however, the major part of N and P remains unutilized by first crop; its effect is invariably reflected in succeeding crop (Mahala *et al.*, 2006). An attempt was therefore, made to evaluate the effect of land configuration, direct and residual effect of nutrient management in pearl millet–mustard cropping system.

MATERIALS AND METHODS

An experiment was carried out at Indian Agricultural Research Institute, New Delhi during rainy and winter seasons of 2005-06 and 2006-07 at a fixed site. The soil was sandy loam with pH 8.0 (1:2.5 soil to water), organic carbon 0.4%, available N 137.5, available P 12.9 and available K 180.1 kg/ha. The soil with a bulk density 1.5 Mg/m³ has a field capacity and permanent wilting point moisture of 19.12% and 6.52% in 0 to 30 cm layer. The total rainfall during *kharif* and *rabi* seasons of 2005-06 and 2006-07 was 502.9 and 3.2 mm and 408.2 and 87.5 mm, respectively. During first year of experiment (2005-06), one irrigation was given on 8 August, 2005 for *kharif* crop and on 25 November, 2005 for *rabi* crop. In 2 year (2006-07), one irrigation on 5 August, 2006 for *kharif* and on 21

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November, 2006 for *rabi* crops (one pre-sowing irrigation for mustard in October 2006 was applied during 2 years) were given due to prolonged dry spell. There were 2 land configurations (flat sowing, and ridge and furrow sowing with dimension of 67 cm and 30 cm at bottom and top, respectively) and 5 fertility level treatments (control, 50% recommended dose of fertilizers (RDF), RDF, 50% RDF + FYM @ 6 t/ha and FYM @ 6 t/ha alone) laid out in randomized block design to pearl millet. During *rabi*, the experiment was laid out in split-plot design with preceding pearl millet treatments in the main plots and directly applied nutrients (control, 50% RDF and RDF) to the succeeding mustard in sub-plots. The RDF for pearl millet and mustard crops is same i.e. 60+17.6 kg N +P/ha and the treatments were replicated thrice. The well decomposed FYM (C 10.4 %, N 0.53%, C: N 19.6:1, P 0.22%, and K 0.59%) was applied 14 days before sowing and incorporated in to soil. Nitrogen and phosphorus were applied as per treatments through urea and single super phosphate, respectively. Pearl millet 'Pusa Composite 383' was sown on 19 July, 2005 and 15 July, 2006 with 50 cm x 15 cm geometry, and harvested on 16 October, and 8 October in 2005 and 2006, respectively. Mustard 'Pusa Agrani' was sown after pearl millet on 25 October, 2005 and 18 October, 2006 with 67 cm x 15 cm spacing, respectively. Other management practices were adopted as per recommendations of crops under limited irrigation. Soil moisture extraction was worked out from three different layers *viz.* 0–30, 30–60 and 60–90 cm separately during the growing seasons. The total soil moisture depleted (SMD) from root zone (0–90 cm) was estimated by summing up the depletion from each layer. The nutrient uptake by the crops was obtained as the product of concentration of nutrient and yield. Likewise oil yield was also obtained as the product of oil concentration in seed and seed yield of mustard.

RESULTS AND DISCUSSION

Plant growth

Over the seasons, land configuration had significant influence on plant height, number of tillers/m row length of pearl millet and plant height of mustard. Ridge and furrow sowing produced significantly taller plants of both pearl millet and succeeding mustard (Tables 1 and 2) over flat sowing in both the years. But among the treatments there were no significant difference during both the years. The improvement in plant height could be due to the fact that ridge and furrow sowing helps in maintaining the favorable moisture condition for relatively longer duration. Similar effect of land configuration in pigeon pea have also been reported by Kantwa *et al.* (2006).

FYM application along with fertilizers significantly increased the plant growth of pearl millet over FYM alone

and fertilizers (control, 50% RDF) during both the years (Table 1). Combined application of fertilizer along with FYM proved better when compared with fertilizers alone. This might be due to the role of FYM in improving soil physio-chemical and biological properties. Moreover, FYM has synergistic relationship with N and P, thereby helping in mineralization of applied N and P and helped in increasing the growth. These results corroborate with the findings of Satyajeet and Nanwal (2007).

Direct application N and P had significant influence on plant growth of pearl millet and succeeding mustard over no nutrients (Tables 1 and 2). Application of RDF recorded significantly higher plant height over control and 50% RDF in pearl millet and succeeding mustard during both the years. In pearl millet, application of RDF and 50% RDF + FYM were at par to each other with respect to plant height (Table 1) in both the years. This might be due to continued and balanced supply of nutrients enhancing their availability and with their active involvement in shoot and root development exhibited better plant growth. Such findings were earlier reported by Meena *et al.* (2001) and Meena and Gautam (2005).

