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Influence of Residual Integrated Nutrient Management Practices on Chickpea Yield and Nutrient Dynamics in Maize-chickpea Cropping Sequence

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ABSTRACT

Background: Chemical fertilizers in integration with organic manures must be used in order to promote sustainability. Using chemical fertilizers in addition to FYM slows down the deterioration of soil health and improves soil quality for upcoming needs. The present research aims to study yield parameters of chickpea and uptake of essential nutrients supplied through residual effect of integrated nutrient management.

Methods: The present research consisting twelve treatment combinations with three replications was conducted in split plot design (SPD). The four levels of RDF (Control, 50, 75 and 100% RDF ha^{-1}) in main plot and three levels of FYM (Control, 5 and 10 t ha^{-1}) in sub plot were taken.

Result: The investigation indicated that residual effect of 100% RD of inorganic fertilizers performs better among all RDF levels and FYM @ 10 t ha^{-1} showed better impact over all FYM levels on yield attributes, yield, nutrient concentration and nutrient uptake of Chickpea. The results of this experiment showed that chickpeas responded more favourably to residual effects of both inorganic fertilizers and FYM levels.

Key words: Chickpea, INM, Maize, Nutrient uptake, Yield.

INTRODUCTION

Pulses holding a distinctive place in Indian agriculture, as well as an essential component of food grain crops due to their high nutrient content. In developing nations, pulses are often referred to as the poor man's meat due to their affordability and high protein content, whereas in developed countries, they are regarded as a "health food" for their nutritional benefits and role in a balanced diet (Rani and Krishna, 2016). Pulses provide about 345 kcal per 100 g and every individual needs 50-60 g of pulses per day. Thus, it is crucial to include pulse crops in cropping systems in order to create nutrient-dense food for the vegetarian population (Singh *et al.,* 2022). Pulses are predominantly grown under low-input conditions, typically on marginal and sub-marginal lands with limited energy and resource availability (Sodavadiya *et al.,* 2023). The chickpea (*Cicer arietinum* L.,) is India's top-ranked pulse crop and is essential for completing the protein needs of vegetarian diet. Chickpea is thought to have originated in the Mediterranean or Fertile Crescent region, where it was first domesticated. From there, it spread to secondary centers of diversity, including Central Asia, the Indian subcontinent and East Africa, particularly Ethiopia (Mohsenzadeh, 2024). In India, chickpea is widely grown as a winter crop, particularly in the northern provinces. It contains high levels of β-carotene, fiber, carbs, vitamins and minerals (phosphorus, calcium, magnesium, iron and zinc) in addition to having a high protein content (Singh *et al.,* 2022). As a result, it lessens malnutrition and enhances human health for the underprivileged who cannot buy animal-derived foods. Chickpea seeds serve both food and feed purposes due to their exceptional nutritional profile and high content of beneficial bioactive compounds like phenolics and flavonoids (Kumari and Malik, 2024). Despite the fact that chickpeas fix atmospheric nitrogen, there is compelling evidence to suggest that applying nitrogen fertilizer boosts seed output, particularly for amino acids and seed protein. To achieve better seed quality and a

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greater yield, it needs less nitrogen fertilizer than other crops (Dhima *et al.,* 2015).

Chemical fertilizers cannot be completely avoided as they may provide significant amounts of easily accessible nutrients. Crop production suffers when chemical fertilizers are overused and applied for extended periods of time because they deteriorate the quality of the soil (Pahalvi *et al.,* 2021).Apart from improving soil health, organic manures meet the requirements for both macro and micronutrients (Antil and Raj, 2020). Balanced nutrient management, following the principles of integrated plant nutrition, is considered one of the most effective strategies to boost crop productivity while maintaining long-term soil fertility (Patil *et al.,* 2024). For the purpose of producing chickpea, a proper combination of chemical fertilizer and organic manure needs to be created.

To maintain soil health and production, different nutrients must be used carefully in combination using both organic and inorganic sources (Sharma *et al.,* 2022). A tried-and-true strategy for increasing crop yield, soil organic matter (SOM), microbial activity, soil sustainability and the amount of major and micronutrients in the soil that plants can access is the application of well-decayed FYM in soil management techniques (Dhaliwal *et al.,* 2021). Declining agricultural output and soil health, as well as growing expenses for inorganic fertilizers, can all be resolved by applying the right amount and combination of nutrients using both organic and inorganic methods (Titirmare *et al.,* 2023). Thus, soil fertility and productivity may be maintained with judicious application of Integrated nutrient management (INM).

