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Residual effect of nitrogen management on succeeding summer moong (*Vigna radiata*) under maize-wheat-moong rotation

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ABSTRACT

Nitrogen management in crop/cropping system plays a significant role to enhance crop growth and productivity in sustainable manner. To ensure sustained soil fertility, optimal crop growth and productivity in subsequent growing seasons, it is necessary to consider the residual effect of N management on moong (*Vigna radiata* L.). Therefore, a field experiment was conducted for two consecutive years (2019–20 and 2020–21) to evaluate the effect of organic and inorganic sources of nutrition with/without residue retention applied to preceding crops on growth and productivity of succeeding moong. Fourteen treatments applied to preceding crops were, T_1, 100% N through FYM without residue; T_2, 100% N through FYM with residue; T_3, 75% N through FYM + 25% RDF without residue; T_4, 75% N through FYM + 25% RDF with residue; T_5, 50% N through FYM + 50% RDF without residue; T_6, 50% N through FYM + 50% RDF with residue; T_7, 25% N through FYM + 75% RDF without residue; T_8, 25% N through FYM + 75% RDF with residue; T_9, 100% RDF + 25% N extra through FYM without residue; T_{10}, 100% RDF + 25% N extra through FYM with residue; T_{11}, 100% RDF without residue; T_{12}, 100% RDF with residue; T_{13}, Cowpea intercropping without fertilizer in maize and residue retention in wheat and; T_{14}, Control. The data revealed that treatment T_6 recorded significantly higher growth parameters [plant height (59.7 cm) and dry matter accumulation (469.8 g/m^2)] and yield attributes (number of pod/plant (27.4), pod length (8.8 cm) and number of seeds/pod (10.2)] of moong over other treatments but was found at par with T_2, T_3, T_4 and T_5 in 2020 and during 2021. Treatment T_2 recorded significantly higher growth parameters [plant height (61.3 cm) and dry matter accumulation (478.9 g/m^2)] and yield attributes (number of pod/plant (30.2), pod length (8.9) and number of seeds/pod (10.3)] being at par with T_1, T_3, T_4, T_5 and T_6 of moong over other treatments. Moreover, due to significant increase in yield attributes, treatment T_6 and T_2 exhibited significant increase in grain yield of about 62.32 and 62.96%, respectively over control in year 2020 and 2021, respectively.

Keywords: Maize-wheat-summer moong, Moong, Productivity

Food security, nutritional security, sustainability, and profitability are the major constraints of India's present agricultural scenario and to achieve these, attempts need to focus on area expansion under agriculture and higher productivity (Kumar and Sharma 2020). Rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) being a dominating cropping system of Indo-Gangetic plain caused groundwater depletion, development of hard plough-pan, soil health deterioration, yield stagnation, water logging, emission of greenhouse gases, resurgence of insect-pests and diseases, and lowering in factor productivity (Kaur *et al.* 2021). For mitigating these problems, diversification of crops and cropping systems create situations which are not only ecologically sound and environment-friendly, but are also conserving natural resource pool efficiently (Walia *et al.* 2022). Intensified agriculture has resulted in reduced productivity and nutrient deficiencies in soil which limits its ability to achieve potential yield of crop. However, inclusion of legumes in a cropping system adds benefits due to their short duration varieties, low input requirements, and ability to increase soil fertility through mutual symbiosis with bacteria (Ratanoo *et al.* 2022). Growing short-duration legume crop such as moong (*Vigna radiata* L.) in cropping system makes it more productive, profitable, and soil recuperative (Kumar *et al.* 2022). Currently, a major emphasis is being made on planning the nutrient management strategy based on the entire cropping system rather than focusing on individual crops because succeeding crops are influenced by inputs applied in preceding crops (Ratanoo *et al.* 2022). The responses of the succeeding crops in a cropping system are influenced greatly by the inputs applied in preceding crops (Devi *et al.* 2015). Relying solely on chemical fertilizers results in decreased soil and crop productivity while imposing high

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input costs on farmers due to the escalating fertilizers prices (Kumar and Dhar 2010). Therefore, the integrated use of organic manures with chemical fertilizers will benefit the succeeding crops due to the carry-over effect (Kumar and Dhar 2010, Ratanoo *et al.* 2022). Keeping in view the above facts, the present study was undertaken to assess the residual effect of different organic and inorganic sources of nutrition with/without residue applied to maize and wheat crop on succeeding moong in maize-wheat- moong rotation.

