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Effect of integrated nutrient management practices on growth, yield attributes and yield of lentil (*Lens esculenta* L.) crop

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Abstract
An experiment was conducted at Uttar Pradesh in rural district Mandhana 10 km from Kanpur during *rabi*, season of 2021-22 on silty loam soil, having pH 7.80, EC 0.39 dSm^{-1}, organic carbon 0.46%, available N, P and K 214.90, 11.12 and 146.0 kg ha^{-1} respectively. The experiment was laid out in randomized block design with three replication. The experiment was conducted with 10treatment combination T_1-RDF 100%, T_2-RDF 75%, T_3-RDF 50%, T_4-RDF 75% +FYM 5 t/ha + RZ + PSB, T_5-RDF 50% +FYM 10 t/ha + RZ + PSB, T_6- RDF 25% +FYM 15 t/ha + RZ + PSB, T_7-RDF 75% + VC 0.5 t/ha + RZ + PSB, T_8-RDF 50% + VC 1.5 t/ha + RZ + PSB, T_9-RDF 25% + VC 2 t/ha + RZ + PSB, T_{10}- Control. The result of the study revealed that Maximum plant height, Number of branches $plant^{-1}$,Leaf area $plant^{-1}$,Dry matter production $plant^{-1,}$ Pods $plant^{-1}$ Seeds pod^{-1}1000-seed weight (g), Biological yield, Seed yield, Harvest index was reported in Treatment T_7- RDF 75% + VC 0.5 t/ha + RZ + PSB fallowed by treatment T_4-:RDF 75% +FYM 5 t/ha + RZ + PSB found to be greater over other treatments during the year of investigation.

Keywords: Lentil, INM, Growth, yield attributes and yield

Introduction
Lentil (*Lens esculenta* L.) is a member of the Leguminaceae family. It typically follows rice, maize, and pearl millet in the order of rainfed crops grown during the Rabi season. After soybean and hemp, lentil ranks third in terms of protein content in the human diet. Pulses are grain legumes that have remained the cornerstone of Indian agriculture because they are valued as food, fodder, and feed. In addition to being a vital component of the human diet, pulses also support soil fertility. A sizable portion of the population relies on them as a less expensive source of protein to meet their needs. They have the capacity to symbiotically work with rhizobium to fix atmospheric nitrogen. Each and every one of the pulse crops contributes significantly to the soil's fortification, acting as a miniature fertilizer factory. Another crucial trait of pulse crops that enables them to make use of the moisture and other resources from the deeper layers of soil is their deep penetrating root system. They thrive in practically all environments, including those that are less suitable for the cultivation of other crops, thanks to their hardiness.

These crops' lower average production is primarily the result of their cultivation on marginal lands with little or no financial input. There have been several initiatives to boost the yield potential of pulses, but they mostly focus on the use of fertilizers, insecticides, and better management techniques in combination with genetic improvement. India appears on the global pulse map. About 5.21% of all pulses are grown in India (29.03 million/ha), which contributed 6.67% to the output of all pulses in 2018–19. (D.P. Malik, Monika Devi *et al.*, 2022). Pulses are a significant component of the Indian food, serve as necessary supplements to a diet that is primarily composed of grains, and increase the biological value of the protein consumed. All annual pulse crops, including chickpea, pigeon pea, mung bean, urad bean, lentil, and field pea, may be grown in the country due to its diverse agroecological conditions. These significant pulse crops account for 41%, 23%, 12%, 9%, and 7% of the nation's total pulse production, respectively (Saxena KB, RV Kumar and R Sultana 2010).

Therefore, it is necessary to increase the production of pulses. In contrast to cereal crops, which are generally cultivated on more fertile grounds with reliable water supplies, pulses are traditionally grown in rainfed conditions on marginal soils with poor fertility.

For the maintenance of soil fertility, physical condition, and biological activity, the use of organic manures in conjunction with inorganic fertilizers is extremely important (Patel *et al*., 2009). Hence, integrated nutrient management-which combines inorganic fertilizers, organic manures, and bio fertilizers with technological advancements-leads to a noticeable improvement in nutrient utilization with increased nutrient-use efficiency and will undoubtedly increase productivity while lowering the cost of producing pulses.

