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Residual effect of organic manure, phosphorus and gypsum application in preceding groundnut (*Arachis hypogaea*) on soil fertility and productivity of Indian mustard (*Brassica juncea*)

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ABSTRACT

A field experiment was conducted during 1997–98 and 1998–99 to evaluate the residual effect of organic manure, phosphorus and gypsum application in preceding groundnut (*Arachis hypogaea* L.) on soil fertility and productivity of Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson]. Groundnut crop received 0, 10 tonnes FYM and 5 tonnes poultry manure/ha as organic manure and 3 levels of P (20, 40 and 60 kg P_2O_5/ha). These 9 treatment combinations were kept in main plots and 3 gypsum levels (control, 250 kg/ha at sowing and 125 kg/ha at sowing + 125 kg ha at 35 days after sowing) in subplots. Residual effect of organic manure significantly increased branches/plant, siliquae/plant and 1,000-seed weight, and the seed yield of Indian mustard. The magnitude of increase in seed yield owing to residual effect of FYM and poultry manure was of 9.3 and 12.1% over the control. Residual effect of 60 kg P_2O_5/ha significantly increased siliquae/plant, seed weight/plant and 1,000-seed weight, and thereby the total seed yield of Indian mustard, which increased by 9.7% over 20 kg P_2O_5/ha. Significant improvement in yield attributes and seed yield of Indian mustard was also recorded where residual effects of gypsum treatments were applied compared with no gypsum residual.

Key words : Groundnut, Indian mustard, Residual effect, Organic manure P, Zn, Soil fertility, Productivity

The fertilizer need of a crop in cropping system mainly depends on the characteristics of preceding crop and kind and quantities of fertilizer applied. Organic manure besides supplying nutrients to the current crop often leaves substantial residual effect on the succeeding crops in the system (Gaur, 1982). The carry-over effect of phosphorus is well known and first crop hardly utilizes 15 to 20% of the applied

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phosphorus. Besides the usual residual effect of phosphorus, groundnut being a legume, benefits the following crop as a result of better N_2-fixation under optimum P. Studies to assess direct and residual effect of sulphur revealed positive influences regardless of which crop was fertilized with S (Pasricha and Aulakh, 1986). Groundnut is usually rotated with wheat and pulses in northern states. But in recent years, with the advent of high- yielding and short-duration varieties of groundnut and Indian mustard, a groundnut–mustard crop sequence had gained momentum particularly under semi- arid agro-climatic conditions of Rajasthan owing to its economic viability. The aim of this study was to evaluate the effect of residual fertility on Indian mustard production.

MATERIALS AND METHODS

A field experiment was conducted at Agronomy farm (*Jung ki Bari*), Rajasthan College of Agriculture, Udaipur, during 1997–98 and 1998–99. The soil was sandy clay loam with pH 7.6 and low to medium in fertility status. Indian mustard was sown in winter season after the harvest of rainy-season (*kharif*) groundnut. Groundnut crop received combination of organic manure (0, 10 tonnes FYM and 5 tonnes poultry manure/ha) and 3 P levels (20, 40 and 60 kg P_2O_5/ha) in main plots and 3 gypsum levels (control, 250 kg/ha at sowing and 125 kg/ha at sowing + 125 kg/ha at 35 DAS) placed in subplots and were replicated 4 times. 'Pusa Bold' Indian mustard was sown on 9 November 1997 and 2 November 1998 in rows 30 cm apart on residual soil fertility without disturbing original layout plan of main crop. Soil samples before and after the harvest and plant samples at harvest were collected and analysed by standard methods.

RESULTS AND DISCUSSION

Residual effect of organic manure

Farmyard manure at 10 tonnes/ha and poultry manure at 5 tonnes/ha brought significant improvement in available N in the soil over the control after the harvest of groundnut crop, during both the years. The effect of FYM on available P was significant during 1997 and on available S during 1998. The effect of poultry manure on available P was significant in 2 years and available S was significant during 1998 (Table 1)

The residual effect of FYM and poultry manure significantly increased branches/plant, siliquae/plant, seed weight/plant (except with FYM during 1998) and 1,000-seed weight during both the years (Table 2). Such conducive effect of these organic manure may be owing to increased availability of nutrients in soil from native pool as well as their residual effect through mineralization and improvement of physico-chemical properties of the soil (Ismail *et al.*, 1998). Increased vegetative growth and yield attributes under organic manure application resulted in additional improvement in seed yield. This has led to the enhancement of seed yield of Indian mustard by 9.3 and 12.1% under residual effect of FYM and poultry manure, over the control respectively (Table 3). This effect is due to enrichment of the soil with nutrients, as evident from significant increase in the uptake of N, P and S (except with FYM

