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Productivity and nutrient uptake of mustard (*Brassica juncea*) influenced by land configuration and residual and directly applied nutrients in mustard under limited moisture conditions

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ABSTRACT

A field experiment was conducted to study the productivity and nutrient uptake of mustard [*Brassica juncea* (L.) Czernj. & Coss.] influenced by land configuration and preceding and directly applied nutrients in greengram [*Vigna radiata* (L.) Wilczek]–mustard cropping system under limited irrigation conditions on a sandy loam soil at research farm of Indian Agricultural research institute, New Delhi, during 2010-11 and 2011-12. The treatment comprised of four land configuration (Flat bed, flat bed with mulch, ridge and furrow and broad bed and furrow methods) and three preceding fertility levels (Control, 15 kg N + 30 kg P_2O_5 + PSM and 15 kg N + 30 kg P_2O_5/ha) as main plot and three directly applied fertility levels (Control, 30 kg N + 30 kg P_2O_5 and 60 kg N + 60 kg P_2O_5/ha replicated thrice in split plot design. Flat bed with mulch was significantly superior over other land configuration system in terms of growth parameter, yield attributes and yield as well as nutrient uptake. The residual nutrient management showed a positive response on influencing the growth attributes, yield attributes and yield of mustard. Application of 15 kg N + 30 kg P_2O_5 + PSM/ha to greengram as residual nutrients for next season significantly made the difference in terms of productivity, profitability and nutrient uptake. The direct applied nutrients to the mustard at the rate of 60 kg N + 60 kg P_2O_5 was significant over other fertility levels in terms of growth parameters, yield attributes and yield. Application of 60 kg N + 60 kg P_2O_5/ha increased the mean net returns and B: C ratio by 59 and 16.8% and 26 and 4.5% over control, 30 kg N + 30 kg P_2O_5/ha, respectively.

Key words: Economics, Growth and yield attributes, Land configuration, Mustard, Nutrient uptake, Nutrient management

In grey areas of the country, the only alternative to increase production of pulses and oilseed by adoption of location-specific cropping systems like greengram [*Vigna radiata* (L.) Wilczek]–mustard [*Brassica juncea* (L.) Czernj & Coss.] sequence in which greengram grown during *kharif* and mustard during *rabi* season have been most important crops of dryland and/or areas with limited water availability under marginal and sub-marginal conditions of land in north-west, west and central parts of India, particularly in states like Haryana, Rajasthan, Uttar Pradesh and Madhya Pradesh, where monocropping of greengram and mustard is common. The most important reason is low requirement of water, inputs and labour in comparison to other mustard based cropping sequences. Not only low input requirement but also attractive price of mustard is a major factor for enhancing area under mustard crop.

If we want to achieve the target of 55 million tonnes oilseeds production by 2020, we should give greater emphasis to increase the production of *rabi* oilseeds in general and rapeseed–mustard in particular. During last two decades irrigated area under these crops has increased from 42% to 64% (FAI 2002). This has made it possible to grow mustard in cropping sequence under limited irrigation. However, yield obtained from mustard is low due to adoption of poor agronomic practices, of which nutrient management and planting methods are most important. The major constraint limiting the productivity of oilseeds is that they are predominantly raised under energy-starved conditions (on poor fertile lands). Dryland areas constitute nearly 64% of the total cultivated area and account 42% of total food production in the scene of Indian agriculture (NRAA 2010). To conserve soil moisture, the mulches play an important role. Mulches prevent soil from blowing and being washed away reduces evaporation, increase infiltration, keep down weeds, improves soil structure and eventually increase crop

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yields. Studies on mulching carried out in India under rainfed agriculture have concentrated on the measurement of crop responses rather than in the manner in which crop responses are influenced. Again the ridge-furrow and broad bed-furrow system of planting help in soil moisture conservation, soil aeration and synergistic effect on the availability of nitrogen and phosphorus. Thus, conservation of moisture is most important for boosting agriculture productivity and enhancing the recovery of applied nutrients.

