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Crop productivity, quality and nutrient uptake of pearl millet (*Pennisetum glaucum*) Indian mustard (*Brassica juncea*) cropping system as influenced by land configuration and direct and residual effect of nutrient management*

C M PARIHAR[1], K S RANA[2] and M D PARIHAR[3]

Indian Agricultural Research Institute, New Delhi 110 012

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Pearl millet [*Pennisetum glaucum* L.R.Br.] plays a significant role in nutritious food as it is a rich source of vitamin, mineral and protein (protein tablets). However, its production and productivity is still very low in India. It is the stable food for millions of people in the low productive soils of semi-arid tropics. It had a distinct position in the agricultural economy of the country. At present it is occupying 9.6 million ha area with the total production of 7.70 million tonnes (Economic Survey 2006–07). Indian mustard [*Brassica juncea* (L.) Czernj and Coss.] is also one of the major oilseed crops of the country but production of this crop need to be enhanced to meet the national shortfall, as availability of edible oil in India is about 20 g/day/head against the balanced nutritional requirement of 30 g/day/head respectively (Economic Survey 2006–07). To meet the vegetable oil requirement of the country at optimum level, we have to increase our production from present level of 20 million tonnes to about 50 million tonnes by 2020 AD (Hegde 2005). At present these crops are grown over an area of 7.1 million ha with production of 7.9 million tonnes (Economic Survey 2006–07). If we want to achieve the target of 55 million tonnes oilseeds production by 2020 AD, we should give greater emphasis on proper agro-techniques, viz ridge and furrow sowing method and proper and balanced nutrition to these crops.

Keeping this in mind, an investigation was undertaken to study the effect of nutrient management (prilled urea nitrogen, single super phosphate phosphorus and farmyard manure application alone and in their different combinations and land configuration (flat sowing and ridge and furrow sowing). Pearl millet– Indian mustard is an efficient, potential and sustainable cropping system in northern plains of India. Therefore an attempt was made to assess the effect of land configuration (flat sowing and ridge and furrow sowing) and direct and residual effect of nutrient management on grain, stover yield, nutrient removal and quality in pearlmillet-mustard cropping system.

The field experiment was carried out at research farm of Indian Agricultural Research Institute, New Delhi during rainy and winter season of 2005–06 and 2006–07. The soil was sandy loam with *p*H 7.9–8.1, organic carbon 0.39–0.41%, available N 135.4–139.7, available P 12.8–13.2 and available K 178.8–181.4 kg/ha. The total rainfall was 506.1 mm in 2005–06 and 495.7 mm in 2006–07. There were two land configurations (flat sowing and ridge and furrow sowing) and 5 fertility levels (control, 30 kg N + 20 kg P_2O_5/ha, 60 kg N + 40 kg P_2O_5/ha, 30 kg N + 40 kg P_2O_5 + farmyard manure@ 6 tonnes/ha, farmyard manure@ 6 tonnes/ha alone) laid out in randomized block design to pearl millet. During winter season the experiment was laid out in split-plot design with land configuration and preceding nutrient levels applied to pearl millet in the main plots and three direct nutrient levels (control, 30 kg N + 20 kg P_2O_5/ha and 60 kg N + 40 kg P_2O_5/ha) through prilled urea and single superphosphate applied to succeeding mustard in the sub-plots. These treatments were replicated thrice. The well decomposed farmyard manure was applied 2–3 weeks before sowing and incorporated in the soil. Each year 'Pusa compositae 383' pearlmillet and 'Pusa Agrini' mustad cultivars were sown. Other management practices were adopted as per recommendations of the crops. Data obtained from pearlmillet and mustard crops for consecutive two years were statistically analyzed by using the F-test as per the procedure given by Gomez and Gomez (1984). LSD at *P*=0.05 were

*Short note

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[1]Scientist (Agronomy) (email: parihar.iari@yahoo.co.in), Directorate of Maize Research, Pusa, New Delhi 110 012

[2]Principal Scientist (email: ksrana04@yahoo.com) Division of Agronomy, IARI, New Delhi and; [3] PhD Scholar (email: muli_parihar@rediffmail.com) CCSHAU, Hisar 125 001

used to determine the significance differences between treatment means.