MATERIALS AND METHODS

The present study was carried out at School of Organic Farming, Punjab Agricultural University, Ludhiana, Punjab (located at 30°56'N, 75°52' and 247 m amsl) during two consecutive years (2019–20 and 2020–21). Ludhiana is situated in the central plain zone of Punjab in trans-gangetic agro-climatic zone of India. The climate of this region is semi-arid, sub-tropical with dry and hot summers during April to June, humid and hot monsoon periods during July to September, mild early winters during October to November and cold winters during December to February. The average annual rainfall of the region is 755 mm, out of which about 70% is received during July to September due to the south western monsoons.

Site description and methodology: The soil of the experimental site was sandy loam in texture and was analyzed by Bouyoucous hydrometer method (Piper 1966), normal in reaction (*p*H 7.79) and safer range of electrical conductivity (0.212 dS/m) measured by standard *p*H and EC meter (1:2.5 soil:water ratio) as per Jackson (1973), low in OC (0.35%) by using dichromate oxidation method (Walkley and Black 1934), low in available nitrogen (173.9 kg/ha) analysed through alkaline $KMnO_4$ method (Subbiah and Asija 1956), medium in available phosphorous (18.2 kg/ha) and potassium (111.3 kg/ha) estimated by $NaHCO_3$ method and ammonium acetate extraction method (Jackson 1973), respectively. Fourteen treatments of different nutrition sources with/without residue retention, viz. T_1, 100% N through FYM without residue; T_2, 100% N through FYM with residue; T_3, 75% N through FYM + 25% RDF without residue; T_4, 75% N through FYM + 25% RDF with residue; T_5, 50% N through FYM + 50% RDF without residue; T_6, 50% N through FYM + 50% RDF with residue; T_7, 25% N through FYM + 75% RDF without residue; T_8, 25% N through FYM + 75% RDF with residue; T_9, 100% RDF + 25% N extra through FYM without residue; T_{10}, 100% RDF + 25% N extra through FYM with residue; T_{11}, 100% RDF without residue; T_{12}, 100% RDF with residue; T_{13}, Cowpea intercropping without fertilizer in maize and residue retention in wheat and; T_{14}, Control were applied to preceding crops (maize and wheat), and moong was grown under residual soil fertility in randomized complete block design with three replications. The whole residue of the preceding crop (wheat) was maintained in the respective plots as per the treatments. Seeds (30 kg/ha) of moong were sown at specified distance between the rows (22.5 cm) and plants (7 cm) at 5 cm depth in furrows by Pora method for the SML-832 variety. The organic manure used was farmyard manure (FYM) having NPK composition (%) of about 0.5:0.25:0.5 and the NPK (%) content of wheat residue was 0.4:0.3:0.9. The chemical fertilizers applied were N, P_2O_5 and K_2O in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. The rate of recommended N, P_2O_5 and K_2O in maize was 125, 60 and 30 kg/ha, respectively and for wheat was 125 kg/ha N and 62.5 kg/ha P_2O_5. Organic manure (FYM) was applied 15 days before sowing in pre-marked plots and inorganic fertilizer were applied as per the treatment in 3 splits. Succeeding summer mung bean was sown on the same plots after the harvest of wheat crop. The average data of five tagged plants from each plot were used for evaluating plant height (cm), dry matter accumulation (g/m^2), number of pods/plant, number of seeds/pod, length of pod (cm) and 1000-seed weight. Seed yield and biological yield were calculated from net plot area and were converted into yield per hectare. Stover yield was computed by subtracting total seed yield from the total biological yield. The total cost of cultivation was calculated by adding all the expenditure involved in all kinds of operations and input used as per treatment on per hectare basis. Gross returns were calculated by multiplying the total seed yield with prevalent market prices, net return (₹/ha) of each treatment was computed by deducting its cost of cultivation from gross returns. B:C was calculated by:

$$\text{B:C ratio} = \frac{\text{Net returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Statistical analysis: The data on each parameter (growth, yield attributes and yield) were statistically analysed using technique of analysis of variance following the basic principles which were explained by Cochran and Cox (1967) and adapted by Cheema and Singh (1991) in statistical package software (CPCS-I) which is developed by Department of Mathematics, Statistics and Physics, Punjab Agricultural University, Ludhiana. The treatment means were compared using 'F' test at 5% level of significance using least significant difference method.