MATERIALS AND METHODS

The experimental trial was carried out at the Agricultural Farm of Lovely Professional University in *kharif* and *Rabi* 2023-24. The experimental location is situated in subtropical zone with hot summers and cool winters. During experiment period temperature range of 4-37°C and 650 mm of rainfall was recorded. Twelve combinations of treatments were used in the experiment, using a split-plot design (SPD) with three replication for maize crop. The combinations included four RDF levels (Control, 50, 75 and 100% RDF ha^{-1}) and three FYM levels (Control, 5 and 10 tonnes ha^{-1}). The well-decayed FYM @ 5 and 10 t ha^{-1} were incorporated 15 days before to maize sowing. To find out the residual effect of INM, 50% RDF (10 kg N, 20 kg P and 0 kg K ha^{-1}) applied to chickpea at sowing using urea and single super phosphate (SSP).

In order to quantify the amounts of nitrogen, phosphorus and potassium, representative plant samples were taken during harvest, oven dried for 48 hours at 105°C and then grind into a fine powder. Concentrations of N, P and K were determined for each plot's seed and straw yield during harvest to determine the uptake of each nutrient. The uptake was calculated by Nutrient uptake (kg ha^{-1}) = Content of specific nutrient (%) × Yield of seed or straw (kg ha^{-1})/100. The observations made during the investigation were tabulated and subjected through analysis of variance procedures in accordance with Gomez and Gomez (1984) procedure.

RESULTS AND DISCUSSION

Yield attributes

Yield attributes of chickpea were significantly impacted by the residual effect of varying inorganic fertilizers and FYM levels as showed by the data presented in Table 1. At harvest, maximum pods plant^{-1} (56.21), weight of pods plant^{-1} (33.20 g), seed yield (19.94 q ha^{-1}) and biological yield (52.25 q ha^{-1}) was noted under 100% RDF which was

Table 1: Residual effect of RDF and FYM levels on yield attributes and yield of chickpea.

Treatments	Number of pods plant^{-1}	Weight of pods plant^{-1}	Test weight (g)	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
Main plot treatments							
Control	31.40	23.20	27.20	10.74	21.12	31.86	33.09
50% RDF	39.07	25.87	27.97	14.35	24.96	39.31	36.32
75% RDF	48.43	29.73	28.61	17.72	29.79	47.52	37.18
100% RDF	56.21	33.20	29.46	19.94	32.31	52.25	38.13
SE (m) ±	0.83	0.40	0.37	0.34	0.74	0.65	1.30
CD 5%	2.88	1.39	1.28	1.16	2.58	2.23	4.49
Sub plot treatments							
Control	40.14	25.81	27.80	14.24	25.23	39.47	35.42
5 t ha^{-1} FYM	43.92	27.96	28.38	15.72	27.28	43.01	36.02
10 t ha^{-1} FYM	47.28	30.22	28.76	17.10	28.62	45.72	37.10
SE (m) ±	0.39	0.31	0.25	0.18	0.23	0.26	0.45
CD 5%	1.16	0.93	0.74	0.55	0.69	0.78	1.34
Interaction M*S							
SE (m) ±	0.78	0.62	0.50	0.37	0.46	0.52	0.89
CD 5%	2.33	NS	NS	1.10	1.38	1.56	NS

significantly superior over 50%, 75% RDF and control. Meanwhile highest test weight (29.46 g) and straw yield (32.31 q ha^{-1}) was observed in 100% RDF which was significantly greater over 50% RDF and control but found statistically at par with 75% RDF. Highest value of harvest index was observed in 100% RDF (38.13%) which was significantly higher over control but statistically at par with 50% and 75% RDF. In terms of FYM levels, highest number of pods plant^{-1} (47.28), weight of pods plant^{-1} (30.22 g), seed yield (17.10 q ha^{-1}), straw yield (28.62 q ha^{-1}) and biological yield (45.72 q ha^{-1}) was noted under 10t ha^{-1} FYM which showed significant superiority over 5t ha^{-1} FYM and control. Meanwhile highest test weight (28.76 g) and harvest index (37.10%) was observed in 100% RDF, which was significantly superior over control but found at par with 5 t ha^{-1} FYM.