Yield attributes and yield

The yield attributes in ridge and furrow sowing indicated significant difference with respect to number of ear heads /m row length, length of ear head (cm) and higher grain yield (12.8%) and total biomass of pearl millet over flat sowing (Table 1) in 2005-06 and 2006-07. In succeeding mustard, ridge and furrow sowing method recorded higher siliquae /plant, seeds/siliquea, seed yield (11.0%) and total biomass over flat sowing (Table 2). The superiority of ridge and furrow sowing could be ascribed to proper drainage of water from excess rainfall and moisture conservation after post-monsoon. Similar effect of land configuration has also been reported by Kantwa *et al.* (2006).

Integrated use of fertilizers + FYM in preceding pearl millet exhibited a significant improvement in yield attributes, grain and stover yield of mustard (Table 1). These results are in close conformity with the findings of Satyajeet and Nanwal (2007).

Application of fertilizer directly to pearl millet and succeeding mustard had significant influence on yield attributes and yield of pearl millet (Table 1) and mustard (Table 2). In pearl millet, direct application of RDF enhanced grain yield on an average by 33.4, 12.3 and 12.9% over control, 50% RDF and FYM alone, respectively. While the increment in mustard yield was to the tune of 37.9 and 8.8% due to direct application of RDF over control and 50%RDF, respectively. This might be owing to role of nitrogen in cytokinin synthesis, thereby higher

Table 1. Effect of land configuration and nutrient management on growth, yield attributes and yield of pearl millet and total N and P uptake in pearl millet–mustard sequence

Treatment	Plant height (cm) at harvest*	Tillers/row length*	Earheads/m row length		Grain yield (t/ha)		Biological yield (t/ha)		Total N uptake (kg/ha)*		Total P uptake (kg/ha)*	
			2005	2006	2005	2006	2005	2006	Pearlmillet	Mustard	Pearlmillet	Mustard
<i>Land configuration</i>												
Flat sowing	168.2	18.7	13.7	12.2	2.44	2.21	9.26	8.00	78.2	51.2	29.5	12.9
Ridge and furrow sowing	184.8	22.1	15.7	13.8	2.71	2.53	10.53	9.33	90.4	57.7	34.4	16.6
SEM ±	4.2	0.5	0.5	0.3	0.05	0.04	0.17	0.15	1.5	0.8	0.5	0.2
CD (P=0.05)	11.9	1.6	1.5	1.0	0.15	0.12	0.51	0.46	4.4	2.4	1.6	0.6
<i>Nutrient management (N-P kg/ha) in pearl millet</i>												
Control	162.1	16.5	10.9	9.3	2.18	1.94	8.56	7.17	63.5	41.4	24.1	11.2
30 + 8.8	173.6	19.9	14.1	12.7	2.52	2.37	9.57	8.63	81.4	52.6	30.6	13.9
60 + 17.6	186.4	22.9	17.7	14.9	2.81	2.58	10.78	9.52	97.1	62.0	37.1	16.9
30 + 8.8 + FYM @ 6 t/ha	187.7	23.6	16.8	15.2	2.86	2.63	11.05	9.47	99.1	64.4	37.4	19.0
FYM @ 6 t/ha	172.7	20.2	13.8	12.9	2.51	2.35	9.51	8.52	80.4	52.8	30.3	14.5
SEM ±	6.6	0.8	0.8	0.5	0.08	0.06	0.27	0.24	2.3	1.3	0.9	0.3
CD (P=0.05)	19.4	2.3	2.3	1.6	0.24	0.19	0.81	0.73	6.9	3.8	2.5	0.9
<i>Direct applied nutrients (N-P kg/ha) to mustard</i>												
Control										42.0		11.5
30 + 8.8										56.8		15.4
60 + 17.6										64.6		17.5
SEM ±										1.3		0.3
CD (P=0.05)										3.6		0.9

*Pooled data of 2 years

number of effective tillers and better root growth coupled with higher photosynthetic area helped in better growth and development and ultimately higher seed and stover yield. Phosphorus also play vital role in root development, energy transformation and metabolic processes of plant, which resulted in greater translocation of photosynthates towards the sink development. The results are in close conformity with those of Mahala *et al.* (2006) and Satyajee *et al.* (2007).

Residual effects on mustard

Mustard sown on re-shaped ridge and furrow of preceding pearl millet recorded higher plant height and yield attributes and yield over flat sowing in both the years (Table 2). Ridge and furrow sown mustard recorded 11% higher seed yield over flat sowing. Similar findings were also reported by Kantwa *et al.* (2006). The superiority of ridge and furrow sowing over flat sowing could be ascribed to conservation of moisture that led to better development of yield attributes, which in turn increased the yield of mustard in pearl millet–mustard sequence.