Dryland areas are not only thirsty but also hungry. Nitrogen and phosphorus are the major nutrients which play an important role in crop production. The nitrogen recognized as kingpin to the fertilization programme for higher yield. Nitrogen is an important constituent of chloroplast which plays in important role in photosynthesis. Phosphorus increases the root length and root branching which in turn improves moisture utilization under dryland conditions. Nitrogen and phosphorus are involved in wide range of plant processes from permitting cell division to the development of plant.

MATERIALS AND METHODS

The experiment was conducted during 2010-11 and 2011-12 at research farm Indian agricultural research institute, New Delhi, situated at a latitude of 28^0 $40^/$ N, longitude of $77°12^/$ E and altitude of 228.6 m above the mean sea level. The mean annual rainfall of Delhi is 650 mm and more than 80% generally occurs during the south west monsoon season with mean annual evaporation of 850 mm. The rainfall was 954 mm during first year and 662 in second year. Thus, establishment of crops, their growth and productivity were better in 2010-11. The soils of experimental field had 145.5 kg/ha alkaline permanganate oxidizable, 11.8 kg available P kg/ha, 212 kg 1 N ammonium acetate exchangeable K, 0.33% organic carbon with 7.6 pH of soil (1:2.5 soil: water). The moisture at 1/3 and 15 atmospheric tensions were 16.61 % and 7.63 %, respectively with bulk density 1.5 (g/cc) of 0-30 cm layer.

The experiment was laid out in factorial randomized block design during *kharif a*nd split plot in *rabi* season. The treatment comprised four land configuration (Flat bed, flat bed with mulch, ridge and furrow and broad bed and furrow methods) and three preceding fertility level to greengram (Control, 15 kg N +30 kg P_2O_5 + PSM/ha and 15 kg N + 30 kg P_2O_5/ha) as main plot and direct applied nutrient to mustard (Control, 60 kg N + 60 kg P_2O_5 and 30 kg N + 30 kg P_2O_5/ha) replicated thrice. In mustard, spacing was 45 cm row to row and 10 cm plant to plant. Mustard (Pusa Agrani) was grown as per recommended package of practices without any irrigation. The plot size in *kharif* season for greengram was 24 m^2 and 8.1 m^2 in *rabi* season for mustard.

Table 1 Effect of land configuration, residual nutrient management and direct applied nutrients on plant height (cm) at different growth stages of mustard

Treatment	Plant height (cm)				Dry matter (g/plant)			
	30 DAS	60 DAS	90 DAS	At maturity	30 DAS	60 DAS	90 DAS	At maturity
Land configuration								
Flat bed	11.8	97.7	146.9	152.0	1.6	8.60	16.5	23.3
Flat bed with mulch	14.4	124.1	172.2	177.8	2.2	12.7	30.3	39.9
Ridge and furrow	12.8	109.2	159.3	162.9	1.9	10.5	24.7	32.7
Broad bed and furrow	13.3	114.3	163.4	168.4	2.0	11.2	25.8	35.0
SEm±	0.3	2.7	32.1	2.4	0.1	0.3	0.4	0.7
CD (P=0.05)	0.9	7.8	6.3	7.0	0.2	0.9	1.3	2.2
Residual nutrient management								
Control	12.3	102.7	155.4	158.9	1.7	9.5	21.1	28.4
15 kg N + 30 kg P_2O_5	13.3	114.4	162.0	166.7	2.0	11.1	25.4	34.1
15 kg N + 30 kg P_2O_5 + PSB + VAM	13.7	117.0	164.1	170.3	2.1	11.7	26.4	35.7
SEm±	0.3	2.3	1.9	2.1	0.1	0.3	0.4	0.6
CD (P=0.05)	0.8	6.8	5.5	6.1	0.2	0.8	1.1	1.9
Fertility levels								
Control	11.8	98.9	151.8	158.0	1.6	9.0	19.3	27.0
30 kg N + 30 kg $P_2 O_5$	13.1	113.3	161.8	166.2	2.0	11.0	25.0	33.7
60 kg N + 60 kg P_2O_5	14.5	121.8	167.8	171.6	2.1	12.3	28.5	37.6
SEm±	0.3	2.0	1.5	1.8	0.04	0.2	0.4	0.5
CD (P=0.05)	0.8	5.6	4.1	5.1	0.1	0.6	1.1	1.3