The ridge and furrow sowing (2.62 tonnes/ha) enhanced the grain yield of preceding pearl millet by 12.5% over the flat sown crop (2.33 tonnes/ha) in pearl millet Indian mustard cropping system (Table 1). Similar findings were observed in ridge and furrow sowing system (1.21 tonnes/ha) recorded 11.1% higher seed yield over the flat sowing (1.09 tonnes/ha) in succeeding mustard crop of pearl millet-mustard cropping system (Table 2). The higher seed yield of component crops in ridge and furrow system finally led to 11.6% higher total productivity in terms of pearl millet equivalent yield. Ridge and furrow sowing gave the higher net return (Rs 8 345 and 24 490) and net returns/Re invested (0.98 and 2.28) (Table1 2) over the flat sowing to preceding pearl millet and pearl millet–mustard cropping sequence. The superiority of ridge and furrow system could be ascribed to proper drainage of excess water coupled with adequate aeration at the time of excess rainfall, and moisture conservation during post- monsoon period. Similar effects of land configuration have also been reported by Kantwa *et al*. (2006). Higher yield (grain and stover) coupled with higher N, P, protein and oil content in plant (data not reported here) consequently resulted in higher N and P uptake by the component crops.

Integrated application of nutrients (30 kg N + 20 kg P_2O_5 + farmyard manure@ 6 tonnes/ha) to pearl millet significantly enhanced the grain and stover yield and total N and P uptake of pearl millet over the control, 30 kg N + 20 kg P_2O_5/ha and sole application of farmyard manure@ 6 tonnes/ha and remained at par with 60 kg N + 40 kg P_2O_5/ha through urea and single superphosphate in both the seasons and recorded 33.5% higher mean grain yield over control (Table 1). Integrated application of 30 kg N + 20 kg P_2O_5 + farmyard manure@ 6 tonnes/ha to pearl millet fetched highest mean net return (Rs 25 342),while the minimum was (Rs 18 193) with control during both the years of study (Table 2). This could be due to efficient utilization of nutrients from combined sources of prilled urea, single superphosphate and farmyard manure as compared to single chemical source. In addition to major nutrients, availability of micronutrients from farmyard manure might have helped in improvement of yield. The results are in conformity with those of Satyajeet and Nanwal (2007). Further the protein content in pearl millet grain also increased significantly due to integrated nutrient management over control and other lower fertility levels in both the seasons. It might be due to the fact that added nitrogen and phosphorus increased the N and P content in grain by providing favourable environment inside the plant, and higher photosynthetic efficiency, which favoured better growth and crop yields. Since, the uptake of nutrient increases in grain and stover yields together with higher N and P content resulted in greater uptake of these elements. These results are in conformity with those of Bhagchand and Gautam (2000) and Yakadari and Gautam (2001).

In mustard, marked positive residual effect of nutrient management to preceding pearl millet was noticed over unfertilized pearl millet in both the years. The residual effect of integrated application of 30 kg N + 20 kg P_2O_5 + farmyard manure@ 6 tonnes/ha to preceding pearl millet recorded significantly higher yield (seed and stalk), total N and P uptake and net returns in succeeding mustard (Table 2). The

Table 1 Effect of land configuration and nutrient management on yield, total N and P uptake, protein content (grain), and economics (mean data of two years) of pearlmillet

Treatment	Grain yield (tonnes/ha)	Stover yield (tonnes/ha)	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Protein content (%)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Land configuration									
L_1: Flat sowing	2.33	6.36	78.24	29.45	11.42	7 957	14 904	6 948	0.88
L_2: Ridge and furrow sowing	2.62	7.31	90.39	34.39	11.53	8 525	16 869	8 345	0.98
SEm ±	0.05	0.13	1.47	0.54	0.07		283	283	0.03
CD (*P*=0.05)	0.14	0.38	4.36	1.61	NS		841	841	0.10
Nutrient management									
F_0: Control	2.06	5.81	63.48	24.11	11.08	7 138	13 282	6 145	0.86
F_1: 30 kg N + 20 kg P_2O_5/ha	2.45	6.65	81.40	30.65	11.48	7 916	15 626	7 710	0.98
F_2: 60 kg N + 40 kg P_2O_5/ha	2.70	7.45	97.14	37.13	11.65	8 865	17 007	8 445	0.96
F_3: 30 kg N + 20 kg P_2O_5 + FYM @ 6 tonnes/ha	2.75	7.54	99.14	37.42	11.85	9 116	17 628	8 524	0.94
F_4: FYM @ 6 tonnes/ha	2.46	6.59	80.42	30.30	11.36	8 168	15 578	7 410	0.91
SEm ±	0.07	0.20	2.32	0.86	0.11		447	447	0.06
CD (*P*=0.05)	0.22	0.59	6.89	2.55	0.32		1 330	1 329	NS

