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Integrated nutrient management in lentil (*Lens culinaris* L.)

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Abstract
A field experiment was carried out during Rabi season of 2021-22 at the research form of AKS University Sherganj, Satna, Madhya Pradesh to integrated nutrient management of Lentil (*Lens Culinaris* L.). The experiment consisted of twelve treatment combinations comprising variety of lentil. The experiment was laid out in randomized block design (RBD) with three replication. Growth parameter like plant height, number of branches per plant and dry matter accumulation per plant (g), yield attributing characters like number of pod per plant, Number of seed per pod, seed yield per plant, seed yield per plot, seed yields (q/ha). Based upon the experiment, it is conducted the application of 100% RDF prove best treatment. Among the INM treatment, application of 100% nitrogen through poultry manure recorded the significantly higher grain yield (8.33 q/ha), maximum gross returns (64090.00 Rs/ha) and maximum net returns (46858.00 Rs/ha) and highest B: C ratio of 2.24:1.

Keywords: Integrated nutrient management, lentil, growth, yield, quality

Introduction
Pulses form an integral part of the vegetarian diet and the cheapest source of protein for the resource of poor farmers of the Indian sub-continent. The pulses are also known to increase productivity of soil through fixation of nitrogen from atmosphere, addition of biomass to soil and secretion of growth promoting substances. From the nutritional point of view, pulses have been an important source of plant- protein which are usually lacking in animal- proteins. India is the world's largest grower, producer and consumer of pulses accounting 34 per cent of total acreage, 26 per cent of the total production and about 30 per cent (23-24 million tons) of the total consumption in the world. In India, the area under pulses was >29 million ha with the total production of 25.23 million tons at a productivity of 841 kg /ha during 2017-18 (MoA & FW, 2018).

INM system may be defined as an intelligent use of an optimum combination of organic, inorganic and biological nutrient sources in a specific crop rotation or cropping system to achieve and sustain optimum yield without harming the soil ecosystem. Such a package of plant nutrients formulated must be technically sound, economically viable, practically feasible, socially acceptable and environmentally safe. Briefly, the integrated nutrient management (INM) has assumed greater significance in the recent past. Work on INM, as a whole is very less. Besides, the prohibitive cost of chemical fertilizers often compels to use organic manures. Therefore, INM involving inorganic and organic sources has potential to improve soil fertility on sustainable basis, since it supplies almost all the nutrients besides increasing nutrient use efficiency and improving physio-chemical properties of soil. Hence, there is need to study the effect of combined use of organic and inorganic nitrogenous sources on productivity in lentil.

INM system entails the maintenance of soil fertility to an optimum level for crop productivity to obtain the maximum benefit from all possible sources of plant nutrients-organic as well as inorganic- in an integrated manner is an essential step to address the twin concerns of nutrient excess and nutrient depletion.

Integrated nutrient management holds great promise in meeting the growing nutrient demands of intensive agriculture. It can also help in maintaining production and sustainability without deterioration in quality of the ecosystem. The benefit of integrated nutrient management increases water holding capacity, amount of nutrients, resistance to diseases and make the soil able to withstand drought and also plays a great role in seed quality and storability. These aspects on lentil cultivation have received very little attention particularly in Vindhya region. There is a possibility of ranging the productivity per unit area by integrated nutrient management.

Materials and Methods

The present experiment was conducted during the *rabi* season of 2021- 22 at the Student Instructional field, department of Agronomy, Faculty of Agriculture, AKS University, Sherganj, Satna (M.P.). Mean temperature and humidity ranged from 10.20 ºC (min) to 45.0 ºC (max) and 87.00% (morning) to 75.00% (evening), respectively. The soil of experimental field was silty clay loam with low level of organic carbon (0.39%), available nitrogen (150.4kg ha^{-1}), available phosphorus (16.8 kg ha^{-1}) and medium level of available potassium (279.50 kg ha^{-1}) having 7.9 pH and 0.14 ds/m EC.

The experiment was conducted in randomize block design with three replications. different Fertility levels *viz*., RDF (NPK @ 20: 40: 20 kg/ha) – T1, 100% nitrogen through FYM – T2, 100% nitrogen through vermicompost –T3, 100% nitrogen through poultry manure - T4, 75% nitrogen through FYM + 25% nitrogen through vermicompost – T5, 75% nitrogen through vermicompost + 25% nitrogen through poultry manure – T6, 75% nitrogen through poultry manure + 25% nitrogen through FYM – T7, 50% nitrogen through FYM + 50% nitrogen through poultry manure – T8, 50% nitrogen through vermicompost + 50% nitrogen through poultry manure – T9, 50% nitrogen through FYM + 50% nitrogen through vermicompost – T10, 50% nitrogen through FYM + 25% nitrogen through vermicompost + 25% nitrogen through poultry manure – T11 & 25% nitrogen through FYM + 25% nitrogen through vermicompost + 50% nitrogen through poultry manure – T12. The gross and net plot size was 5 m x 3 m, respectively. The experimental plots were fertilizers as per recommended dose.