RESULTS AND DISCUSSION

Growth and yield attributes of mustard

All the growth parameters of mustard (plant height, crop growth rate and leaf area index) were significantly influenced due to land configuration (Table 1). On an average 9.4, 14.9 and 25.8 cm plant height of mustard were more at maturity stage in flat bed with mulch method than broad bed and furrow, ridge & furrow and flat bed method, respectively. Flat bed decreased leaf area index by 29.3, 20.6 and 15.8% over flat bed with mulch method, broad bed and furrow, ridge and furrow at maturity stage, respectively. The dry matter of mustard in flat bed with mulch was 71% more at maturity stage over flat bed land configuration. Among the land configuration, primary branches/plant (5.6), secondary branches/plant (12.1), number of siliquae/plant (460.9) and number of seeds/siliqua (13.4) were found maximum in flat bed mulching than other land configuration methods (Table 2). The seed yield of mustard was lower by 34.3% in flat bed as compared to flat bed with mulch land configuration method (Table 2). The results were also reported by (Kantwa *et al.* 2005).

The residual nutrient management showed a positive response on influencing the growth attributes, yield attributes and yield of mustard. Application of 15 kg N + 30 kg P_2O_5 + PSM/ha to greengram as residual nutrients for next season significantly increased the plant height, dry matter and leaf area index of mustard over control. The highest number of primary branches/plant (5.6), secondary branches/plant (12.1), number of siliquae/plant (460.9) and number of seeds/siliqua (13.4) were also found maximum under the same treatment (Table 2). The mustard crop receiving from previous season applied nutrients for greengram crop (15 kg N + 30 kg P_2O_5 + PSM/ha) as residual nutrients, enhanced the 15.8% seed yield over control.

Fertility levels for mustard crop significantly increased the growth attributes and yield of mustard as compared to control. The maximum plant height (14.5, 121.8, 167.8 and 171.6 cm), dry weight (2.1, 12.3, 28.5 and 37.6 g/plant) at 30, 60, 90 DAS and maturity stage respectively was recorded with the application of 60 kg N + 60 kg P_2O_5/ha over control. The maximum leaf area index (0.47, 1.57 and 1.9 at 30, 60 and 90 DAS, respectively) were also significantly higher under same fertility levels than control. The maximum seed yield was obtained with the application of 60 kg N + 60 kg P_2O_5/ha (2.40 tonnes/ha) followed by 30 kg N + 30 kg P_2O_5 (2.10 tonnes/ha), which was 46 and 31.7, and 27% higher over control, respectively (Table 2). This might be resulted from favourable influence of phosphorus nutrition on the growth parameters (plant height, LAI, branching and dry matter production). Which was improve greater nutrient uptake, efficient partitioning of metabolites, adequate translocation and accumulation of photosynthates. The observations of the present study are in line with the findings of Kumar and Rana (2007).

Nutrient concentration and their uptake

Nutrient (N, P and K) concentration in seed and stover remained unaffected by land configuration (Table 3). Land configuration had significant effect on N, P and K uptake by seed and stover by mustard (Table 4). Flat bed with mulch method increased the N, P and K uptake in seed by 39, 41 and 39.5% and 26, 27 and 24% in stover, respectively over flat bed.