Table 1. Effect of organic manure, phosphorus and gypsum application in groundnut on soil fertility after its harvest

Treatment	Available N (kg/ha)		Available P (kg/ha)		Available S (kg/ha)	
	1997	1998	1997	1998	1997	1998
Organic manure/ha						
Control	252.1	246.4	20.05	18.95	22.61	22.72
FYM 10 tonnes	263.2	263.4	21.62	19.97	23.14	25.03
PM 5 tonnes	265.1	261.7	21.51	21.49	23.43	24.94
CD (P=0.05)	9.0	11.9	1.38	1.27	NS	1.28
Phosphorus (kg P_2O_5/ha)						
20	254.4	249.0	20.07	18.84	22.41	23.41
40	260.0	258.4	21.24	20.07	23.05	24.79
60	266.1	264.1	21.87	21.50	23.72	24.50
CD (P=0.05)	9.0	11.9	1.38	1.27	NS	12.8
Gypsum (250 kg/ha)						
Control	254.9	252.0	20.84	19.83	19.87	21.51
Full at sowing	262.3	259.5	21.25	20.23	23.25	25.38
Half at sowing + half at 35 DAS	263.3	251.9	21.09	20.35	26.06	25.80
CD (P=0.05)	5.5	6.3	NS	NS	0.68	0.95

FYM, Farmyard manure; PM, poultry manure

Table 2. Residual effect of organic manure, phosphorus and gypsum on yield attributes of Indian mustard

Treatment	Branches/ plant		Siliquae/ plant		Seed weight (g/plant)		1,000-seed weight (g)	
	1997	1998	1997	1998	1997	1998	1997	1998
Organic manure/ha								
Control	4.6	3.9	197.4	206.3	10.8	9.8	3.37	3.26
FYM 10 tonnes	5.1	4.4	211.5	223.6	11.4	10.4	3.51	3.54
PM 5 tonnes	5.0	4.6	213.3	219.9	11.7	10.6	3.58	3.63
CD (P=0.05)	0.3	0.3	9.7	12.9	0.6	0.7	0.12	0.11
Phosphorus (kg P_2O_5/ha)								
20	4.6	4.1	197.1	207.7	10.5	9.9	3.35	3.26
40	4.8	4.3	207.8	217.9	11.6	10.1	3.51	3.50
60	5.2	4.5	217.2	224.2	11.8	10.8	3.61	3.67
CD (P=0.05)	0.3	0.3	9.7	12.9	0.6	0.7	0.12	0.11
Gypsum (250 kg/ha)								
Control	4.7	4.2	200.4	209.9	10.4	9.3	3.39	3.25
Full at sowing	4.9	4.3	208.7	219.6	11.5	10.8	3.53	3.59
Half at sowing + half at 35 DAS	5.0	4.5	213.1	220.2	11.9	10.7	3.55	3.60
CD (P=0.05)	0.2	NS	6.0	7.3	0.6	0.6	0.10	0.10

FYM, Farmyard manure; PM, poultry manure

during 1997) by Indian mustard under residual effect of FYM and poultry manure (Table 4). Significant increase in oil content of Indian mustard seed under residual effect of FYM and poultry manure may be attributed to improvement in S uptake.

Organic manure applied to the preceding groundnut crop significantly increased the net returns of Indian mustard crop as well as groundnut + Indian mustard cropping system during both the years. Residual effect of 10 tonnes FYM and 5 tonnes poultry manure/ha recorded higher net returns of Indian mustard by Rs 1,731 and Rs 2,271/ha, respectively, over the control. For groundnut + Indian mustard cropping system, application of 10 tonnes FYM and 5 tonnes poultry manure recorded net return by a mean of Rs 40,411 and Rs 39,926/ha compared with Rs 36,477/ha recorded under the control.

