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Integrated nutrient management in pea (*Pisum sativum* 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 pea (*Pisum Sativum*). The experiment consisted of twelve treatment combinations comprising variety of pea. 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 maximum and significantly higher grain yield (19.25 g/ha) net return (105836.00 Rs/ha), maximum gross returns (133702.00 Rs/ha) and highest B: C ratio of 3:80:1.

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

Introduction
Pea is marketed as a dry and shelled product for either human or livestock food. It differs from fresh or succulent pea which is marketed as a fresh or canned vegetable. Being a rich source of protein, it occupies an important place in the vegetarian diet. It is highly nutritive and contains a major proportion of digestible protein, carbohydrates, fats, minerals, vitamins and characterized by relatively high antioxidant activity (Han and Baik, 2008) [1]. It possesses 25 to 28 % protein, 60 to 65 % carbohydrates, 2 % fats and other minerals. Pea has high levels of amino acids, lysine and tryptophan which are relatively low in cereal grains. The seeds are low in fat, high in fire and contain no cholesterol. It may be grown as a forage crop, for hay, pasturage and green manure. It contains 5 to 20 % less of the trypsin inhibitors than soybean. This allows it to be directly fed to livestock without having to go through the extrusion heating process. Pea maintains soil fertility through biological nitrogen fixation in association with symbiotic rhizobium prevalent in its root nodules and thus plays a vital role in fostering sustainable agriculture (Negi *et al.*, 2006) [2].

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, INM system is a holistic approach of maintaining soil fertility and plant nutrient supply to an optimum level for sustaining the crop productivity at the desired level (Mahajan and Gupta, 2009) [3]. This system aims to achieve a harmony in the judicial use of chemical fertilizers in conjunction with organic manures, well-decomposed crop residues, recyclable waste, compost, green manures, bio fertilizers, legumes in cropping system and other locally available nutrient sources for sustaining soil health and amelioration of the environment as well as crop productivity on long-term basis (Mahajan and Sharma, 2005) [4]. 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.

Hence, there is need to study the effect of combined use of organic and inorganic nitrogenous sources on productivity in pea.

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 @ 50:40:20 kg/ha) – T_1, 100 % nitrogen through FYM – T_2, 100 % nitrogen through vermicompost –T3, 100 % nitrogen through poultry manure - T_4, 75 % nitrogen through FYM + 25% nitrogen through vermicompost – T_5, 75 % nitrogen through vermicompost + 25% nitrogen through poultry manure – T_6, 75 % nitrogen through poultry manure + 25 % nitrogen through FYM – T_7, 50 % nitrogen through FYM + 50 % nitrogen through poultry manure – T8, 50 % nitrogen through vermicompost + 50 % nitrogen through poultry manure – T_9, 50 % nitrogen through FYM + 50% nitrogen through vermicompost – T_{10}, 50 % nitrogen through FYM + 25 % nitrogen through vermicompost + 25 % nitrogen through poultry manure – T_{11} & 25 % nitrogen through FYM + 25 % nitrogen through vermicompost + 50 % nitrogen through poultry manure – T_{12}. 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 pea, Kashi Nandini variety was obtained from IIVR, Varanasi. The pea variety was sown as per treatments. As per treatment the crop was sown using seed rate of 80 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 30.0 cm x 5.0 cm apart. The crop was sown on 25th October 2021. Pre-sowing irrigation was given 7-10 days before sowing. The seeds were sown manually at about 5 cm depth followed by irrigation.

Results and Discussion

The result shows that plant height, number of branches per plant, Number of root nodules/plant Number of Pods/plant, Length of pod, 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 (61.19 cm) was recorded under the application of treatment, T1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (47.97 cm), while the crop was fertilize with 100 % nitrogen through FYM. Among the INM treatments, application of 100 % nitrogen through poultry manure (T_4, 60.03 cm) was found significantly better than T_3 (100 % nitrogen through vermicompost) of 59.54 cm which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 58.16 cm and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 57.33 cm).

The highest number of branches per plant (11.33) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (7.00), while the crop was fertilize with 100 % nitrogen through FYM. Among the INM treatments, application of 100 % nitrogen through poultry manure (T_4, 10.40) was found significantly better than T_3 (100% nitrogen through vermicompost) of 10.20 which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 9.93 and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 9.67).

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest number of root nodules per plant of pea. The highest number of root nodules per plant (70.33) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (50.00), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100 % nitrogen through poultry manure (T_4, 66.67) was found significantly better than T_3 (100 % nitrogen through vermicompost) of 63.80 which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 62.13 and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 61.53).