FYM, Farmyard manure

Table 2 Effect of land configuration, preceding treatments and direct applied nutrients on yield of mustard (tonnes/ha), total productivity (tonnes/ha), production efficiency (kg/ha/day), protein content (%), total N and P uptake (kg/ha) and economics (mean data of two years) in pearl millet–mustard cropping system

Treatment	Mustard seed yield (tonnes/ha)	Mustard stalk yield (tonnes/ha)	Pearl millet equivalent yield	Total N uptake, mustard (kg/ha)	Total P uptake, mustard (kg/ha)	Production efficiency	Protein content (%)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Land configuration										
L_1: Flat sowing	1.09	3.17	5.84	51.23	12.90	27.81	19.10	9 928	21 078	2.11
L_2: Ridge and furrow sowing	1.21	3.47	6.52	57.69	16.64	31.05	19.41	10 661	24 490	2.28
SEm ±	0.02	0.04	0.06	0.79	0.21	0.27	0.14		294	0.03
CD (*P*=0.05)	0.05	0.13	0.17	2.39	0.61	0.79	NS		873	0.09
Nutrient management										
F_0: Control	0.95	2.75	5.14	41.43	11.24	24.45	17.66	8 939	18 193	2.03
F_1: 30 kg N + 20 kg P_2O_5/ha	1.10	3.19	5.97	52.64	13.91	28.38	19.24	9 888	21 908	2.21
F_2: 60 kg N + 40 kg P_2O_5/ha	1.27	3.64	6.78	61.96	16.87	32.26	20.06	10 836	25 247	2.36
F_3: 30 kg N + 20 kg P_2O_5 + FYM @ 6 tonnes/ha	1.31	3.76	6.95	64.41	18.97	34.60	20.10	11671	25342	2.23
F_4: FYM @ 6 tonnes/ha	1.13	3.27	6.06	52.84	14.46	28.81	19.23	10 139	22 104	2.17
SEm ±	0.03	0.07	0.09	1.27	0.32	0.41	0.22	–	465	0.05
CD (*P*=0.05)	0.08	0.22	0.27	3.78	0.96	1.26	0.61	–	1 380	0.14
Direct applied nutrients										
M_0: Control	0.95	2.79	5.55	41.99	11.45	26.43	17.81	9 229	20 186	2.17
M_1: 30 kg N + 20 kg P_2O_5/ha	1.20	3.47	6.32	56.83	15.41	30.10	19.42	10 178	23 480	2.29
M_2: 60 kg N + 40 kg P_2O_5/ha	1.31	3.70	6.67	64.55	17.51	31.74	20.54	11 477	24 010	2.11
SEm ±	0.03	0.07	0.08	1.27	0.31	0.36	0.22		416	0.04
CD (*P*=0.05)	0.07	0.21	0.23	3.62	0.90	1.07	0.64		1 187	0.11

FYM, Farmyard manure

yield increment in mustard due to residual effect of integrated applied nutrients to preceding pearl millet being 37.9, 19.1 and 15.9%, respectively, over the unfertilized, 30 kg N + 20 kg P_2O_5/ha and sole application of farmyard manure@ 6 tonnes/ha to pearl millet respectively. Integrated application of 30 kg N + 20 kg P_2O_5 + farmyard manure@ 6 tonnes/ha to pearl millet failed to bring significant increase in seed and stalk yield, total N and P uptake and net returns in succeeding mustard crop over the 60 kg N + 40 kg P_2O_5/ha applied to preceding pearl millet. Similar results were also reported by Satyajeet *et al*. (2007).