The maximum N (3.02 and 0.60%), P (0.88 and 0.63%) and K (0.30 and 0.41%) concentration in seed and stover of mustard, respectively was noticed with the residual nutrients (applied for greengram) of 15 kg N + 30 kg P_2O_5 + PSM/ha as compared to other fertility levels. Inclusion of biofertilizers with 15 kg N + 30 kg P_2O_5 /ha improved the quality and nutrient concentration of mustard over only 15 kg N + 30 kg P_2O_5 /ha (Table 3). Application of 15 kg N + 30 kg P_2O_5 + PSM/ha had significant effect on nutrient uptake of N, P and K by seed and stover followed by over control (Table 4). The

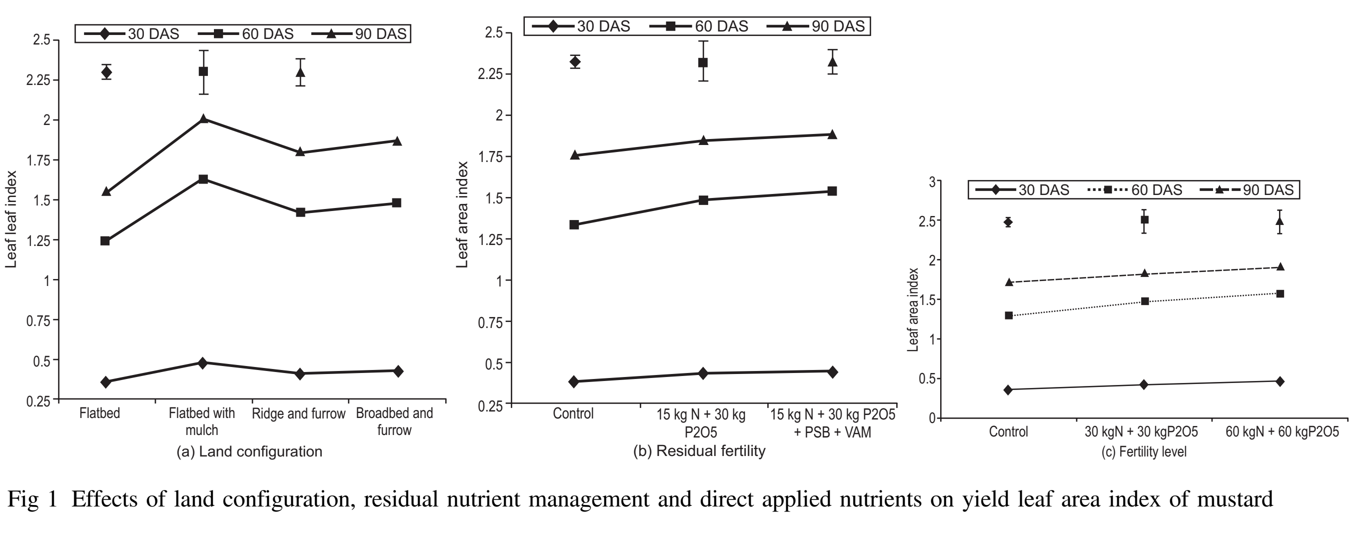

Fig 1 Effects of land configuration, residual nutrient management and direct applied nutrients on yield leaf area index of mustard

Table 2 Effects of land configuration, residual nutrient management and direct applied nutrients on yield attributes and yield of mustard

