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Effect of sowing dates and nitrogen levels on growth and yield of vegetable pea (*Pisum sativum*) and its residual effect on wheat (*Triticum aestivum*) and maize (*Zea mays*) in vegetable pea–wheat–maize cropping sequence*

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Potato-wheat-maize cropping sequence is dominant in Uttar Pradesh. The farmers of the state are looking for alternate remunerative cropping sequence. Recently farmers initiated to grow early vegetable pea (*Pisum sativum* L.) for green pods in place of potato (*Solanum tuberosum* L.) in the same sequence and the cropping sequence proved more remunerative and also sustains soil health by including the crop which has the capacity to build root nodules and fix nitrogen from the environment (Snapp and Silim 2002). Fertilizer and water requirement of pea is lesser than potato and its harvesting is earlier than potato. After picking of green pods, plants parts of pea may be used as fodder for livestock or may be used as green manure. The information for time of sowing and suitable dose of nitrogen for vegetable pea crop and its effect on succeeding wheat crop is megre. Thus, the study was conducted to study the effect of sowing date and nitrogen levels on growth and yield of vegetable pea in vegetable pea–wheat (*Triticum aestivum* L. emend. Fiori & Paol.)–maize cropping sequence and its residual effect on wheat.

The field experiment was conducted during 2005–07 at instructional farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur on sandy loam soils. The soil was slightly saline (*p*H 7.8), low in organic carbon (0.45%) and available N (225 kg/ha) and medium in available P_2O_5 (15.1 kg/ha) and K_2O (186 kg/ha) (Table 1). The experiment was laid out in split-plot design keeping date of sowing (10 Sept., 10 and 20 Oct.) as main plot with a net plot size of 14.4 m^2 and nitrogen levels (0, 10, 20, 40, 60 and 80 kg/ha) as sub plot. '*Arkel*' vegetable pea was used as a test crop. The study, Residual effect of nitrogen applied in pea was observed in succeeding 'K–7903, *Halna*' wheat, which was sown in the third week of December to first week of January and harvested in to last week of April. After harvest of wheat, '*Azad uttam*' maize was grown during *kharif* season. Wheat and maize yield were raised on factor of residual fertility status of pea applying uniform recommended dose of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha in wheat and 100 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha in maize. This crop rotation of vegetable Pea–wheat–maize was grown continuously for 2 years on the same site with same recommended fertilizer levels. The phosphorus and potassium were applied through single superphosphate and muriate of potash. The nitrogen applied through urea was as per treatments. In pea, 2 irrigations at 30 and 50 days after sowing, in wheat 5 irrigations at an interval of 20–25 days while for maize 3 irrigations before sowing, 25 and 55 days after sowing were given in both the years. Hand weeding before first irrigation was done in pea while Isoproturon and 2, 4–D was sprayed in wheat crop for weeds control and in maize crop one manual weeding and hoeing during July was done during both the years of experimentation. Other management practices were adopted as per recommendations and need of the crop. Yield attributes were based on the net randomly selected 4 plants. Net returns and benefit : cost of cultivation was worked out on the basis of prevailing market rates. Soil samples were taken from 0–22.5 cm depth at the beginning and end of experiment to find out the initial status of experimental soil and changes in available N, P and K status of the soil after the end of cropping sequence. Soil samples at the beginning and end of sequence were analyzed for organic carbon, *p*H and available NPK by following standard procedure. Total rains of 18.2 and 11.8 mm were received during vegetable pea, 35.5 and 39.5 mm during wheat and negligible rains was received for maize cropping in 2005–06 and 2006–07, respectively as the variety of maize was harvested in the mid July.

The growth characters of vegetable pea, ie plant height, number of nodules; dry weight/plant (g), days of 50%

*Short note

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flowering and days to picking of pods (Table 1) clearly indicated that the date of sowing significantly varies with the yield attributes of the vegetable pea. The plant height increased significantly with each delay in sowing and maximum height was observed when pea was sown on 20 October with pooled height (both the years) of 43.5 cm, which was 3.5 and 8.3% higher than 10 October and 30 September sowing treatments. It has been found on the pooled basis that 20 October soon pea gave 15.6 nodules/plant while 10 October and 30 September sowing pea gave 15.1 and 14.5 nodules/plant, respectively which were found to be 3.4 and 7.5% more than 10 October and 30 September. The dry weight/plant of vegetable pea is significantly higher in 20 October sowing (9.1 g) which was found 3.9 and 8.4% more than dry weight under 10 October and 30 September sowing. On pooled basis (Table 1), 20 October took significantly maximum number days to flowering (39.4 days) and 30 September took minimum (37.5 days). The time to marketable pods delayed in later sowing, thus 20 October sowing took maximum of 73.6 days to picking (Table 2) which were found to be 2.7 and 1.3 days more than 10 October and 30 September sown. These results of early sowing of vegetable pea confirms by the finding of Sharma (2002). The benefit : cost ratio for vegetable pea was also worked out (Table 2) which shows that early sowing of vegetable pea on 30 September fetches higher price in the market with the B:C ratio of 1.72 as compared to 1.13 and 0.79 in case of 10 and 20 October sowing treatments.