RESULTS AND DISCUSSION

Growth parameters: The various growth parameters differ significantly with respect to treatments applied to preceding crop during both the years (Table 1). The application of 50% N through FYM + 50% RDF with residue (T_6) in preceding crops recorded significantly higher plant height and leaf area index in moong of about 59.7 cm and 4.79, respectively over other treatments but was found at par with the treatment (T_2) 100% N through FYM with residue, (T_3) 75% N through FYM + 25% RDF without residue, (T_4) 75% N through FYM + 25% RDF with residue, and (T_5) 50% N through FYM + 50% RDF with residue in the year 2020 at maturity. However, in 2021, application of 100% N through FYM with residue (T_2) recorded significantly higher plant height (61.3 cm) and leaf area index (4.87)

Table 1 Residual effect of different sources of nutrition with/without residue retention on growth parameters of summer moong at harvest

Treatment	Plant height (cm)		Leaf area index		Dry matter accumulation (g/m^2)	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
T_1	53.4	59.4	4.15	4.53	427.1	458.3
T_2	57.7	61.3	4.23	4.87	445.6	478.9
T_3	57.9	60.0	4.39	4.51	443.9	454.9
T_4	58.4	59.6	4.55	4.55	468.9	478.7
T_5	57.3	58.9	4.63	4.39	449.6	456.0
T_6	59.7	60.1	4.79	4.41	469.8	473.0
T_7	53.7	55.4	3.93	3.99	366.9	371.2
T_8	56.4	57.8	3.98	4.07	378.6	384.7
T_9	54.2	55.0	3.87	3.90	348.6	356.6
T_{10}	55.5	57.2	3.92	4.01	360.1	369.2
T_{11}	48.5	50.3	3.72	3.73	315.6	321.6
T_{12}	50.6	53.4	3.75	3.81	318.3	329.5
T_{13}	50.1	52.4	3.58	3.55	301.1	309.4
T_{14}	48.9	49.8	3.41	3.31	287.8	288.5
LSD (P=0.05)	2.66	2.50	0.42	0.43	37.0	40.9

Treatment details are given under Materials and Methods.

being at par with (T_1), (T_3), (T_4), (T_5) and (T_6) (60.1 cm) in 2021 at maturity. Moreover, application of 50% N through FYM + 50% RDF with residue (T_6) in preceding crops accumulated significantly higher dry matter accumulation (469.8 g/m^2) in moong, being at par with T_2, T_3, T_4 and T_5 over other treatments in 2020. The dry matter accumulation was recorded significantly higher under T_2 of about 478.9 g/m^2 over other treatments but found at par with T_1, T_3, T_4, T_5 and T_6. The significantly higher growth parameters in treatment receiving nutrition relatively higher through FYM in preceding crop improved residual nutrient availability to moong resulting into more conversion of carbohydrates into protein and consequently, elaborated into protoplasm and cell wall material which enhanced the size of the cell, and expressed in terms of higher plant height and dry matter accumulation. Similar findings in succeeding crop due to application of higher doses of FYM applied to previous crop have been reported by Devi *et al.* (2015) and Ratanoo *et al.* (2022).

Yield attributes: There was significant difference in various yield attributing characters of moong with respect to treatments applied to preceding crop during both the years (2020 and 2021) as presented in Table 2. It was observed that application of 50% N through FYM + 50% RDF with residue (T_6) recorded significantly higher number of pods/plant (27.4), length of pods (8.8) and number of seeds/pod (10.2) as compared to other treatments but was found at par with T_5, T_4, T_3 and T_2 in 2020. However, in 2021, the treatment comprised of T_2 recorded significantly higher number of pods/plant (30.2), length of pods (8.9) and number of seeds/pod (10.3) over other treatments, being at par with T_1, T_3, T_4, T_5 and T_6. This is due to the fact that cellulose is highly resistant to degradation, requiring more time for decomposition. Thus, application of FYM with chemical fertilizer was not been fully utilized by the preceding crop (maize and wheat) and notably benefitted the succeeding crop due to better sink source relationship. Ratanoo *et al.* (2022) also stated significant and positive residual with higher doses of FYM applied to preceding crop on succeeding moong in terms of yield attributing characters.

Yield and economics: The seed, biological and stover yield recorded under different treatments is presented in Table 2 and economics has been presented in Table 3. The data revealed that in 2020, application of 50% N through FYM + 50% RDF with residue (T_6) recorded significantly higher seed, biological and stover yield of about 922 kg/ha, 4460 kg/ha and 3531 kg/ha, respectively in comparison to other treatments but was found at par with the treatment T_2, T_3, T_4 and T_5. However in 2021, treatment T_2 recorded significantly higher seed yield (937 kg/ha), biological yield (4478 kg/ha) and stover yield (3515 kg/ha) over other treatments but found at par with T_1, T_3, T_4, T_5 and T_6. Significantly higher yield (seed, biological and stover) of moong in treatments receiving higher doses of

Table 2 Residual effect of different sources of nutrition with/without residue retention on yield attributes of summer moong