Treatments	Primary branches/ plant	Secondary branches/ plant	Siliquae/ plant	Seeds/ siliqua	Test weight (g)	Seed yield (tonnes/ ha)	Stover yield (tonnes/ha)	Harvest index (%)
Land configuration								
Flat bed	5.0	9.6	368.5	11.5	4.7	1.75	5.35	24.45
Flat bed with mulch	5.6	12.1	460.9	13.4	4.8	2.35	6.55	26.50
Ridge and furrow	5.3	10.6	427.5	13.0	4.8	2.05	5.95	25.30
Broad bed and furrow	5.4	11.1	403.6	12.7	4.8	2.10	6.15	25.75
SEm±	0.1	0.3	10.4	0.3	0.04	0.10	0.10	0.70
CD (P=0.05)	0.3	0.9	30.4	0.9	NS	0.20	0.30	NS
Residual fertility level								
Control	5.0	10.0	381.1	11.9	4.7	1.90	5.70	24.70
15 kg N + 30 kg P_2O_5	5.4	10.9	423.8	12.8	4.8	2.10	6.00	25.80
15 kg N + 30 kg P_2O_5 + PSB + VAM	5.5	11.6	440.5	13.3	4.8	2.20	6.20	26.00
SEm±	0.1	0.3	9.0	0.3	0.03	0.10	0.10	0.65
CD (P=0.05)	0.3	0.8	26.4	0.8	NS	0.20	0.25	NS
Fertility levels								
Control	4.8	9.3	341.0	11.1	4.7	1.65	4.95	24.90
30 kg N + 30 kg P_2O_5	5.4	11.0	431.3	12.7	4.8	2.10	6.10	25.60
60 kg N + 60 kg P_2O_5	5.7	12.3	473.0	14.2	4.8	2.40	6.90	26.00
SEm±	0.1	0.3	7.2	0.2	0.03	0.00	0.10	0.45
CD (P=0.05)	0.3	0.7	20.5	0.5	NS	0.10	0.25	NS

improvement in quality and nutrient concentration could be attributed to higher N and P concentration in seed where crops were sown with N and P-fertilizers (Singh and Rana 2006). This could be attributed to higher N concentration in seed where crops were sown with N and P-fertilizers (Ansari *et al.* 2012).

The maximum N (3.22 and 0.59%), P (0.88 and 0.65%) and K (0.32 and 0.41%) concentration in seed and stover,

Table 3 Effect of land configuration, residual nutrient management and direct applied nutrients on nutrient concentration of mustard

Treatment	Nutrient concentration in seed (%)			Nutrient concentration in stover (%)		
	N	P	K	N	P	K
Land configuration						
Flat bed	2.92	0.56	0.84	0.59	0.28	0.39
Flat bed with mulch	3.00	0.58	0.87	0.62	0.30	0.41
Ridge and furrow	2.95	0.56	0.86	0.61	0.29	0.40
Broad bed and furrow	2.98	0.57	0.86	0.61	0.29	0.40
SEm±	0.02	0.01	0.02	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Residual nutrient management						
Control	2.86	0.51	0.83	0.57	0.27	0.39
15 kg N + 30 kg P_2O_5	3.01	0.59	0.86	0.63	0.30	0.41
15 kg N + 30 kg P_2O_5 + PSB + VAM	3.02	0.60	0.88	0.63	0.30	0.41
SEm±	0.02	0.01	0.01	0.01	0.00	0.01
CD (P=0.05)	0.06	0.02	NS	0.02	0.01	NS
Fertility levels						
Control	2.55	0.54	0.83	0.55	0.25	0.39
30 kg N + 30 kg P_2O_5	3.12	0.57	0.86	0.62	0.30	0.40
60 kg N + 60 kg P_2O_5	3.22	0.59	0.88	0.65	0.32	0.41
SEm±	0.02	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.05	0.03	NS	0.02	0.03	NS

Table 4 Effect of land configuration, residual nutrient management and direct applied nutrients on nutrient uptake of mustard

Treatment	Nutrient uptake in seed (kg/ha)			Nutrient uptake in stover (kg/ha)		
	N	P	K	N	P	K
Land configuration						
Flat bed	51.70	9.7	14.70	32.20	15.30	21.30
Flat bed with mulch	72.00	13.7	20.50	40.60	19.45	26.45
Ridge and furrow	60.60	11.35	17.30	36.10	17.25	23.85
Broad bed and furrow	64.35	12.25	18.20	37.60	17.95	25.05
SEm±	1.85	0.40	0.65	0.85	0.50	0.75
CD (P=0.05)	5.40	1.10	1.95	2.35	1.35	2.25
Residual fertility level						
Control	55.25	9.65	15.70	33.00	15.75	22.25
15 kg N + 30 kg P_2O_5	63.65	12.35	18.00	37.70	17.90	24.45
15 kg N + 30 kg P_2O_5 + PSB + VAM	67.50	13.30	19.30	39.15	18.65	25.80
SEm±	1.60	0.35	0.60	0.70	0.40	0.65
CD (P=0.05)	4.70	0.95	1.65	2.05	1.15	1.95
Fertility levels						
Control	41.75	8.85	13.60	27.35	12.45	19.20
30 kg N + 30 kg P_2O_5	66.10	11.95	18.05	38.00	18.10	24.60
60 kg N + 60 kg P_2O_5	78.55	14.40	21.40	44.60	21.75	28.70
SEm±	1.25	0.25	0.50	0.65	0.30	0.80
CD (P=0.05)	3.45	0.70	1.40	1.80	0.80	2.30

