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Direct and residual effect of nitrogen and phosphorus fertilization on groundnut (*Arachis hypogaea*) – wheat (*Triticum aestivum*) cropping system

GAJENDRA GIRI

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

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ABSTRACT

A 3-year field experiment conducted on direct and residual effects of N and P on groundnut (*Arachis hypogaea* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) sequence showed that groundnut responded to direct application of N and P in initial season only. Neither nutrients applied to wheat nor directly applied to groundnut in subsequent seasons caused significant improvement in pod yield of groundnut. Groundnut needed 12.5 kg N and 21.5 kg P/ha in the first season only.

There was no carry-over effect of N on the wheat crop. P @ 21.5 kg/ha benefitted the succeeding wheat crop in the second year only. Directly applied N up to 100 kg/ha and P up to 10.7 kg/ha increased the wheat yield significantly in all the 3 seasons.

Generally fertilizer dose is recommended on the basis of individual crop response to direct application of nutrients, without apportioning the weightage to the previous crops and fertilizer applied to them in sequence. Since a limited part of the applied nutrients is utilized by a crop, fertilizer requirement of the succeeding crop may be modified by the residual nutrients. Studies on legume and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system have shown that where the legume crop removed less applied phosphorus, yield of succeeding crop increased (Mahajan and Khanna, 1968).

Groundnut (*Arachis hypogaea* L.)–wheat sequence is becoming very popular in the groundnut-growing, irrigated tracts of India. Fertilizer requirement of such system may deviate from the total requirement of these individual crops. An experiment was, therefore, conducted to study the direct and residual effect of N and P on groundnut and wheat in fixed sequence, and to work out the optimum doses of these nutrients for the crops in system.

MATERIALS AND METHODS

The experiment was started with groundnut in the rainy season (monsoon season) 1987, followed by wheat in the winter season at New Delhi. Three cycles of the system were completed in fixed plots. The soil of the experimental site was sandy loam having low organic carbon (0.5%), available phosphorus (8.00 kg/ha) and available potassium (120 kg/ha), with pH 7.6.

The treatments consisted of 3 levels each of N (0, 12.5 and 25.0 kg/ha) and P (0, 10.7 and 21.5 kg/ha) to groundnut and 3 levels

each of N (0, 50 and 100 kg/ha) and P (0, 10.7 and 21.5 kg P/ha) to wheat. Thus 81 treatment combinations were tested in a 3^4-confounding design without replications. Treatments allotted to plots were fixed for 3 years on same site.

The N and P were supplied through urea (46% N) and single superphosphate (6.9% P) respectively. All the N and P were applied at sowing in groundnut, whereas all the P and half the N was applied to the wheat at sowing, and the remaining N at the first irrigation. Three or four irrigations were given to wheat and 1 or 2 irrigations, depending upon rainfall distribution, for groundnut. Each year 'Kadiri 3' groundnut (Virginia bunch type semispreading) and 'HD 2285' wheat were sown in the second week of July and December, and harvested in the first week of December and second week of April respectively. A net plot of 5 m × 2.0 m in groundnut and 5 m × 2.07 m in wheat was harvested for computing yield.

RESULTS AND DISCUSSION

Groundnut

Direct effect of N: Direct application of N up to 25 kg/ha significantly improved the pod weight/plant in 1987 and 1989 only (Table 1). However, N @ 12.5 and 25 kg/ha in 1987 and 0 and 12.5 kg/ha in 1989 remained at par. Pod yield of groundnut

Table 1. Effect of direct and residual N and P on yield attributes of groundnut

Treatment	Pod weight/ plant (g)			Shelling (%)			100-seed weight (g)		
	1987	1988	1989	1987	1988	1989	1987	1988	1989
Direct N (kg/ha)									
0	21.4	25.3	13.5	73.1	63.6	70.7	46.0	42.2	44.5
12.5	23.7	29.2	13.8	74.2	63.0	70.1	47.0	42.4	43.3
25.0	23.5	27.8	16.2	74.0	61.2	69.9	47.6	41.6	43.7
F test	Sig.	NS	Sig.	NS	NS	NS	NS	NS	NS
Direct P (kg/ha)									
0	20.4	24.9	15.0	72.5	62.1	69.2	45.3	42.1	44.3
10.7	23.9	29.7	14.0	74.0	62.3	70.9	47.1	42.6	43.4
21.5	24.7	27.6	14.3	75.0	63.0	70.7	48.2	41.5	43.7
F test	Sig.	NS	NS	Sig.	NS	NS	Sig.	NS	NS
Residual N (kg/ha)									
0		27.3	13.2		62.1	69.9		41.7	43.9
50		27.0	14.3		62.3	70.6		42.3	43.8
100		28.0	15.9		63.0	70.3		42.3	43.8
F test		NS	NS		NS	NS		NS	NS
Residual P (kg/ha)									
0		25.7	15.0		60.8	69.8		42.1	43.5
10.7		28.4	14.0		64.1	70.5		41.7	44.8
21.5		28.2	14.3		62.5	70.4		42.4	43.2
F test		NS	NS		NS	NS		NS	NS
CD (P = 0.05)	1.7		2.3	1.4			1.8		