Treatment	2019–20							2020–21						
	No. of pods/plant	Length of pod (cm)	No. of seeds/pod	1000-seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	No. of pods/plant	Length of pod (cm)	No. of seeds/pod	1000-seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)
T_1	22.2	7.9	8.8	52.1	842	3172	4070	27.8	8.4	9.7	52.7	898	3406	4304
T_2	24.6	8.2	9.3	52.6	866	3292	4225	30.2	8.9	10.3	53.2	937	3515	4478
T_3	24.2	8.1	9.3	52.3	863	3322	4215	27.3	8.3	9.8	52.4	893	3379	4272
T_4	26.9	8.4	9.6	52.9	904	3516	4453	29.8	8.6	9.9	52.8	933	3539	4476
T_5	25.2	8.2	9.2	52.6	877	3390	4279	28.2	8.6	9.6	52.8	889	3358	4247
T_6	27.4	8.8	10.2	53.1	922	3531	4460	29.1	8.8	10.3	53.1	929	3545	4444
T_7	20.5	7.4	8.2	52.4	714	2755	3483	22.7	7.5	8.6	52.4	728	2755	3483
T_8	21.3	7.8	8.5	52.5	725	2840	3583	24.5	8.0	9.1	52.6	743	2842	3585
T_9	18.8	7.0	8.4	52.2	672	2610	3300	19.9	7.1	8.7	52.1	690	2623	3313
T_{10}	20.7	7.3	8.7	52.3	702	2682	3401	22.3	7.4	9.2	52.4	719	2715	3434
T_{11}	16.0	6.3	7.4	51.6	613	2365	2990	16.5	6.4	8.0	51.5	625	2370	2995
T_{12}	16.9	6.8	7.7	51.8	634	2368	3015	17.0	6.9	8.3	51.9	647	2430	3077
T_{13}	13.8	5.7	6.5	51.2	595	2239	2852	14.8	5.8	7.0	51.3	613	2325	2938
T_{14}	12.5	5.4	5.9	50.2	568	2151	2726	13.1	5.4	6.3	49.8	575	2169	2744
LSD (P=0.05)	3.23	0.78	0.95	NS	76	284	359	2.52	0.79	0.89	NS	79	300	379

Treatment details are given under Materials and Methods.

Table 3 Residual effect of different sources of nutrition with/without residue retention on economics of summer moong

Treatment	2019–20				2020–21			
	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T_1	27370	62234	34864	1.27	27370	64566	37196	1.36
T_2	27370	64013	36643	1.34	27370	67083	39713	1.45
T_3	27370	63826	36456	1.33	27370	64207	36837	1.35
T_4	27370	66894	39524	1.44	27370	67370	40000	1.46
T_5	27370	64901	37531	1.37	27370	63919	36549	1.34
T_6	27370	68176	40806	1.49	27370	66795	39425	1.44
T_7	27370	52814	25444	0.93	27370	52343	24973	0.91
T_8	27370	53666	26296	0.96	27370	53422	26052	0.95
T_9	27370	49723	22353	0.82	27370	49616	22246	0.81
T_{10}	27370	51903	24533	0.90	27370	51696	24326	0.89
T_{11}	27370	45340	17970	0.66	27370	44938	17568	0.64
T_{12}	27370	46826	19456	0.71	27370	46519	19149	0.70
T_{13}	27370	43960	16590	0.61	27370	44075	16705	0.61
T_{14}	27370	41977	14607	0.53	27370	41354	13984	0.51

Treatment details are given under Materials and Methods.

FYM in preceding crop is because higher doses of FYM increased the availability of nutrients and also improved the soil properties (porosity and soil organic carbon), with slow release of nutrients for long duration leading to mineralization of organic materials, and accumulation of organic carbon. The treatments of higher doses of FYM to the preceding maize and wheat minimise the crusting problem in soil which are major raw material for soil microorganism to feed on for increasing nitrogen fixation sustaining the productivity. Similar type of beneficial residual effects of treatments enriched with higher amount of organic manure under cropping system on yield of legume has been reported by Ratanoo *et al.* (2022). The data presented in Table 3 revealed that during 2019–2020, application of 50% N through FYM + 50% RDF with residue fetched higher net returns of about ₹40806/ha consequently resulted in higher B:C ratio (1.49). However, in 2020–2021, the treatment comprised of application of 75% N through FYM + 25% RDF with residue recorded higher net returns (₹40000/ha) and B:C ratio (1.46).

The findings of this study can be safely summarised by stating that the integrated use of FYM with higher doses along with chemical fertilizers in preceding maize and wheat crop had significantly higher carry-over effect on succeeding moong with respect to growth and productivity. The supplementation of organic nutrients (FYM) has progressive residual impact on nutrient availability and growth of subsequent moong crop. Hence, it may be concluded that treatment T_2, T_3, T_4, T_5 and T_6 can be applied in preceding maize and wheat crop for significantly higher growth and productivity of succeeding moong thus, sustaining the productivity of maize-wheat-moong cropping system in trans-gangetic plains.

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