respectively was noticed with the application of 60 kg N + 60 kg P_2O_5 as compared to other fertility levels (Table 3). Application of 60 kg N + 60 kg P_2O_5 increased the N (89 and 18.8%), P (62.7 and 20.5) and K (57.3 and 18.5%) in seed over control and 30 kg N + 30 kg P_2O_5, respectively. P being responsible for synthesis of DNA and RNA and as an ingredient of phospho-proteins plays a central role in synthesis of proteins. Improvement in nutrient concentration in seed and stover due to N and P fertilization has also been reported by Parihar *et al.* (2009).

Economics

Flat bed with mulch land configuration on an average fetched ₹ 14.8 × 10^3/ha and ₹ 12.35 × 10^3/ha more gross and net returns over flat bed method, respectively and thus has 0.44 more B: C ratio than flat bed (Fig 2). The higher seed yield with the corresponding stover yield and with minimal increases in cost of cultivation has resulted in higher net returns and B: C ratio in flat bed with mulch land configuration (Chaudhary and Thakur 2005).

Among the residual nutrient management, the maximum net returns and B: C ratio were recorded with application of 15 kg N + 30 kg P_2O_5 + PSM/ha, followed by 15 kg N + 30 kg P_2O_5 (Fig 2). The higher net returns with combined fertilizer source were due to higher pod yield. With the inclusion of biofertilizers with 15 kg N + 30 kg P_2O_5, the net returns were increased over other fertility levels. Significant increase in yield with application of biofertilizers through organic and inorganic sources over control was due to enhancement of yield resulting in higher net returns. Minimum B: C ratio with control was due to the lower yield. Similar findings were reported by Ghosh *et al.* (2009).

Application of 60 kg N + 60 kg P_2O_5/ha through fertilizer enhanced mean net returns by ₹ 15.55 × 10^3/ha over control. Further, application of 30 kg N + 30 kg P_2O_5/ha enhanced net returns by ₹ 9.55 × 10^3/ha over control. Application of 60 kg N + 60 kg P_2O_5/ha increased the mean net returns and B: C ratio by 59 and 16.8% and 26 and 4.5% over control, 30 kg N + 30 kg P_2O_5/ha, respectively. These findings are in line with those of Ghosh *et al*. (2009).

Coefficient of determination

A significant correlation between siliquae/plant and seeds/siliqua with seed yield further justified the beneficial effect of land configuration, residual nutrients from preceding crops for succeeding crops and direct nutrient application for mustard. Siliquae/plant and seeds/siliqua of mustard was linearly related to seed yield with coefficient of determination 0.95 and 0.94, respectively. In the same way significant correlation was also found between N and P uptake by seed with seed yield (R^2=0.95 and 0.96, respectively). It showed that with the increase of yield attributing characters and nutrient uptake with various land configuration and nutrients application by directly/indirectly, increased the seed yield of mustard (Fig 2).