The study found that interaction between two factors *i.e.* residual effect of different RDF and FYM levels was found significant in number of pods plant^{-1}, seed yield, straw yield and biological yield but it was found that non significant in weight of pods plant^{-1}, test weight and harvest index (Table 2). These results are in conformity with the findings of Gudadhe *et al.,* (2011).

The amount of chickpea pods increased when organic manures were added to the previous crop and this can be linked to the build-up of residual soil fertility resulting from addition of organic manures. The combination of RDF and FYM resulted in a higher number of pods might be due to improvement in root development, energy translocation and plant growth metabolism, all of which boost photosynthetic translocation towards sink (Singh *et al.,*

Table 2: Interaction effect of residual RDF and FYM levels on yield attributes and yield of chickpea.

Interaction M*S	Control	5 t ha^{-1} FYM	10 t ha^{-1} FYM	Interaction M*S	Control	5 t ha^{-1} FYM	10 t ha^{-1} FYM
	Number of pods plant^{-1}				**Seed yield (q ha^{-1})**		
Control	29.44	30.92	33.84	Control	8.71	10.87	12.64
50 % RDF	35.97	38.99	42.27	50 % RDF	13.74	14.26	15.06
75 % RDF	44.09	48.02	53.18	75 % RDF	15.97	17.37	19.84
100 % RDF	51.06	57.76	59.82	100 % RDF	18.54	20.40	20.87
SE (m)±		0.78		SE (m)±		0.37	
CD 5%		2.33		CD 5%		1.10	
	Straw yield (q ha^{-1})				**Biological yield (q ha^{-1})**		
Control	18.66	22.22	22.47	Control	27.37	33.09	35.11
50 % RDF	23.99	24.81	26.07	50 % RDF	37.73	39.07	41.13
75 % RDF	27.85	29.15	32.39	75 % RDF	43.82	46.51	52.23
100 % RDF	30.43	32.96	33.54	100 % RDF	48.97	53.36	54.41
SE (m)±		0.46		SE (m)±		0.52	
CD 5%		1.38		CD 5%		1.56	

Table 3: Residual effect of RDF and FYM levels on nutrient content of chickpea.

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Seed	Straw	Seed	Straw	Seed	Straw
Main plot treatments						
Control	1.952	0.557	0.289	0.127	0.426	0.954
50 % RDF	2.147	0.644	0.316	0.142	0.485	1.100
75 % RDF	2.352	0.761	0.335	0.160	0.553	1.189
100 % RDF	2.549	0.840	0.341	0.171	0.600	1.252
SE (m)±	0.032	0.008	0.005	0.004	0.005	0.019
CD 5%	0.110	0.029	0.017	0.013	0.019	0.064
Sub plot treatments						
Control	2.159	0.653	0.313	0.144	0.489	1.064
5 t ha^{-1} FYM	2.240	0.703	0.321	0.150	0.517	1.132
10 t ha^{-1} FYM	2.352	0.747	0.327	0.156	0.542	1.176
SE (m)±	0.020	0.007	0.003	0.001	0.006	0.013
CD 5%	0.059	0.022	0.009	0.004	0.017	0.038
Interaction M*S						
SE (m)±	0.039	0.015	0.006	0.003	0.011	0.025
CD 5%	NS	NS	NS	NS	NS	NS

2017). These results are corroborate with Gudadhe *et al.,* (2011) and Sonboir *et al.* (2020). Higher chickpea production as a result of the residual influence of RDF might be due to improved growth, which produced a sufficient supply of photosynthates for the sink's development. Thus, the increased values of the yield parameters and overall improved growth performance translated into increased seed yield (Lakum *et al.,* 2020). Boosted chickpea output as a result of FYM's residual effects, might be created to improved physical, chemical and biological qualities of the soil and increased nutrient availability, CO_2 release and fertilizer use efficiency. Improved plant growth and overall development leading to an increase in the haulm yield of chickpeas by the residual action of RDF (Lakum *et al.,* 2020). Increased plant height, branch count and leaf area may be the cause of the greater stover output with RDF and FYM treatments (Koireng *et al.,* 2018). Benefits of using organic manures, especially FYM, which improved rhizospheric development and nutrient absorption and therefore raised the output of chickpea biomass (Meena *et al.,* 2024). Essential elements were supplied in greater amounts from both organic and inorganic sources; as a result, their availability, mobilization and influx into plant tissues boosted growth and yield components and ultimately the chickpea seed, straw and biological yield (Singh *et al.,* 2023). The current results are in accordance with the findings of Meena *et al.* (2024); Lakum *et al.* (2020) and Sonboir *et al.* (2020).