Plant height, number of branches per plant, number of root nodules per plant and 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, root nodules, early flowering 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 maximum plant height, branches and root nodules 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 pea. Similar results were obtained by Pandey *et al*. (2017) [5] who had reported that an appropriate supply of nutrients through organic and inorganic sources increased the growth attributes of pea through active photosynthesis. The results are in agreement with the findings of Mandhata *et al*. (2016) [6] and Teli *et al*. (2016). In which they reported the positive impact of judicious nutrient management with organic manure and inorganic fertilizers on performance of plant attributing parameters of pea.

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest number of pods per plant of pea. The highest number of pods per plant (28.67) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (13.60), while the crop was fertilize with 100 % nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T_4, 26.40) was found significantly better than T_3 (100 % nitrogen through vermicompost) of 22.73 Which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 21.33 and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6,

20.60).

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest length of pod of pea. The highest length of pod (9.75 cm) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (4.76 cm), while the crop was fertilize with 100 % nitrogen through FYM. Among the INM treatments, application of 100 % nitrogen through poultry manure (T_4, 8.90 cm) was found significantly better than T_3 (100 % nitrogen through vermicompost) of 8.78 cm which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 8.55 cm and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 8.16 cm).

Based on application of 100% RDF @ 20:30:40 kg NPK/ha produced significantly highest number of grains per pod of pea. The highest number of grains per pod (7.53) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (3.47), while the crop was fertilize with 100 % nitrogen through FYM. Among the INM treatments, application of 100 % nitrogen through poultry manure (T_4, 6.67) was found significantly better than T_3 (100 % nitrogen through vermicompost) of 5.93 which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 5.80 and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 5.67).

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest test weight of pea. The highest test weight (204.86 g) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (161.42 g), while the crop was fertilize with 100 % nitrogen through FYM. Among the INM treatments, application of 100 % nitrogen through poultry manure (T_4, 199.59 g) was found significantly better than T_3 (100 % nitrogen through vermicompost) of 196.43 g which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 193.50 g and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 191.89 g).

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest seed yield per hectare of pea. The highest seed yield per hectare (20.44 q/ha) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T2 (14.06 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, 19.25 q/ha) was found significantly better than T_3 (100 % nitrogen through vermicompost) of 19.03 q/ha which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 18.89 q/ha and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 17.36 q/ha).

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest stover yield per hectare of pea. The highest stover yield per hectare (44.07 q/ha) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T2 (36.60 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, 42.88 q/ha) was found significantly better than T_3 (100 % nitrogen through vermicompost) of 42.75 q/ha which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 42.16 q/ha and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 41.61 q/ha).

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest harvest index of pea. The highest harvest index (31.67 %) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (27.75 %), while the crop was fertilize with 100 % nitrogen through FYM. Among the INM treatments, application of 100 % nitrogen through poultry manure (T_4, 30.98 %) was found significantly better than T_9 (50 % vermicompost + 50 % poultry manure) of 30.80% which was on par with 100 % nitrogen through vermicompost (T_3) of 30.93 % and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 29.44 %).

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest protein content of pea. The highest protein content (22.70 %) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (19.27 %), while the crop was fertilize with 100 % nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T_4, 22.23 %) was found significantly better than T_3 (100 % nitrogen through vermicompost) of 21.79 % which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of 21.72 % and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 21.37 %).

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest net monetary return of pea. The highest net monetary return (₹ 112652.56 Rs/ha) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (₹ 69644.11 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, ₹ 105835.67 Rs/ha) was found significantly better than T_3 (100 % nitrogen through vermicompost) of ₹ 103509.56 Rs/ha which was on par with 50 % vermicompost + 50 % poultry manure (T_9) of ₹ 102918.78 Rs/ha and 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, ₹ 92668.89 Rs/ha).

Based on application of 100 % RDF @ 20:30:40 kg NPK/ha produced significantly highest B: C ratio of pea. The highest B: C ratio (3.88:1) was recorded under the application of treatment, T_1 (100 % RDF @ 20:30:40 kg NPK/ha) which was significantly better than T_2 (2.40:1), while the crop was fertilize with 100 % nitrogen through FYM. Among the INM treatments, application of 100 % nitrogen through poultry manure (T_4, 3.80:1) was found significantly better than T_9 (50 % vermicompost + 50 % poultry manure) of 3.60:1 which was on par with 100 % nitrogen through vermicompost (T_3) of 3.64:1, 75 % nitrogen through vermicompost + 25 % poultry manure (T_6, 3.25:1).