Residual effect of phosphorus

Application of 60 kg P_2O_5/ha to the preceding groundnut crop significantly increased post-harvest available N and P soil status compared with 20 kg P_2O_5/ha but had no significant effect on available S content during both the years (Table 1). Further, the effect of 60 kg P_2O_5/ha was not statistically different from 40 kg P_2O_5/ha that showed marginal gain in post-harvest available N and P content of soil over 20 kg P_2O_5/ha. This increased availability of nutrients may be assigned to better N_2-fixation and usual residual effect of applied P fertilizer. Besides, legume roots secret certain acidic substances which dissolve insoluble P converting into easily assimilable form (Subba Rao, 1982).

Residual effect of 60 kg P_2O_5/ha significantly increased siliquae/plant, seed weight/plant and 1,000-seed weight compared with 20 kg P_2O_5/ha during both the years. However, branches/plant increased significantly during 1997–98 only (Table 2). Residual effect of 60 kg P_2O_5/ha significantly increased total N uptake over 20 and 40 kg P_2O_5/ha during both the years and P uptake over 20 kg P_2O_5/ha during 1997–98 and over 20 and 40 kg P_2O_5/ha during 1998–99. This treatment increased S uptake significantly over 20 kg P_2O_5/ha during 1998–99 (Table 4). This increase in total nutrient uptake might be due to their increased availability in soil following P fertilization at 60 kg P_2O_5/ha as reflected by improvement in yield-attributing characters of Indian mustard, which finally resulted in significantly higher seed yield and oil content. The magnitude of increase in seed yield of Indian mustard was 9.7% over 20 kg P_2O_5/ha (Table 3).

Application of P at 60 kg P_2O_5/ha to the preceding groundnut crop significantly increased net returns by Indian mustard crop as well as groundnut + Indian mustard cropping system during both the years. Its application caused additional net returns of Rs 1,851/ha in Indian mustard and Rs 4,955/ha in groundnut + Indian mustard cropping over 20 kg P_2O_5/ha on mean basis.

Residual effect of gypsum

Application of gypsum to the preceding groundnut crop significantly increased post-harvest available N and S content of soil, but had no significant effect on available P content during both the years.

Table 3. Residual effect of organic manure, phosphorus and gypsum on yields and oil content of Indian mustard and its economics

Treatment	Groundnut pod yield (q/ha)		Indian mustard						Net returns (Rs/ha)			
			Biological yield (q/ha)		Seed yield (q/ha)		Oil control (%)		Indian mustard		Groundnut + mustard	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Organic manure/ha												
Control	15.45	17.00	72.14	72.07	14.72	15.31	35.2	34.5	15,916	16,616	34,842	38,113
FYM 10 tonnes	17.82	19.17	74.76	76.43	15.72	17.10	37.5	37.1	17,164	18,834	38,157	42,066
PM 5 tonnes	17.21	18.89	77.72	77.23	16.62	17.04	37.7	37.4	18,293	18,782	38,295	41,557
CD (P=0.05)	1.00	1.12	NS	NS	0.90	1.03	1.3	1.4	1,144	1,258	2,101	2,613
Phosphorus (kg P_2O_5/ha)												
20	15.47	17.17	73.18	73.29	14.96	15.78	35.8	35.2	16,231	17,195	34,254	38,052
40	17.20	18.61	74.66	74.65	15.74	16.32	37.2	36.6	17.176	17,872	37,740	40,767
60	17.81	19.27	76.77	77.79	17.36	16.36	37.4	37.2	17,964	19,164	39,299	42,917
CD (P=0.05)	1.00	1.12	NS	NS	0.90	1.03	1.3	1.4	1,144	1,258	2,101	2,613
Gypsum (250 kg/ha)												
Control	15.82	17.35	72.77	71.47	14.92	15.35	35.7	35.2	16,173	16,647	34,618	37,652
Full at sowing	17.39	18.77	75.80	76.44	15.94	16.72	37.2	37.0	17,452	18,373	38,293	41,487
Half at sowing + half at 35 DAS	17.26	18.94	76.04	77.82	16.19	17.40	37.4	36.8	17,748	19,211	38,283	42,597
CD (P=0.05)	0.73	0.75	NS	3.62	0.54	0.87	0.9	0.9	0.2	1,029	1,302	16,42.7

FYM, Farmyard manure; PM, poultry manure

Table 4. Residual effect of organic manure, phosphorus and gypsum on nitrogen, phosphorus and sulphur uptake by Indian mustard crop and fertility status of soil after its harvest