Direct application of nitrogen and phosphorus to mustard markedly increased the seed and stalk yield, total N and P uptake and net returns. However, direct application of 60 kg N + 40 kg P_2O_5/ha to mustard recorded significantly higher total N and P uptake over the control and 30 kg N + 20 kg P_2O_5/ha to mustard. Application of 60 kg N + 40 kg P_2O_5/ha significantly increased the seed yield of mustard by 37.9 and 9.2% over the control and 30 kg N + 20 kg P_2O_5/ha, respectively. Direct application of 60 kg N + 40 kg P_2O_5/ha to mustard fetched highest mean net returns (Rs 24 010), While the lowest mean net return was obtained with control (Rs 20 186). However, the net returns/Re invested was highest (2.29) with direct application of 30 kg N + 20 kg P_2O_5/ha and lowest (2.11) with 60 kg N + 40 kg P_2O_5/ha in pearl millet–mustard cropping sequence (Table 2).This might be due to continued and balanced supply of nutrients enhancing their availability and with their active involvement in shoot and root growth exhibited better plan growth which consequently leds to higher yield of mustard. These results are in conformity with those of Sharma and Singh (2009).

Regarding directly applied nutrients, nitrogen and phosphorus and protein concentration in seed registered higher values with 60 kg N + 40 kg P_2O_5/ha. It was mainly because of close inter-relationship between nitrogen and phosphorus metabolism of plant cells and combined application of N and P. The total uptake of N and P by seed and stalk increased significantly with 60 kg N + 40 kg P_2O_5/ha. This expected phenomenon was the consequence of increased N and P concentration and total biomass with increasing levels of fertility. These results are in close agreement with those of Mahala *et al*.(2006).

Integrated application of 30 kg N + 20 kg P_2O_5 + farmyard manure@ 6 tonnes/ha to pearl millet markedly increased the pearl millet equivalent yield (PEY), production efficiency,

total N and P uptake and net returns of the system (Table 2). The increment in PEY and production efficiency were due to residual effect of integrated application of prilled urea nitrogen, single super phosphate phosphorus and farmyard manure to preceding pearl millet being 35.2 and 41.5, 16.4 and 21.9 and 14.7 and 20.1% in pearl millet– Indian mustard cropping sequence, respectively over the control, 30 kg N + 20 kg P_2O_5/ha and sole application of farmyard manure@ 6 tonnes/ha and remained at par with 60 kg N + 40 kg P_2O_5/ ha.

As far as the direct effect of prilled urea nitrogen and single super phosphate phosphorus on pearl millet–mustard cropping is concerned application of 60 kg N + 40 kg P_2O_5/ ha being significantly increased the PEY and production efficiency (20.1 and 20.2, 5.3 and 5.4%) in pearl millet–Indian mustard cropping sequence, respectively, and total N and P uptake over the control and 30 kg N + 20 kg P_2O_5/ha. The increase in total uptake of N and P with nitrogen and phosphorus fertilization could be attributed to the fact that added N and P increased the availability of N and P to plant due to priming effect which in turn might have resulted in profuse shoot and root growth and thereby activating greater absorption of N and P from soil and thus improved seed and stalk yields. The present trend is in line reported by Tomar *et al*. (1997) and Mishra and Giri (2004).

SUMMARY

Field experiments were carried out during 2005–07 to assess the effect of land configuration and nutrient management in pearl millet (*Pennisetum glaucum* (L.) R. Br. Emend Stuntz) – Indian mustard [*Brassica juncea* (L.) czernjscoss] cropping system. The principal findings revealed that ridge and furrow sowing method improved grain yield (12.5 and 11.1%), stover yield (14.9 and 9.5%), protein content (0.96 and 1.6%),total N (15.5 and 12.6%)and P(16.8 and 29.0%) uptake, net returns (20.1 and 16.2%) and pearl millet equivalent yield and production efficiency in pearl millet and also to succeeding mustard over the flat sowing respectively. The integrated application of 30 kg N + 20 kg P_2O_5 + farmyard manure@ 6 tonnes/ha gave significantly higher grain yield(33.5 and 37.9,%), stover yield(29.8 and 36.7%), protein content (6.9 and 13.8%),total N (56.2 and 55.5%) and P (55.2 and 68.7%) uptake, net returns (38.7 and 39.3%) and pearl millet equivalent yield and production efficiency to pearl millet and succeeding mustard respectively over the control and remained at par with 60 kg N + 40 kg P_2O_5/ha. However direct application of 60 kg N + 40 kg P_2O_5/ha to Indian mustard gave significantly higher seed yield (37.9 and 9.2%), stalk yield (32.6 and 6.6%), protein content (15.3 and 5.8%), total N (53.7 and 13.6%) and P (52.9 and 13.6%) uptake, net returns (18.9 and 22.6%), pearl millet equivalent yield and production efficiency in pearl millet–mustard cropping system over the control and 30 kg N + 20 kg P_2O_5/ha, respectively.

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