Lentils are one of the most widely produced crops in India among pulses. India is ranked first in terms of the area used for lentil farming and second in terms of production, behind Canada. The total amount of lentils produced in the 2019–2020 crop year was 1096.5 tons, with Uttar Pradesh producing the most, at 452.8 tons, followed by Madhya Pradesh, at 294.48 tons. Lentil is a winter crop with excellent nutritional value; the seeds are particularly abundant in protein, carbohydrates, fiber, and manganese. A cup of lentils has 198 grams, 17.9 grams of protein, 15.6 grams of fiber, and folate (vitamin B9), as well as 230 calories.

In terms of quantity, phosphorus is the second most significant nutrient needed by plants after nitrogen. One of the key nutrients for plants, phosphorus is required for all significant developmental processes as well as plant reproduction. Both organic and inorganic forms of phosphorus are abundant in soil, but the majority are present in an insoluble form that cannot be taken by plants. Phosphorous is essential for the formation of healthy roots in legume crops and promotes the plant's ability to thrive. Nucleic acid, proteins, lipids, adenylate, and sugar content are some significant chemicals found in plant cells that are necessary for a cell's healthy operation. Phosphorous is involved in several activities, such as the production of energy, photosynthesis, the synthesis of nucleic acids, glycolysis, the manufacture and stability of membranes, the activation and inactivation of enzymes, and the signalling of nitrogen fixation (Vance *et al*. 2003).

Materials and Methods

The experiment was conducted at Rama University, Kanpur, which is situated in the alluvial tract of Indo - Gangetic plains in central part of Uttar Pradesh during *Rabi* season of 2021-22 on silty loam soil, having pH 7.80, EC 0.39 dSm^{-1}, organic carbon 0.46%, available N, P and K 214.90, 11.12 and 146.0 kg ha^{-1} respectively. The experiment was laid out in randomized block design with three replication. The experiment was conducted with 10 treatment combination T_{1-} RDF 100%, T_{2-} RDF 75%, T_{3-} RDF 50%, T_{4-} RDF 75% +FYM 5 t/ha + RZ + PSB, T_{5-} RDF 50% +FYM 10 t/ha + RZ + PSB, T_{6-} RDF 25% +FYM 15 t/ha + RZ + PSB, T_{7-} RDF 75% + VC 0.5 t/ha + RZ + PSB, T_{8-} RDF 50% + VC 1.5 t/ha + RZ + PSB, T_{9-} RDF 25% + VC 2 t/ha + RZ + PSB, T_{10-} Control. The sowing of Lentil was done on October 24, 2021 at a row spacing of 30 cm and plant spacing of 10 cm apart.As per the treatment. Sowing of crop was done behind country plough @ 45 kg seed ha^{-1}. As lentil crop requires adequate water supply only at flowering and pod formation stages which are the critical crop growth stages. Coincidently, during both the years of experimentation, little rainfall occurred at the same time (Fig. 3.1; standard week 4) which fulfilled the water needs of the crop. Therefore, no irrigation was given after sowing to harvest of the crop. The lentil cultivars were harvested manually with the help of sickle at physiological maturity by judging visually when 70-80% of pods turned brownish yellow and stated drying. Crop was harvested immediately as per the maturity period of cultivar to avoid the shedding of pods and subsequent yield losses. For grain yield, after harvest it was bundled and left for proper sun-drying for three days in the field to attain optimum moisture for threshing and then they were tagged. After proper drying it was carried out to threshing floor and total biomass yield of tagged bundle was recorded. Each bundle was weighed, threshed and cleaned separately and seed yield per plot was calculated in kg ha-1. Grain and straw yields were recorded separately. Straw yield was obtained by subtracting grain yield from the total biomass yield. Yield was expressed in q ha^{-1}.

Results and Discussion

Growth Characters: It is visualized from the data given in table 1 among the growth characters *viz;* plant height, Number of branchesplant^{-1}, Leaf area index and Dry matter production plant$^{-1,}$ were studied.