The seed of lentil, JL- 3 variety was obtained from JNKVV, Jabalpur. The lentil variety was sown as per treatments. As per treatment the crop was sown using seed rate of 30 kg/ ha. Seeds were treated with Bavistin before sowing the seeds to control the seed borne disease. In order to obtain uniform plant height stand, seeds were weighed for each plot separately in small packets for sowing. Sowing was done manually in furrows 20.0 cm x 5.0 cm apart. The crop was sown on 25th October 2020. Pre-sowing irrigation was given 7-10 days before sowing. The crop was irrigated two times. The seeds were sown manually at about 5 cm depth followed by irrigation. Required quantity of healthy, bold, unbroken and fully developed seeds were used.

Results and Discussion

The result shows that plant height, Number of branches per plant, Number of root nodules/plant Number of Pods/plant, Number of grain/pod, test weight of seed, grain and Stover yield, harvest Index, protein was influenced significantly due to INM. The highest plant height (22.91 cm) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (18.16 cm), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 22.34 cm) was found significantly better than T_3 (100% nitrogen through vermicompost) of 21.65 cm which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of 21.63 cm and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 21.53 cm).

The highest number of branches per plant (5.20) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (2.87), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 5.07) was found significantly better than T_3 (100% nitrogen through vermicompost) of 4.73 which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of 4.47 and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 4.27).

The highest number of root nodules per plant (12.73) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (10.07), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 12.40) was found significantly better than T_3 (100% nitrogen through vermicompost) of 11.80 which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of 11.60 and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 11.27).

Plant height, production of branches showed marked variation due to the combined application of inorganic fertilizers and organic manure i.e. vermicomposting, FYM, poultry manure. The treatment of 100% Nitrogen through poultry manure showed significant improvement in plant height, number of branches as compared to remaining practices. The basal application of chemical fertilizers meets the nutritional requirement of crop for proper establishment and growth during the initial period. The use of poultry manure would have facilitated better aeration, adequate drainage, improved soil biological activities and created a favorable soil environment for deeper proliferation of roots and higher nutrient extraction from soil, caused more vigorous plant growth. The increased plant height and branches might be due to the involvement of nutrients in cell wall development and cell differentiation which resulted in elongation of shoot and root in plants. The maximum height and branches might be due to more functional leaves and associated increased light interception and enhanced photosynthetic rate, which ultimately resulted in higher leaf area index. The beneficial effect of organic/poultry manure on leaf area might be due to synthesis of certain phytohormones, vitamins and more interception of solar radiation and synthesis of more chlorophyll which together all increased leaf area index in lentil. Similar results were obtained by Prajapati *et al*. (2017) [4] who had reported that an appropriate supply of nutrients through organic and inorganic sources increased the growth attributes of lentil through active photosynthesis. The results are in agreement with the findings of Biswash *et al*. (2014) [5] and Singh and Singh (2014) [6]. In which they reported the positive impact of judicious nutrient management with organic manure and inorganic fertilizers on performance of plant attributing parameters of lentil.

The highest number of pods per plant (69.60) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (50.27), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 69.13) was found significantly better than T_3 (100% nitrogen through vermicompost) of 69.00 which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of

69.00 and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 66.67).

The highest number of grains per pod (1.93) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (1.07), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 1.87) was found significantly better than T_3 (100% nitrogen through vermicompost) of 1.73 which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of 1.67 and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 1.53).

The highest test weight (22.91 g) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (20.07 g), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 22.80 g) was found significantly better than T_3 (100% nitrogen through vermicompost) of 22.74 g which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of 22.74 g and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 22.60 g).

The highest grain yield per hectare (8.67 q/ha) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (6.44 q/ha), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 8.33 q/ha) was found significantly better than T_3 (100% nitrogen through vermicompost) of 8.19 q/ha which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of 8.11 q/ha and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 7.83 q/ha).

The highest stover yield per hectare (16.17 q/ha) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (13.39 q/ha), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 15.90 q/ha) was found significantly better than T_3 (100% nitrogen through vermicompost) of 15.86 q/ha which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of 15.81 q/ha and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 15.60 q/ha).

Based on application of 100% RDF @ 20: 40: 20 kg NPK/ha produced significantly highest harvest index of lentil at each growth stages of the crop. The highest harvest index (34.91%) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (32.48%), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 34.40%) was found significantly better than T_3 (100% nitrogen through vermicompost) of 34.07% which was on par with 50% Nitrogen through FYM + 25% Nitrogen through Vermicompost + 25% Nitrogen through Poultry Manure (T_{11}) of 34.01% and 75% Nitrogen through Poultry Manure + 25% Nitrogen through FYM (T_7, 33.92%).

The highest protein content (25.20%) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (21.36%), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, 24.70%) was found significantly better than T_3 (100% nitrogen through vermicompost) of 24.47% which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of 24.30% and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 24.01%).

The highest net monetary return (₹ 49788.00 Rs/ha) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (₹ 31971.67 Rs/ha), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through Poultry Manure (T_4, ₹ 46857.67 Rs/ha) was found significantly better than T_3 (100% nitrogen through vermicompost) of ₹ 45472.67 Rs/ha which was on par with 75% nitrogen through Poultry Manure + 25% nitrogen through FYM (T_7) of ₹ 45842.00 Rs/ha and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, ₹ 43573.33 Rs/ha).