Table 2. Direct and residual effect of N and P fertilizers on yield attributes of wheat

Treatment	Tillers/m			Spikes/m			Grains/spike			1,000-grain weight (g)		
	1987–88	1988–89	1989–90	1987–88	1988–89	1989–90	1987–88	1988–89	1989–90	1987–88	1988–89	1989–90
Residual N (kg/ha)												
0	84	93	94	72	79	90	32	29	29	42.6	43.6	42.4
12.5	78	93	90	69	75	90	32	30	29	42.2	44.0	42.2
25.0	81	96	97	70	76	89	33	31	29	42.1	44.0	42.4
F test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Residual P (kg/ha)												
0	82	90	91	72	73	89	32	30	30	42.1	43.6	42.2
10.7	79	94	92	67	78	89	33	31	29	42.4	43.8	42.3
21.5	82	98	91	72	80	81	32	30	28	42.5	44.2	42.5
F test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Direct N (kg/ha)												
0	67	83	82	60	71	79	29	26	28	42.6	43.6	43.9
50	81	97	98	71	79	91	33	32	28	42.9	44.6	42.4
100	94	102	109	80	81	99	35	33	31	41.5	43.4	40.7
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Direct P (kg/ha)												
0	79	83	91	68	72	73	31	29	29	42.1	43.4	41.9
10.7	82	101	94	73	81	92	31	30	28	42.3	44.1	42.5
21.5	82	98	93	72	78	93	35	32	30	42.6	44.1	42.6
F test	NS	Sig.	NS	NS	NS	Sig.	Sig.	Sig.	NS	NS	NS	NS
CD (P = 0.05)	6.7	9.1	7.5	6.0	7.2	7.4	2.7	1.7	1.9	0.9	0.6	0.8

increased by direct application of N up to 12.5 kg/ha in 1987 only (Table 3).

Groundnut did not respond to applied N in subsequent years because there might be sufficient build up of N-fixing bacteria as a result of continuous groundnut cultivation in the same field.

Residual N effect: The residual effect of N applied to the preceding wheat crop was not significant on yield attributes (Table 1) and pod yield of groundnut in either of the years.

Low response of legumes to applied N might be the reason for insignificant residual effect of N on groundnut.

Direct P application: Direct application of P up to 10.7 kg/ha significantly increased the pod weight/plant, shelling % and 100-seed weight in 1987 only. In subsequent seasons, P application did not make significant changes in these yield attributes. As attributed by yield characters, in 1987 the pod yield of groundnut was significantly increased due to P application. However, response was recorded up to 21.5 kg P/ha in 1987 (Table 2). In rest of the years pod yield of groundnut remained unchanged due to various P doses.

Effect of residual P: Phosphorus applied to wheat did not show residual effect on yield-attributing characters and pod yield of groundnut in any of the seasons.

There might be sufficient build-up of P in soil profile which had vitiated its direct and residual effect on groundnut in subsequent seasons as treatments were fixed for 3 years in the same plots.

Wheat

Direct application of N: Directly applied N up to 100 kg/ha increased the number of tillers/m, number of spikes/m and number of grains/spike. However, 50 and 100 kg N/ha remained statistically at par in respect of number of tillers and spikes during 1988–89 and of number of grains during 1987–88 and 1988–89. N application reduced the 1,000-grain weight in wheat except 50 kg/ha which significantly increased it over the control during 1988–89. As a result of increase in yield attributes, grain yield of wheat was benefitted by the direct application of N up to 100 kg/ha in all years but magnitude of response over 50 kg N was less (Table 3).

Nitrogen being an essential constituent of chlorophyll, protoplasm and enzymes is well known to govern the utilization of P and K to promote growth of plants. This is evident from Table 4 where interaction between directly applied N and P on wheat yield is shown. The increased vegetative growth (tillers) with N application might have helped to trap more radiant energy, with the result more photosynthates had formed and further translocated to sink through different yield attributes (Table 2).

Residual effect of N: Nitrogen applied to groundnut did not show its carry-over effect on succeeding wheat crop, hence yield attributes as well as grain yield of wheat remained unchanged under various N doses used in previous groundnut crop. Since optimal and suboptimal doses were applied, crop might have utilized whole amount leaving negligible for subsequent crop.

Groundnut preceded wheat, consumed greater amount of N than the other legumes. Gogoi and Sandhu (1984) also reported lower cation-exchange capacity of the roots in wheat after groundnut. Due to this reason wheat might have not responded to N applied to groundnut in the previous season.

Direct effect of P: Direct application of P up to 10.7 kg/ha significantly increased the number of tillers/m during 1988–89 and number of spikes/m during 1989–90.