Treatment	N uptake (kg/ha)		P uptake (kg/ha)		S uptake (kg/ha)		Available N (kg/ha)		Available P (kg/ha)		Available S (kg/ha)	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Organic manure/ha)												
Control	93.4	89.5	18.0	18.0	30.4	29.8	215.2	210.7	15.3	14.6	18.9	18.1
FYM 10 tonnes	101.1	101.6	19.4	19.9	32.4	32.5	224.9	217.3	15.9	15.1	19.8	18.8
PM 5 tonnes	108.8	105.1	20.0	20.1	34.1	32.9	222.2	216.7	16.1	15.2	19.3	18.9
CD (P=0.05)	7.2	5.0	1.2	1.1	2.2	2.0	NS	NS	NS	NS	NS	NS
Phosphorus (kg P_2O_5/ha)												
20	97.0	93.8	18.1	18.3	31.0	30.6	220.3	213.5	15.4	14.8	18.9	18.2
40	99.5	97.9	19.1	19.1	32.3	31.4	218.3	214.2	15.6	14.9	19.8	18.6
60	106.8	104.4	20.1	20.5	33.6	32.2	223.7	217.0	16.2	15.2	19.4	19.0
CD (P=0.05)	7.2	5.0	1.2	1.1	2.2	2.0	NS	NS	NS	NS	NS	NS
Gypsum (250 kg/ha)												
Control	97.5	92.8	18.2	18.0	30.6	29.4	217.1	211.2	15.8	14.9	18.9	18.3
Full at sowing	103.6	100.3	19.5	19.7	32.8	32.3	222.5	215.9	15.8	15.1	19.5	18.6
Half at sowing + half at 35 DAS	102.2	103.1	19.6	20.2	33.5	33.4	222.7	217.6	15.7	15.1	19.7	18.8
CD (P=0.05)	NS	4.0	1.0	0.9	1.7	1.4	NS	NS	NS	NS	NS	NS

Further, split application of gypsum showed marginal gain in available S content over single application at sowing (Table 1).

Residual effect of gypsum significantly increased siliquae/plant, seed weight/plant and 1,000-seed weight over no gypsum application during both the years (Table 2). The seed yield of Indian mustard improved significantly owing to residual effect of gypsum, applied full at sowing and in 2 splits, representing mean increase of 6.1 and 11.0% over the control respectively. A significant increase in biological yield of Indian mustard was also observed under residual effect of gypsum treatments, over the control during 1998–99 (Table 3). Residual effect of gypsum applied either in single or in split dose increased N uptake significantly during 1998–99, but the P and S uptake increased significantly over the control during both the years. The significant increase in oil content of Indian mustard seed may be attributed to significant increase in S uptake under gypsum treatments.

The split application of gypsum performed better in terms of post-harvest available nutrients vis-à-vis seed yield of Indian mustard. This may be due to the obvious reason that half of it was applied 35 DAS to groundnut crop in the fruitizing zone and it is possible that part of it remained unutilized in the soil. Rao *et al.* (1984) reported significant residual effect of gypsum on succeeding groundnut. Kalita and Kalita (1992) opined that application of single superphosphate (SSP) to the preceding greengram significantly increased seed yield of Indian mustard because $CaSO_4$ was a major component of SSP. On soils high in available P, residual effect of gypsum applied to groundnut crop did not bring significant variation in yield attributes and yield of the following Indian mustard crop (Giri, 1998).

Application of gypsum treatments to groundnut crop significantly increased net returns by the following Indian mustard crop and overall cropping system during both the years. Gypsum applied in single and split dose caused additional net returns of Rs 1,502/ha and Rs 2,069/ha by Indian mustard crop over the control. The corresponding increase in net returns by groundnut + Indian mustard cropping system was Rs 3,755/ha and Rs 4,355/ha, respectively, over control on mean basis.

Post-harvest soil available nutrient

Soil fertility measured in terms of soil available N, P and S content depleted after Indian mustard crop compared to its initial level (before Indian mustard) (Tables 1 and 4). Variation in soil available N, P and S content between different treatments means was not significant after the harvest of Indian mustard crop during both the years (Table 4). This may be due to heavy uptake of nutrients by the succeeding Indian mustard crop. Besides, the rapeseed–mustard crop is efficient to extract more nutrients through its extensive and deep root-system.

Thus, it may be concluded that application of organic manure, phosphorus and gypsum to preceding groundnut crop improved the soil fertility status and showed significant residual effect on growth, yield and quality of following Indian mustard crop.

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