The highest B:C ratio (2.43:1) was recorded under the application of treatment, T_1 (100% RDF @ 20: 40: 20 kg NPK/ha) which was significantly better than T_2 (1.50:1), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 75% Nitrogen through Poultry Manure + 25% Nitrogen through FYM (T_7, 2.26:1) was found significantly better than T_4 (100% nitrogen through vermicompost) of 2.24:1 which was on par with 100% Nitrogen through Vermicompost (T_3) of 2.14:1 and 75% nitrogen through vermicompost + 25% nitrogen through Poultry Manure (T_6, 2.13:1).

Summary and Conclusion

Based upon this experiment it is concluded that application of the 100% nitrogen through poultry manure recorded the significantly higher grain yield (8.33q/ha), maximum gross returns (₹ 64090.00 Rs/ ha) and maximum net returns (₹ 46858.00 Rs/ ha) and highest B: C ratio of 2.24:1. Hence, application of these nutrient can be adopted in semi-arid eastern plain zone of Madhya Pradesh.

Table 1: Integrated nutrient management on growth, yield and quality of Lentil (*Lens Culinaris* L.)

Treatment	Plant height (cm)	Number of branches/Plant	Root nodule/plant	No. of Pod/plant	No. of grain/pod	Test weight of seed
RDF (NPK @ 20: 50: 20 kg/ha)	22.91	5.20	12.73	69.60	1.93	22.91
100% nitrogen through FYM	18.16	2.87	10.07	50.27	1.07	20.07
100% nitrogen through vermicompost	21.65	4.73	11.80	69.00	1.73	22.74
100% nitrogen through PM	22.34	5.07	12.40	69.13	1.87	22.80
75% nitrogen through FYM + 25% nitrogen through vermicompost	18.29	2.93	10.20	52.40	1.13	21.50
75% nitrogen through vermicompost + 25% nitrogen through PM	21.53	4.27	11.27	66.67	1.53	22.60
75% nitrogen through PM + 25% nitrogen through FYM	21.63	4.47	11.60	69.00	1.67	22.74
50% nitrogen through FYM + 50% nitrogen through poultry manure	20.13	3.93	10.60	58.47	1.33	22.15
50% nitrogen through vermicompost + 50% nitrogen through PM	20.99	4.13	11.07	64.13	1.47	22.50
50% nitrogen through FYM + 50% nitrogen through vermicompost	19.03	3.47	10.27	53.60	1.13	21.80
50% nitrogen through FYM + 25% nitrogen through vermicompost + 25% nitrogen through poultry manure	19.64	3.80	10.40	56.67	1.27	22.01
25% nitrogen through FYM + 25% nitrogen through vermicompost + 50% nitrogen through poultry manure	20.82	4.07	10.93	61.53	1.40	22.44
S. Em±	0.26	0.20	0.32	0.56	0.09	0.39
C.D. (P=0.05)	0.76	0.57	0.94	1.64	0.26	1.13

Table 2: Integrated nutrient management on yield, quality and economics of Lentil (*Lens Culinaris* L.)

Treatment	Seed yield/ha.	Stover yield/ha.	Harvest Index	Protein content	Net return (Rs/ha)	B:C ratio
RDF (NPK @ 20: 50: 20 kg/ha)	8.67	16.17	34.91	25.20	49788.00	2.43
100% nitrogen through FYM	6.44	13.39	32.48	21.36	31971.67	1.50
100% nitrogen through vermicompost	8.19	15.86	34.07	24.47	45472.67	2.14
100% nitrogen through PM	8.33	15.90	34.40	24.70	46857.67	2.24
75% nitrogen through FYM + 25% nitrogen through vermicompost	6.58	13.61	32.60	21.69	33067.00	1.55
75% nitrogen through vermicompost + 25% nitrogen through PM	7.83	15.60	33.42	24.01	43573.33	2.13
75% nitrogen through PM + 25% nitrogen through FYM	8.11	15.81	33.92	24.30	45842.00	2.26
50% nitrogen through FYM + 50% nitrogen through poultry manure	7.50	14.79	33.65	23.09	40261.67	1.90
50% nitrogen through vermicompost + 50% nitrogen through PM	7.81	15.45	33.56	23.68	43184.67	2.10
50% nitrogen through FYM + 50% nitrogen through vermicompost	6.97	14.07	33.14	21.94	36626.33	1.77
50% nitrogen through FYM + 25% nitrogen through vermicompost + 25% nitrogen through poultry manure	7.42	14.39	34.01	22.04	40077.00	1.94
25% nitrogen through FYM + 25% nitrogen through vermicompost + 50% nitrogen through poultry manure	7.72	15.17	33.73	23.43	42000.00	1.99
S. Em±	0.07	0.20	0.37	0.23	559.32	0.03
C.D. (P=0.05)	0.22	0.58	1.08	0.68	1626.30	0.08

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