Thus results of the present investigation clearly

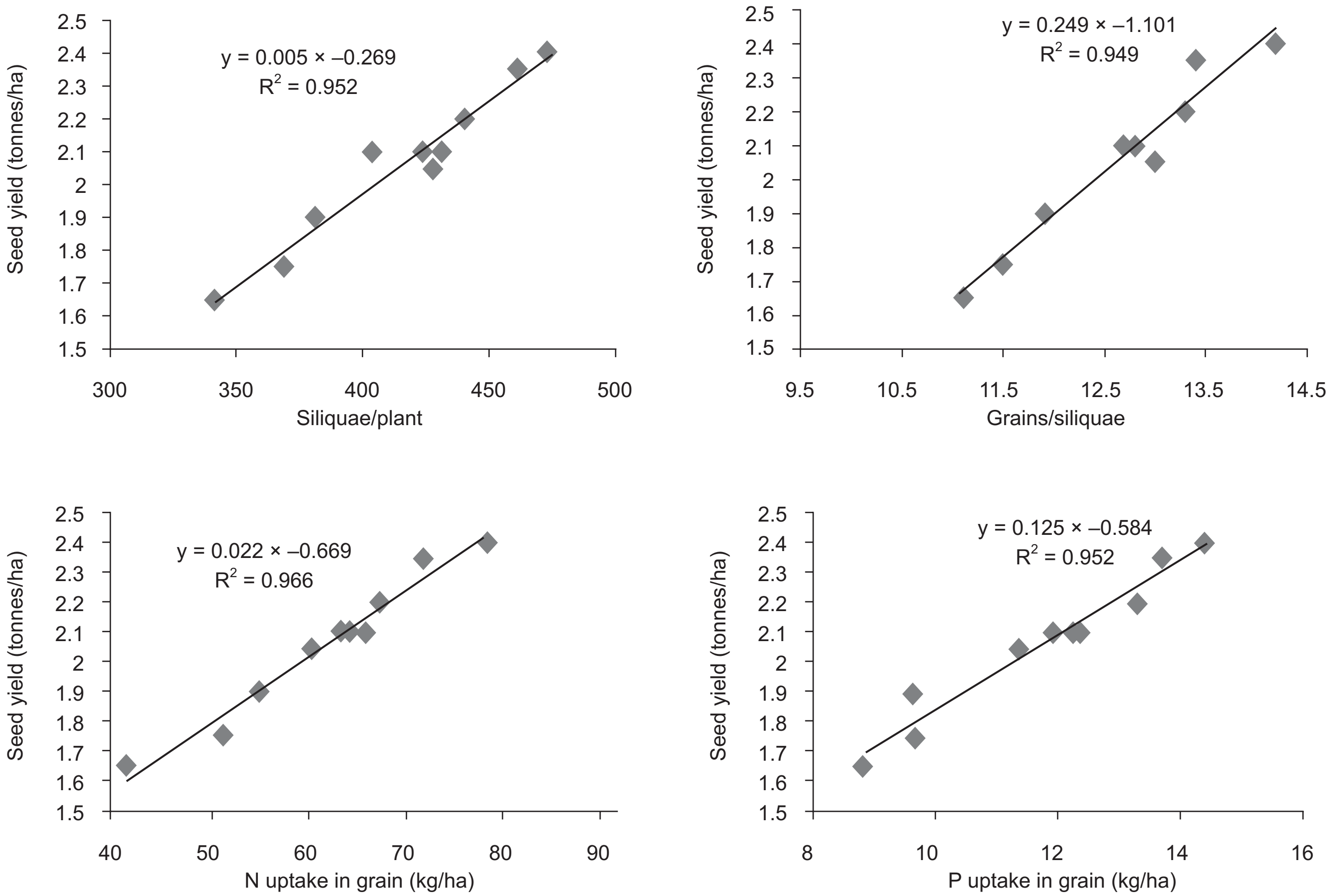

Fig 2 Relationship between siliquae/plant, seed/siliqua and N and P uptake with seed yield of mustard under land configuration, residual nutrient management and direct applied nutrients (mean of two years data)

demonstrate that flat bed with mulch land configuration system can be practiced to achieve better high yield as well as profitability and nutrient uptake than other land configuration system. Application of 60 kg N + 60 kg P_2O_5/ha was found to be more productive over other fertilizer doses.

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