Summary and Conclusion

Based upon this experiment it is concluded that among the INM treatment, application of the 100 % nitrogen through poultry manure recorded the significantly higher seed yield (19.25 q/ha), maximum gross returns (₹ 133702.00 Rs/ ha), net returns (₹ 105836.00 Rs/ ha) and highest B: C ratio of 3.80:1. Hence, application of these nutrient can be adopted in semi-arid eastern plain zone of Madhya Pradesh. Hence, it can be concluded that application of 100 % nitrogen through

poultry manure recorded B: C ratio >3, can be used as remunerative strategies. However, these results are only indicative and require further experimentation to arrive at more consistent and final conclusion to be passed on to growers.

Table 1: Integrated nutrient management on growth, yield and quality of Pea (*Pisum sativum L*)

Treatment	Plant Height (cm)	Number of branches / Plant	Root Nodule / plant	No. of Pod / plant	Length of Pod	No. of grain / pod	Test Weight of seed
RDF (NPK @ 20:50:20 kg/ha)	61.19	11.33	70.33	28.67	9.75	7.53	204.86
100 % nitrogen through FYM	47.97	7.00	50.00	13.60	4.76	3.47	161.42
100 % nitrogen through vermicompost	59.54	10.20	63.80	22.73	8.78	5.93	196.43
100 % nitrogen through PM	60.03	10.40	66.67	26.40	8.90	6.67	199.59
75 % nitrogen through FYM + 25 % nitrogen through vermicompost	49.75	7.40	52.80	14.07	6.11	4.00	167.75
75 % nitrogen through vermicompost + 25 % nitrogen through PM	57.33	9.67	61.53	20.60	8.16	5.67	191.89
75 % nitrogen through PM + 25 % nitrogen through FYM	55.15	9.0	61.00	20.40	8.03	5.53	188.16
50 % nitrogen through FYM + 50 % nitrogen through poultry manure	54.73	8.87	59.73	19.67	7.81	5.07	183.38
50 % nitrogen through vermicompost + 50 % nitrogen through PM	58.16	9.93	62.13	21.33	8.55	5.80	193.50
50 % nitrogen through FYM + 50 % nitrogen through vermicompost	52.61	8.40	56.47	16.60	7.07	4.53	174.97
50 % nitrogen through FYM + 25 % nitrogen through vermicompost + 25 % nitrogen through poultry manure	53.78	8.60	58.20	19.00	7.60	4.60	179.35
25 % nitrogen through FYM + 25 % nitrogen through vermicompost + 50 % nitrogen through poultry manure	55.22	9.33	59.93	20.00	7.98	5.27	186.15
S.EM±	1.14	0.34	0.69	1.03	0.34	0.29	1.18
C.D. (p = 0.05)	3.31	0.98	2.00	2.98	1.00	0.86	3.44

Table 2: Integrated nutrient management on yield, quality and economics of Pea **(*Pisum sativum L*)**

Treatment	Seed yield / ha.	Stover yield / ha.	Harvest Index	Protein content	Net return	B: C ratio
RDF (NPK @ 20:50:20 kg/ha)	20.44	44.07	31.67	22.70	112653.00	3.88
100 % nitrogen through FYM	14.06	36.60	27.75	19.27	69644.00	2.40
100 % nitrogen through vermicompost	19.03	42.75	30.80	21.79	103510.00	3.60
100 % nitrogen through PM	19.25	42.88	30.98	22.23	105836.00	3.80
75 % nitrogen through FYM + 25 % nitrogen through vermicompost	14.36	36.79	28.08	19.78	71745.00	2.48
75 % nitrogen through vermicompost + 25 % nitrogen through PM	17.36	41.61	29.44	21.37	92669.00	3.25
75 % nitrogen through PM + 25% nitrogen through FYM	16.92	41.23	29.07	21.14	90042.00	3.20
50 % nitrogen through FYM + 50 % nitrogen through poultry manure	16.22	40.18	28.76	20.61	85020.00	2.99
50 % nitrogen through vermicompost + 50 % nitrogen through PM	18.89	42.16	30.93	21.72	102919.00	3.64
50 % nitrogen through FYM + 50 % nitrogen through vermicompost	14.94	38.53	27.95	19.84	75969.00	2.63
50% nitrogen through FYM + 25 % nitrogen through vermicompost + 25 % nitrogen through poultry manure	15.33	39.20	28.11	20.07	78836.00	2.75
25% nitrogen through FYM + 25 % nitrogen through vermicompost + 50 % nitrogen through poultry manure	16.75	40.51	29.25	20.89	88594.00	3.12
S.EM±	0.44	0.32	0.54	0.23	2833.84	0.10
C.D. (p = 0.05)	1.27	0.92	1.56	0.67	8239.73	0.29

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