In mustard, the residual effect of nutrient management to preceding pearl millet in respect to plant height, siliquae/plant, seeds/siliqua and yield was noticed in all the treatments over control (Table 2) in 2005-06 and 2006-07. The residual effect of 50% RDF+FYM and RDF to preceding

pearlmillet recorded higher growth, yield attributes, leading to a mean increase in seed yield of mustard by 38.2, 19.3 and 16.1% over control, 50% RDF and FYM alone, respectively. The ridge and furrow sowing recorded significantly higher oil yield over flat sowing. Similar findings were also reported by Satyajee and Nanwal (2007). The increase in vigour and growth owing to residual nutrients led to better development of yield attributes, which in turn increased the mustard yield.

Interaction effect of nutrient management in pearl millet and mustard

The interaction effect of nutrient management in pearl millet–mustard sequence on system productivity measured as pearl millet equivalent yield (PEY) was significant in 2006-07 (Table 4). The PEY of system was higher with 50% RDF + FYM in pearl millet and RDF in mustard over all the treatments except RDF for both the crops. This shows that the integrated application of nutrients in pearl millet have positive interactive effects on the succeeding mustard and thus enhanced PEY of system.

Nutrient application in preceding pearl millet and direct applied nutrients to mustard could bring out significant difference in oil yield. Oil yield of mustard with 50% RDF + FYM, being on par with RDF was significantly higher over control, 50% RDF and FYM alone application to

Table 2. Effect of land configuration and nutrient management and direct applied nutrients on growth, yield attributes, yield and oil yield of succeeding mustard

Treatment	Plant height at harvest (cm)*	Siliquae/plant		Seeds/siliqua		Seed yield (t/ha)		Biological yield (t/ha)		Oil yield (kg/ha)*
		2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	
<i>Land configuration</i>										
Flat sowing	130.3	272.8	285.5	11.1	11.1	1.06	1.11	4.13	4.39	430.6
Ridge and furrow sowing	141.9	293.0	301.1	12.1	12.0	1.16	1.25	4.42	4.93	482.2
SEm ±	1.4	2.5	3.0	0.2	0.2	0.02	0.01	0.06	0.05	9.3
CD (P=0.05)	4.2	7.6	8.9	0.5	0.7	0.06	0.03	0.18	0.15	27.8
<i>Nutrient management (N-P kg/ha) in pearl millet</i>										
Control	116.4	230.1	245.6	10.1	10.1	0.91	0.98	3.48	3.91	381.9
30 + 8.8	134.8	277.4	287.7	11.3	11.4	1.05	1.14	4.07	4.49	430.9
60 + 17.6	145.6	309.9	321.0	12.7	12.2	1.24	1.30	4.72	5.08	498.8
30 + 8.8 + FYM @ 6 t/ha	147.0	315.2	320.2	12.3	12.3	1.29	1.32	4.92	5.20	520.3
FYM @ 6 t/ha	137.1	282.2	292.2	11.5	11.5	1.08	1.17	4.16	4.63	450.2
SEm ±	2.2	4.0	4.7	0.3	0.4	0.03	0.02	0.10	0.08	14.8
CD (P=0.05)	6.6	11.9	14.0	0.8	1.1	0.10	0.06	0.30	0.24	43.9
<i>Direct applied nutrients (N-P kg/ha) to mustard</i>										
Control	122.4	253.7	264.3	10.4	11.4	0.89	1.00	3.48	3.99	377.3
30 + 8.8	137.8	289.2	300.5	11.7	11.6	1.17	1.22	4.50	4.84	473.3
60 + 17.6	148.3	306.0	315.2	12.7	12.6	1.27	1.33	4.84	5.16	518.7
SEm ±	2.3	4.2	3.9	0.3	0.3	0.03	0.02	0.10	0.07	10.9
CD (P=0.05)	6.7	11.9	11.1	0.9	1.0	0.08	0.06	0.30	0.21	33.0

*Pooled data of 2 years.

pearlmillet in both the years (Table 2). This was due to higher seed yield in these treatments. Oil yield increased with increasing fertilization of mustard up to RDF over control and 50% RDF. This gradual enhancement in oil yield was mainly due to steady improvement in seed yield. The present trend of increased oil yield is in line with the findings of Mishra and Giri (2004).

Nutrient uptake

Application of 50% RDF + FYM being on par with RDF markedly increased the N, P uptake of individual crops over control, 50% RDF and FYM (Table 1) in both the years.

Application of RDF to mustard significantly increased the N, P uptake over control and 50% RDF in both the years of study. The increase in dry matter yield together with higher concentration of N and P led to higher uptake of nutrients by crops. The added N and P through fertilizers has increased the availability of them to plants, which in turn might have resulted in profuse shoot and root growth, thereby activating greater absorption from the soil and improving the grain/seed and stover/stalk yields. The present trend of increased nutrient uptake is in line with those of Mahala *et al.* (2006) and Satyajeet *et al.* (2007).