Nutrient content (%)

Nitrogen, phosphorus and potassium content in seeds and straw were considerably affected by different levels of inorganic fertilizers and FYM as showed by the data presented in Table 3. Highest N content in seeds (2.549%) and in straw (0.840%) was observed in 100% RDF which showed significant superiority over 50% and 75% RDF and control. Meanwhile highest content of P in seeds (0.341%) and straw (0.171%) was observed under 100% RDF, which were significantly superior over 50%, control but statistically at par with 75% RDF. Highest K content in seeds (0.600%) was observed under 100% RDF which were significantly superior over 50%, 75% RDF and control. While highest K content in straw (1.252 %) was observed under 100% RDF, which were significantly superior over 50%, control but found at par with 75% RDF. In terms of FYM levels, highest N content (2.352%), P content (0.327%), K content (0.542%) in seeds and highest N content (0.747%), P content (0.156%), K content (1.176%) in straw was noted under 10 t ha^{-1} FYM which showed significant superiority over 5 t ha^{-1} FYM and control.

The study found that interaction between two factors *i.e.* RDF and FYM levels were found non-significant in nitrogen, phosphorus and potassium content of seeds and straw.

Nutrient uptake

Nitrogen, phosphorus and potassium uptake by seeds and straw were significantly affected by different levels of inorganic fertilizers and FYM as showed by the data presented in Table 4. Highest N uptake (51.07 kg ha^{-1}), P uptake (6.86 kg ha^{-1}), K uptake (12.21 kg ha^{-1}) by seeds and highest N uptake (27.23 kg ha^{-1}), P uptake (5.53 kg ha^{-1}), K uptake (40.69 kg ha^{-1}) by straw were observed under 100% RDF, which showed significant superiority over 50% and 75% RDF and control. In terms of FYM levels, highest N uptake (41.20 kg ha^{-1}), P uptake (5.72 kg ha^{-1}), K uptake

Table 4: Residual effect of RDF and FYM levels on nutrient uptake of chickpea.

Treatments	Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})	
	Seed	Straw	Seed	Straw	Seed	Straw
Main plot treatments						
Control	21.44	11.83	3.21	2.72	4.91	20.44
50 % RDF	30.91	16.14	4.60	3.57	7.22	27.52
75 % RDF	42.02	22.86	6.02	4.83	10.08	35.82
100 % RDF	51.07	27.23	6.86	5.53	12.21	40.69
SE (m) ±	0.81	0.78	0.08	0.16	0.39	1.17
CD 5%	2.81	2.70	0.28	0.56	1.35	4.03
Sub plot treatments						
Control	31.60	16.93	4.61	3.73	7.42	27.70
5 t ha^{-1} FYM	36.27	19.67	5.18	4.19	8.64	31.44
10 t ha^{-1} FYM	41.20	21.95	5.72	4.56	9.75	34.21
SE (m) ±	0.47	0.23	0.07	0.05	0.17	0.46
CD 5%	1.42	0.68	0.21	0.14	0.51	1.38
Interaction M*S						
SE (m) ±	0.94	0.45	0.14	0.10	0.34	0.92
CD 5%	2.83	1.36	0.42	0.29	1.01	2.76

Table 5: Interaction effect of residual RDF and FYM levels on nutrient uptake of chickpea.