Plant height

Application of RDF 75% along with VC 0.5 t/ha, RZ, PSB significantly was found highest value as compared to remaining treatment combinations harvest stage, followed by T8, T_1, T_5, T_6 and T_2 at all the observation of plant growth. The absolute control had considerably lowest value at all the stages of observation Similar finding has been reported by other workers Kundu *et al.* (2017) [16].

Number of branchesplant^{-1}

As per data presented in table 1the Number of Branches plant^{-1} was increased with crop duration and the maximum branching of plant^{-1} was observed between 60 to 90 DAS, after that increased but at decreased rate in all the nutrient management practices. The significantly higher Number of Branches plant^{-1} was observed of within the nutrient management practices at all the observed of crop growth except 30 DAS. Application of (T_7) RDF 75% along with VC 0.5 t/ha, RZ, PSB significantly was found highest Branches plant^{-1} as compared to remaining treatment combinations. Similar finding has been reported by Lakpale *et al.* (2003).

Leaf area index

The data depicted in table 1, the LAI was increased with increasing days from sowing to harvest and the maximum LAI was observed between 60 to 90 DAS, after that increased but at decreased rate in all the nutrient management practices. The significantly different was observed of within the nutrient management practices at all the observed stages of crop growth except 30 DAS. Application of RDF 75% along with VC 0.5 t/ha, RZ, PSB significantly was found highest Leaf are index as compared to remaining treatment combinations, followed by T_8, T_4, T_5, T_6, T_2 and T_9 at all the observation of plant growth. The absolute control had considerably lowest Leaf are index at all the stages of observation.

Dry matter production plant^{-1}

The data presented in table 1the Dry matter production was increased with increasing days from sowing to harvest and the maximum Dry matter production was observed between 60 to 90 DAS, after that increased but at decreased rate in all the nutrient management practices. The significantly higher dry matter production was observed of within the nutrient management practices at all the observed stages of crop growth except 30 DAS. Application of RDF 75% along with VC 0.5 t/ha, RZ, PSB significantly was found highest dry matter production as compared to remaining treatment combinations. Similar finding has been reported by Layek *et al.* (2014) [17].

Yield and yield attributes: It is visualized from the data given in table 1 among the growth characters *viz*;, Pods plant^{-1} Seeds pod^{-1} 1000-seed weight (g), Biological yield, Seed yield, Harvest index were studied.

Pods plant^{-1}

Pods per plant of lentil influenced significantly by integrated nutrient management depicted in Table 2. Integration of $T_{7:}$ RDF 75% + Vermicompost 0.5 t/ha + Rhizobium+ PSB (42.13) being produced significantly maximum Pods per plant and at par with T6 and T4 similar to most of the integrated nutrient managements were significantly higher than other integrated management practices and control (30.38). Similar finding has been reported by Singh *et al.* (2011) [19].

Seeds pod^{-1}

Grains per pod of lentil not significantly in by integrated nutrient management (Table – 2). However, the numerically higher value (1.72) were recorded with the crop receiving nutrients either through integration of RDF with Vermicompost or FYM with Bio fertilizers and PSB.

1000-seed weight (g)

Test weight of lentil seed significantly influenced by integrated nutrient management depicated in table-2. Irrespective of nutrient management, 1000-grain weight of lentil ranges form 14.45 – 16.14g being maximum with crop receiving nutrients from of $T_{7:}$ RDF 75% + Vermicompost 0.5 t/ha + Rizobium+ PSB and the minimum with control.Similar finding has been reported by other workers Kumar and Yadav (2003).

Biological yield

Biological yield (q/ha) of lentil presented in table 2 and found that Biological yield of lentil (q/ha**)** were significantly affected by integrated nutrient management practices. Addition of T_7 RDF 75% + VC 0.5 t/ha + RZ + PSB (47.35 q/ha) produced maximum and significantly higher Biological yield than all other nutrient management practices. All the treatment receiving higher Biological yield as compare to the control.