Table 3. Yield of groundnut and wheat as affected by direct and residual N and P fertilization

Treatment	Groundnut yield (tonnes/ha)			Wheat yield (tonnes/ha)		
	1987	1988	1989	1987–88	1988–89	1989–90
Groundnut						
N (kg/ha)						
0	2.67	2.21	2.02	3.63	3.16	3.41
12.5	3.00	2.44	1.90	3.55	3.17	3.49
25.0	3.02	2.30	1.87	3.67	3.26	3.47
F test	Sig.	NS	NS	NS	NS	NS
P (kg/ha)						
0	2.54	2.24	2.01	3.62	3.06	3.35
10.7	2.98	2.37	1.94	3.58	3.23	3.50
21.5	3.20	2.35	1.85	3.66	3.32	3.52
F test	Sig.	NS	NS	NS	Sig.	NS
Wheat						
N (kg/ha)						
0		2.29	1.93	2.49	2.07	2.81
50		2.29	1.86	3.90	3.34	3.66
100		2.38	2.00	4.47	4.19	3.89
F test		NS	NS	Sig.	Sig.	Sig.
P (kg/ha)						
0		2.43	1.87	3.41	2.68	3.30
10.7		2.36	1.98	3.69	3.36	3.51
21.5		2.17	1.94	3.76	3.56	3.56
F test		NS	NS	Sig.	Sig.	Sig.
CD (P = 0.05)	0.16	0.13	0.07	0.23	0.19	0.21

Number of grains/spike were also increased by 21.5 kg P/ha over 0 and 10.7 kg, while later 2 remained at par. There was no change in 1,000-grain weight due to P application in either of the years. Increase in total and ear-bearing tillers and grains/spike attributed to grain yield of wheat. Hence doses of P significantly increased the grain yield in 3 years; however response was recorded up to 10.7 kg during 1987–88 and 1989–90 and up to 21.5 kg during 1988–89 (Table 3).

The results showed that the release of P from the soil was not sufficient to meet the requirement of wheat.

Effect of residual P: Residual effect of P at 21.5 kg/ha was noted on the grain yield of wheat during 1988–89 only (Table 3). This was due to numerical increase in number of tillers and spikes/m in this season.

Interaction effects of N and P

Direct N and P application in groundnut: The interaction between direct N and P application in groundnut was significant in 1987 only (Table 4). In the absence of N, groundnut responded to P up to 10.7 kg/ha, whereas with the application of 12.5 kg N an increase in pod yield of groundnut was recorded up to 21.5 kg/ha. In the presence of 25 kg N, 0 and 10.7 kg P/ha remained at par,

Table 4. Effect of interaction between directly applied N and P on groundnut and wheat yields

P (kg/ha)	Groundnut yield (tonnes/ha) at N (kg/ha)			Wheat yield (tonnes/ha) (1988–89) at N (kg/ha)		
	0	12.5	25.0	0	50	100
0	2.09	2.69	2.88	1.89	2.84	3.32
10.7	3.00	3.01	2.91	2.04	3.44	4.57
21.5	2.99	3.36	3.26	2.27	3.72	4.69
CD (P = 0.05)		0.28			0.34	

whereas 21.5 kg P/ha increased the pod yield of groundnut significantly over lower doses.

Direct N and P application in wheat: The interaction effects between direct N and P application was significant during 1988–89 only (Table 4). Results show that without N, there was no response to P, whereas with the application of 50 and 100 kg N, an increase in wheat yield was recorded up to 10.7 kg/ha in the present study.

Response function and optimum doses

Groundnut: Groundnut responded to directly applied N and P in 1987 only. Response of N was quadratic (Table 5) and optimum dose was worked out to be 18.2 kg/ha. Response at this dose of N was 19.5 kg pod yield/kg N. The regression equation for the relationship between yield and direct P fertilization was found to be linear in our investigation.

Table 5. Regression equations for the relationship between yields and nutrients applied to groundnut and wheat crops and economic optimum doses

Crop and season	N or P	Equation	Economic optimum dose (kg/ha)	Response at optimum dose (kg/ha)
Groundnut 1987	N	$YN = 26.9 + 0.3640\,X - 0.0093\,X^2$	18.23	19.47
	P	$YP = 25.77 + 0.1320\,X$		
Wheat	Direct N	$YN = 26.30 + 0.198\,X$	15.4	21.6
1987–88	Direct P	$YP = 34.10 + 0.1540\,X - 0.0017\,X^2$		
1988–89	Direct N	$YN = 21.40 + 0.2120\,X$	19.0	46.5
	Direct P	$YP = 26.80 + 0.3680\,X - 0.0038\,X^2$		
	Residual P	$YP = 30.60 + 0.084\,X - 0.0006\,X^2$	18.5	13.5
1989–90	Direct N	$YN = 30.03 + 0.108\,X$	13.8	17.2
	Direct P	$YP = 33.00 + 0.1160\,X - 0.0013\,X^2$		

Wheat: Response to directly applied nutrients was observed in all the 3 seasons (Table 5). Wheat responded to residual P during 1988–89 only. In all the 3 seasons response of wheat to directly applied N was linear, while relationship between wheat yield and direct P application showed quadratic response. Economic optimum dose of P was worked out to be 15.4, 19.0 and 13.8 kg/ha in 3 seasons respectively. Response at these doses was 21.6, 46.5 and 17.2 kg/kg P applied to wheat in different seasons.

Residual effect of P on wheat also showed quadratic relationship during 1988–89. Economic optimum dose was worked out to be 18.5 kg P/ha and response at this dose was 13.5 kg wheat grain/kg P.

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