Interaction M*S	Control	5 t ha^{-1} FYM	10 t ha^{-1} FYM	Interaction M*S	Control	5 t ha^{-1} FYM	10 t ha^{-1} FYM
	Nitrogen uptake by seed (kg ha^{-1})				**Nitrogen uptake by straw(kg ha^{-1})**		
Control	16.95	21.43	25.92	Control	9.52	12.47	13.51
50 % RDF	29.16	30.68	32.90	50% RDF	14.78	16.01	17.65
75 % RDF	35.86	40.33	49.86	75% RDF	19.81	21.81	26.95
100 % RDF	44.43	52.65	56.13	100% RDF	23.62	28.39	29.68
SE (m) ±		0.94		SE (m) ±		0.45	
CD 5%		2.83		CD 5%		1.36	
	Phosphorus uptake by seed (kg ha^{-1})				**Phosphorus uptake by straw (kg ha^{-1})**		
Control	2.53	3.24	3.85	Control	2.27	2.86	3.03
50 % RDF	4.32	4.57	4.92	50% RDF	3.31	3.55	3.84
75 % RDF	5.32	5.87	6.86	75% RDF	4.35	4.70	5.46
100 % RDF	6.29	7.03	7.27	100% RDF	5.00	5.66	5.92
SE (m) ±		0.14		SE (m) ±		0.10	
CD 5%		0.42		CD 5%		0.29	
	Potassium uptake by seed (kg ha^{-1})				**Potassium uptake by straw (kg ha^{-1})**		
Control	3.85	4.94	5.94	Control	15.43	22.21	23.67
50 % RDF	6.82	7.10	7.73	50% RDF	25.75	27.41	29.40
75 % RDF	8.45	9.82	11.98	75% RDF	32.78	34.43	40.26
100 % RDF	10.55	12.70	13.36	100% RDF	36.85	41.72	43.50
SE (m) ±		0.34		SE (m) ±		0.92	
CD 5%		1.01		CD 5%		2.76	

(9.75 kg ha^{-1}) by seeds and highest N uptake (21.95 kg ha^{-1}), P uptake (4.56 kg ha^{-1}), K uptake (34.21 kg ha^{-1}) by straw was noted under 10 t ha^{-1} FYM which showed significant superiority over 5 t ha^{-1} FYM and control.

The study found that interaction between two factors *i.e.* RDF and FYM levels was found statistically significant in nitrogen, phosphorus and potassium uptake of seeds and straw (Table 5).

The residual impact of recommended dose of inorganic fertilizers and well rotten farm yard manure maximize the N uptake due to gradual release of nutrients through organic manure over time throughout the mineralization process, by limiting the nutrient losses either through leaching or volatilization resulted in higher uptake of nutrients (Gudadhe *et al.,* 2011). In the initial phases of crop growth, the crop had a steady supply of P from chemical sources; later on, the crop was able to obtain nutrients from an organic source through a slow and steady release of nutrients. (Vidyavathi *et al.,* 2012). The enhanced uptake of P might be ascribed to comprehensive and well-rounded nourishment, which involves the use of chemical fertilizers based on soil tests in conjunction with organic manures, which control the increased absorption of nutrients (Meena *et al.,* 2024). Under 100% RDF, higher potassium uptake was possible due to the favourable residual effects of INM treatments which supplemented sufficient supply of primary plant nutrients, increasing nutrient absorption through enhanced fertilizer nutrient usage efficiency (Gudadhe *et al.,* 2011). One possible explanation for the increased K absorption with organic manure is the solubilization of the nutrients, the chelation of complex intermediate organic molecules formed during the breakdown of the additional organic manures and the mobilization and accumulation of various nutrients in various plant sections (Thakur *et al.,* 2023). The results of nitrogen, phosphorus and potassium uptake are in conformity with Gudadhe *et al.* (2011) and Dhaliwal *et al.* (2023).

CONCLUSION

Under integrated nutrient management strategies, the residual effect of recommended dose of inorganic fertilizers *i.e.*, 100% RDF showed significant superiority over its lower, levels and 10 t ha^{-1} of FYM performed significantly better over its lower levels on all the yield attributes, yield, concentration of nutrients and its uptake in chickpea. The interaction of inorganic fertilizer dose and FYM showed significant response on number of pods plant^{-1}, seed yield, straw yield, biological yield and nutrient uptake. Inorganic fertilizers provide faster nutrient availability and greater initial yields; on the other hand, organic fertilizers support soil health over the long term and environmental sustainability.

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Conflict of interest

All Authors do not have any conflict of interests to declare.

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