Grain yield

Grain yield of lentil significantly affected by integrated nutrient management (Table – 2). Addition of T_7RDF 75% + VC 0.5 t/ha + RZ + PSB produced maximum and significantly higher (17.56 q/ha) grain yield than all other nutrient management practices. Similar finding has been reported by other workers Rahman *et al.* (2013) [18].

Harvest index

Harvest index of lentil was non-significantly influenced by integrated nutrient management depicted in table 2. Application of $T_{5:}$ RDF 50% +FYM 10 t/ha + RZ + PSB resulted in maximum and significantly higher value (43.06%) of harvest index.

Table 1: Plant height, Number of Branches plant^{-1}, leaf area index, dry matter accumulations as influenced by integrated nutrient management treatments

Treatments	Plant height (cm)	Number of Branches plant^{-1}	Leaf area index	Dry matter production (g m^{-2})
$T_{1:}$RDF 100%	51.53	14.77	2.06	428.33
$T_{2:}$RDF 75%	46.44	13.28	1.77	453.70
$T_{3:}$RDF 50%	43.11	11.81	1.57	333.30
$T_{4:}$RDF 75% +FYM 5 t/ha + RZ + PSB	51.58	14.83	2.14	435.30
$T_{5:}$RDF 50% +FYM 10 t/ha + RZ + PSB	46.49	13.37	1.80	402.19
$T_{6:}$RDF 25% +FYM 15 t/ha + RZ + PSB	46.43	13.17	1.84	360.65
$T_{7:}$RDF 75% + VC 0.5 t/ha + RZ + PSB	51.68	14.92	2.11	536.88
$T_{8:}$RDF 50% + VC 1.5 t/ha + RZ + PSB	51.41	14.74	2.03	388.02
$T_{9:}$RDF 25% + VC 2 t/ha + RZ + PSB	46.54	13.21	1.76	399.02
$T_{10:}$Control (No fertilizer)	39.66	10.33	1.31	255.57
SEm ±	1.75	0.63	0.07	33.01
$CD_{(P=0.05)}$	5.19	1.87	0.20	98.08

Table 2: Yield attributes and yield of Lentil as influenced by integrated nutrient management practices

Treatments	Harvest index (%)	Yield (q/ha)			Pods/plant	Grains/pod	1000 grain wt.(g)
		Grain	Straw	Biological			
$T_{1:}$RDF 100%	37.78	13.5	22.23	35.73	32.57	1.70	15.91
$T_{2:}$RDF 75%	35.66	12.32	20.66	32.98	37.87	1.56	15.64
$T_{3:}$RDF 50%	39.46	11.13	17.08	28.21	31.56	1.67	15.29
$T_{4:}$RDF 75% +FYM 5 t/ha + RZ + PSB	39.09	14.58	22.72	37.30	40.39	1.76	15.92
$T_{5:}$RDF 50% +FYM 10 t/ha + RZ + PSB	43.06	13.36	18.43	31.79	36.65	1.67	15.80
$T_{6:}$RDF 25% +FYM 15 t/ha + RZ + PSB	39.72	12.17	18.47	30.64	37.46	1.67	15.54
$T_{7:}$RDF 75% + VC 0.5 t/ha + RZ + PSB	37.09	17.56	29.79	47.35	42.13	1.79	16.14
$T_{8:}$RDF 50% + VC 1.5 t/ha + RZ + PSB	41.08	13.59	19.49	33.08	33.92	1.67	15.88
$T_{9:}$RDF 25% + VC 2 t/ha + RZ + PSB	39.90	12.34	18.59	30.93	33.11	1.72	15.33
$T_{10:}$Control (No fertilizer)	42.02	7.90	12.76	17.96	30.38	1.60	14.45
SEm ±	2.4	1.64	1.80	2.20	1.76	0.08	0.29
$CD_{(P=0.05)}$	7.2	4.92	5.40	6.60	5.22	NS	0.85

Conclusion

Based on the above result, it can be concluded that application of 75% RDF with 0.5 t/ha vermicompost, Rhizobium and PSB gave maximum and significantly higher, all growth and yield metrics such as plant height, no of branches, dry matter accumulation, higher grain, straw and biological yield than all other nutrient management practices were recorded at their greatest levels.

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