Residual effect was observed in the yield attributes of the succeeding wheat crop. The plant height was significantly more in earlier sowing than later sowing. On pooled basis, wheat crop plant height was maximum (76.7 cm) in 30 September sowing treatment and this height was found to be 4.1 and 15.2% more over 10 and 20 October treatments. The fresh and dry matter accumulation in wheat was significantly influenced by sowing dates of vegetable pea and was significantly more in 30 September treatment and less in 20 October treatment. The dry weight on 30 September treatment produced 5.7 gm/plant of wheat, which were found to be 1.6 and 3.6% more dry weight than 10 and 20 October sowing treatments, respectively. These results supported by the finding of Sharma and Choker (1989), Samre *et al.* (1989).

The pooled data on plant height clearly indicates (Table 1) that increasing N levels increases plant height and N_{80} gave maximum plant height of 45.61 cm which is being at par with N_{60} (44.43 cm) which was found to be 2.7, 6.6, 11.4 and 28.4% higher than N_{60}, N_{40}, N_{20} and N_0 treatments. The number of nodules/plant was found maximum (16.8 root nodules/plant) in N_{80} kg/ha treatment and found to be 3.8,

Table 1 Growth characters of vegetable pea as affected by different treatments (pooled of 2 years)

Treatment	Vegetable pea						Wheat					Maize
	Plant height (cm) (at maturity)	Nodules/ plant	Dry wt/ plant (g/plant)	Days to 50% flowering	Days to picking (marketable pods)	Green pod yield of pea (tonnes/ha)	B:C ratio	Plant height (cm) (maturity)	Fresh weight (g/plant)	Dry weight (g/plant)	Grain yield (tonnes/ ha)	Grain yield (tonnes/ ha)
Date of sowing												
30 Sept.	40.12	14.52	3.87	37.48	70.90	5.03	1.72	76.62	14.32	5.73	3.66	3.23
10 Oct.	42.01	15.09	4.14	38.48	72.30	5.21	1.13	73.69	14.05	5.64	3.56	3.23
20 Oct.	43.46	15.61	4.31	39.42	73.60	5.43	0.79	66.51	13.71	5.53	3.48	3.20
CD (P = 0.05)	0.67	0.39	0.21	0.68	0.56	0.70	0.05	1.06	0.22	0.04	0.72	NS
N levels (kg/ha)												
N_0	35.52	12.52	3.43	35.63	57.00	4.76	1.06	60.50	13.74	5.67	3.41	3.21
N_{20}	40.95	14.57	4.05	37.83	71.00	5.13	1.20	70.23	13.93	5.63	3.52	3.22
N_{40}	42.80	16.78	4.23	38.68	73.33	5.32	1.26	74.63	14.09	5.64	3.58	3.23
N_{60}	44.43	16.17	4.35	39.77	74.50	5.43	1.29	76.98	14.15	5.65	3.65	3.21
N_{80}	45.61	15.33	4.47	40.38	75.50	5.48	1.28	78.85	14.24	5.67	3.68	3.23
CD (P = 0.05)	1.49	0.90	0.41	1.36	1.19	1.43	0.07	2.21	0.43	NS	1.48	NS

NS, Not significant

Table 2 Physico-chemical analysis of the experimental soil before sowing of vegetable pea, after first year (2005–06) and at the end of experiment (2006–07)

Parameter	Before the experiment 2005–06	After first year 2005–06	After second year 2006–07
Coarse sand	0.86	0.85	0.85
Fine sand	57.00	58.78	58.75
Silt	24.20	24.46	24.45
Clay	18.0	17.50	18.00
Electrial conductivity	0.48	0.40	0.35
*p*H	7.90	7.80	7.5
Organic carbon	0.40	0.45	0.55
Available N (kg/ha)	225	248	280
Available P_2O_5 (kg/ha)	16.10	16.85	17.29
Available K_2O (kg/ha)	180.0	178.0	189.0

9.5, 15.2 and 34.0% more than the nodules/plant in N_{60}, N_{40}, N_{20} and N_0 levels of nitrogen, respectively. The dry weight of root nodules produced significantly higher nodules weight of 10.9 mg/plant in N_{80} treatment which was 6.1, 17.1, 35.2 and 59.6% more over the nodules weight at N_{60}, N_{40}, N_{20} and N_0 treatments. The fresh weight/plant was also maximum in N_{80} treatment and significantly lowest in N_0 treatment. The dry weight/plant also increased with increasing N levels and dry weight of 9.4 gm/plant was observed in N_{80} treatment which was found to be 1.3, 5.6, 12.8 and 22.9% higher in N_{60}, N_{40}, N_{20} and N_0 respectively. When compared with N_0 treatment levels it was found that flowering and picking stages in vegetable pea was achieved 4.8 & 8.5 days earlier in N_{80} treatment which was well supported by Basen *et al.* (1985) and Van *et al.* (1990). The B:C ratio for N levels in vegetable pea also shows the highest B:C ratio of 1.29 and 1.28 for N_{60} and N_{80} treatments which is at par with N_{40} treatment and differ significantly from N_{20} and N_0 treatments.