Soil moisture studies

Water use efficiency (WUE) was higher in ridge and

furrow than flat sowing (Table 3). This might be attributed to the availability of more moisture in ridge and furrow system for longer time for proper growth and development of crops. These results are in close agreement with those of Kantwa *et al.* (2006). Fertility levels increased the consumptive use (CU) and WUE during both the years of study (Table 3). The highest WUE was recorded with 50% RDF + FYM and lowest with control. It might be due to the fact that increase in yield was of higher magnitude than the corresponding increase in CU of water that eventually resulted in considerable increase in WUE. Consumptive use increase with different fertility levels might also be attributed to enhanced deeper root system development that enabled the plants to utilize more moisture from deeper soil layers. Similar findings were also reported by Tatarwal and Rana (2006).

Economics

Ridge and furrow sowing fetched significantly higher net return and B:C ratio (Table 3) over the flat sowing in pearlmillet–mustard sequence. Similar findings were also reported by Kantwa *et al.* (2006).

Application of RDF to pearlmillet fetched highest net return in 2005-06 and B:C ratio during both the years. However, in 2006-07, net returns were highest with 50% RDF + FYM. Similar findings were also reported by

Table 3. Effect of land configuration and direct and residual nutrient management on economics, consumptive use and water use efficiency (WUE) of pearlmillet-mustard cropping system

Treatment	Mean cost of cultivation (Rs/ha)	Net return (Rs/ha)		B:C ratio		Consumptive use (mm)		WUE (kg/ha-mm)	
		2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
<i>Land configuration</i>									
Flat sowing	9,928	21,199	20,957	2.15	2.07	466.1	483.3	3.87	3.73
Ridge & furrow sowing	10,661	24,358	24,621	2.22	2.33	486.6	509.6	4.13	4.02
SEM ±		318	270	0.03	0.03	5.9	4.8	0.10	0.06
CD (P=0.05)		944	802	0.09	0.08	17.7	14.4	0.29	0.18
<i>Nutrient management (N-P kg/ha) in pearlmillet</i>									
Control	8,939	18,201	18,184	2.06	2.00	442.2	453.5	3.56	3.49
30 + 8.8	9,888	21,540	22,275	2.20	2.23	473.3	487.4	3.85	3.86
60 + 17.6	10,836	25,223	25,270	2.35	2.37	481.4	527.1	4.45	4.01
30 + 8.8 + FYM @ 6 t/ha	11,671	24,992	25,692	2.17	2.29	505.3	524.5	4.28	4.10
FYM @ 6 t/ha	10,139	21,685	22,523	2.16	2.18	479.5	489.9	3.85	3.90
SEM ±		502	427	0.05	0.04	9.4	7.7	0.15	0.10
CD (P=0.05)		1,492	1,267	0.16	0.12	28.0	27.3	0.45	0.28
<i>Direct applied nutrients (N-P kg/ha) to mustard</i>									
Control	9,229	19,746	20,626	2.16	2.19	467.0	481.2	3.59	3.62
30 + 8.8	10,178	23,545	23,415	2.33	2.26	473.2	499.2	4.19	3.93
60 + 17.6	11,477	23,694	24,326	2.08	2.15	488.7	509.0	4.21	4.07
SEM ±		465	366	0.05	0.04	4.8	1.8	0.09	0.04
CD (P=0.05)		1,329	1,045	0.14	0.10	13.7	5.1	0.27	0.13

Price of pearlmillet (grain and stover) in 2005 and 2006, Rs. 5,250 and 400 and 5,400 and 400/t.

Price of mustard (seed and stalk) Rs. 17,150 and 200/t in both the years.

Table 4. System productivity (pearlmillet equivalent yield, t/ha) as influenced by interactive effect of nutrient management in pearl millet and mustard (2006-07)

Nutrient management in mustard	Nutrient management in pearl millet				
	Control	50% RDF	RDF	50% RDF + FYM	FYM
Control	4.68	5.67	6.24	6.36	5.04
50 % RDF	5.16	6.05	6.78	6.87	6.36
RDF	5.54	6.21	7.11	7.27	6.80
SEm ±			0.08		
CD (P=0.05)			0.24		

Sharma and Singh (2009).

Application of RDF (60+17.6 kg N+P/ha) to mustard fetched highest net return, while the lowest was obtained in unfertilized control treatment in both the years. However, B:C ratio was highest with direct application of 50% RDF and lowest with RDF in pearl millet–mustard cropping sequence during both the years (Table 3). The results are in close agreement with those of Shankar *et al.* (2002).

It was concluded from the 2 year study that ridge and furrow sowing with 30 + 17.6 kg N+P/ha (50% RDF) and 6 t/ha FYM to pearl millet and 60+17.6 kg N+P/ha (RDF) to mustard is promising for productivity, water saving and economy.

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