Wheat crop was grown applying uniform level of fertilizer dose and its study was seen on residual N levels of vegetable pea. The plant height of wheat crop increased with increasing levels of residual nitrogen and attained maximum of 78.85 cm (pooled data) in N_{80} treatment which was found to be 2.4, 5.7, 12.3 and 30.3% higher than in N_{60}, N_{40}, N_{20} and N_0 treatment levels. The effect of residual nitrogen was not found significant on fresh and dry matter accumulation of succeeding wheat except fresh weight only in pooled analysis. Where N_{80} produced significantly higher plant weight only over the control N_0 kg/ha, these results supported by results of Sharma and Choker (1989).

In pooled results, 20 October sowing gave highest pod yield of 5.43 tonnes/ha and 4.3 and 8.0% higher than the pod yields obtained in 10 October and 30 September sowings, respectively. Increasing levels of N increased pod yield up to highest level of N_{80}. The yield at this level of N remained at par with the yield at N_{60} level but significantly higher than all other lower levels of N. In case of pooled data, N_{80} gave highest pod yield of 5.48 tonnes/ha which was 0.8, 2.9, 6.8 and 15% higher than the pod yields obtained in N_{60}, N_{40}, N_{20} and N_0 levels of N, respectively thus results confirms with the study of Honda *et al.* (1994) and Sharma (2002). The pod yield was not influenced significantly by interaction effect.

The grain yield of wheat grown under residual effect of pea treatments is presented in Table 1. In pooled results, 30 September sown pea gave maximum grain yield of 3.66 tonnes/ha of wheat which was 3.0 and 5.2% higher than the grain yield recorded after pea sowing of 10 and 20 October, respectively. The grain yield of succeeding wheat crop increased numerically due to increase in residual N but margins of increase could not touch the level of significance in individual year while in pooled analysis differences became significant. The residue of N_{80} being at par with N_{60} and N_{40} level and gave significantly higher grain yield of wheat than N_0 and N_{20} treatment levels. This much high yield of wheat after pea crop may also be due to biological N fixation carried out by the microbes in vegetable pea which results in higher residual N of the soil. There results supported the findings of Samre *et al.* (1989) & Nayak *et al.* (1983).

The residual effect of treatments applied in vegetable pea was also evaluated on grain yield of maize crop grown after wheat which showed the non-significant relationship by any treatments factors applied to pea crop. Results remained similar during both years experimentation and also in pooled analysis. The residue of vegetable pea after pea harvest was used as a green manure in the same plots, respectively. Physicochemical analysis of experimental soil was conducted before sowing, after first year and after the end of the experiment (Table 2) showed the increase in organic carbon (%) levels from initially 0.40 to final 0.55% which certainly will increase the soil health and yield of the succeeding crop. Also the NPK levels of the soil increased which in turn will increase the net returns to the farmers.

SUMMARY

A field experiment was conducted during 2005–06 and 2006–07 to evaluate sowing date and nitrogen levels in the vegetable pea. The vegetable pea–wheat–maize crop rotation repeated on the fixed plot for 2 years. The different doses of nitrogen were applied in vegetable pea whose residual effect was studied on second (wheat) and third (maize) crop applying uniform level of fertilizer dose in wheat and maize. The growth characteristics of vegetable pea, ie plant height, nodules/plant, dry weight/plant, fresh weight/plant, dry weight/plant, days to 50% flowering and days of first picking of pods is significantly higher when vegetable pea is sown on 20 October compared with 30 September and 10 October sown. The growth characters of vegetable pea and wheat crop is significantly higher in N_{80} treatment compared to N_{60}, N_{40}, N_{20} and No treatments, respectively. The B:C ratio shows the opposite trend which shows the highest ratio of 1:1.72 sown on 30 September than observed on later dates of sowing. This may be due to the fact that early vegetable fetches more prices in the market. The higher pod yield of vegetable pea was 5.43 tonnes/ha sown on 20 October which was 4.3 and 8% higher than the pod yield obtained in 10 October and 30 September sown, respectively. Significantly higher yield of 5.48 tonnes/ha was recorded at N_{80} treatment which was 0.8, 2.7, 6.5 and 1.5% higher than N_{60}, N_{40}, N_{20} and N_o kg/ha. The yield of wheat crop is maximum, ie 3.66 tonnes/ha in first date of sowing which was 3.0 and 6% higher than second and third date of sowing. The residues of N from N_{80} treatment plot being at par with N_{60} and N_{40} levels producing significantly higher yield of wheat than N_{20} and N_o levels. Non-significantly relationship was observed for all nitrogen treatments in maize crop.

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