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Effect of integrated nutrient management on available macronutrient status in rapeseed (*Brassica campestris* L.) var. M-27 cultivated soils of Utlou, Manipur

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Abstract
A field experiment was conducted to study "the Effect of Integrated Nutrient Management on available macronutrient status in Rapeseed (*Brassica campestris* L.) Var. M-27 cultivated soils of Utlou, Manipur" during *rabi* season of 2018- 2019 at the experimental field of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Bishnupur, Utlou, Manipur. Results revealed that integrated nutrient management markedly improved the available macronutrients in soil and highest availability was observed in T_5 treated with 75% RDN using Chemical fertilizer (urea) + 25% RDN using Vermicompost + *Azotobacter* which is at par with T_6, T_7, T_9 and T_{11}. This might be due to release of nutrients from organic sources thereby improved physical and biological properties of soil.

Keywords: Integrated nutrient management, rapeseed, macronutrient, vermicompost, *Azotobacter*

Introduction
Rapeseed (*Brassica campestris* L.) is a cruciferous oilseed crop and is originated from eastern Afghanistan an adjoining part of India and Pakistan (Nand *et al*., 2018) [16]. The seed and oil are used as condiment and preparation of pickles and flavouring curries and vegetables. Rapeseed is a major oilseed crop and it is mainly grown in *Rabi* season under poor management with imbalanced fertilization. The cost of production is increasing due to high prices of inorganic fertilizers. Therefore, the alternatives of chemical fertilizers are to be looked into just to reduce the cost of cultivation. The crops had an area of 6.51 million ha with a total net production of 7.67 million tonnes and with an average yield of 1179 kg ha^{-1} (Anonymous, 2011) [1]. In Manipur rapeseed is grown during *Rabi* season after the harvest of *Kharif* rice, contributing about 80- 90% share in the total oilseed production of the state. Imbalanced nutrition is one of the important constraints toward higher mustard productivity, oil content and other quality parameters (Lal *et al*. 2016) [12]. Balanced combination of organic manures, bio-fertilizers and chemical fertilizer facilitate profitable and sustainable production (Singh and Siniswar, 2006) [22]. Therefore, integrated nutrient management approach underlines the basic concept of maintenance or adjustment of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner.
Keeping the above facts in view, a present investigation was carried out to study the "Effect of Integrated Nutrient Management on available macronutrient status in Rapeseed (*Brassica campestris* L.) Var. M-27 cultivated soils of Utlou, Manipur".

Materials and Methods
The field study was conducted during *rabi* season of 2018-19 at Research Farm of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou. The experimental site was situated at 24º43´54´´N latitude and 93º51´31´´S longitude at an altitude of 790 m above mean sea level. During the months of experiment, the mean maximum and minimum temperatures lies between 29.70 ℃ and 4.60 ℃. The relevant physicochemical properties of the initial soil were presented in Table 1. Soil texture, pH, EC, organic carbon, cation exchange capacity (CEC), available N, P and K were determined following the standard procedure described by Jackson (1973) [10].

Table 1: Initial soil characteristics of the experimental field

Soil characteristics	Results
Textural class	Clayey soil
Sand (%)	23.80
Silt (%)	27.50
Clay (%)	48.70
pH (1:2.5 soil: water ratio)	5.47
EC (1:2.5 soil: water ratio, dsm^{-1})	0.04
CEC [cmol(p^+) kg^{-1}]	12.80
Organic carbon (%)	1.0
Available Nitrogen (Kg N ha^{-1})	313.60
Available Phosphorus (Kg P_2O_5 ha^{-1})	47.17
Available potassium (Kg K_2O ha^{-1})	268.80

Treatment details

The experiment was laid out in Randomized Block Design with 12 (twelve) treatments replicated thrice. The treatments were applied to rapeseed (*Brassica campestris* L. var. M-27). The treatments used in the study were T_0 – Control, T_1- 100% RDN using Chemical fertilizer (urea), T_2- 100% RDN using Vermicompost, T_3- *Azotobacter*, T_4- 75% RDN using Chemical fertilizer (urea) + 25% RDN using Vermicompost, T_5- 75% RDN using Chemical fertilizer (urea) + 25% RDN using Vermicompost + *Azotobacter*, T_6- 50% RDN using Chemical fertilizer (urea) + 50% RDN using Vermicompost, T_7- 50% RDN using Chemical fertilizer (urea) + 50% RDN using Vermicompost + *Azotobacter*, T_8- 25% RDN using Chemical fertilizer (urea) + 75% RDN using Vermicompost, T_9- 25% RDN using Chemical fertilizer (urea) + 75% RDN using Vermicompost + *Azotobacter*, T_{10}- 100% RDN using Chemical fertilizer (urea) + 100% RDN using Vermicompost, T_{11}- 100% RDN using Chemical fertilizer (urea) + 100% RDN using Vermicompost + *Azotobacter*. The recommended dose of NPK fertilizers with a ratio of 40:30:30 were applied as per treatment in the form of Urea, SSP and MOP respectively. However, a constant dose of phosphorus (P_2O_5), potassium (K_2O) and half dose of nitrogen (N) as urea were applied as basal application a day before the date of sowing. Urea and Vermicompost are converted into 25%, 50%, 75% and 100% of nitrogen content. The vermicompost was thoroughly mixed in soil as per treatment after final ploughing. The remaining dose of nitrogen was top dressed at pre -flowering stage. Seed treatment with *Azotobacter* was done by adding proper quantity of jaggery and shaken gently so that the adhesive spreads evenly on all the seeds, the required *Azotobacter* were sprinkled evenly over the seeds and continued shaking so that it forms coating over the seeds, the seeds were shade dried for 30 minutes before sowing. The various standard cultural operations were carried out as per recommended package of practices. Representative surface soil samples (0-20 cm) were collected at 30th, 60th, 90th DAS and at harvest of rapeseed crop for the analyzing various chemical properties of soil using standard laboratory procedures.

Statistical analysis

The analysis of variance method as suggested by Gomez and Gomez (1984) [5] was followed for statistical analysis and interpretation of the results. The significant of the different sources of variation was tested with the help of F test at 5% level of probability and the best treatment was selected by using DMRT.

Results and Discussions

1. Available Nitrogen content in soil (kg ha^{-1})

Data regarding the effect of INM on available nitrogen content in soil at various stages of rapeseed are presented in Table 2. Regardless of the treatments, available nitrogen content in soil increased up to 30th day after sowing (DAS) with exception in untreated control and then gradually decreased in each successive sampling days i.e. 60th and 90th DAS and at harvest. However, the gradual decrease in soil available nitrogen content in untreated soil and with increase in the period of crop growth might be due to utilization of nitrogen, plant uptake (Hattab *et al*., 2000) [8] and loss of nitrogen through volatilization (Reddy *et al.,* 1980) [20]. Differentiate among the different treatments significantly higher available nitrogen at 60th, 90th DAS and at harvest was observed in T_5 which is statistically at par with T_{11}, T_9, T_7, T_6 followed by T_3 and T_0. Further, the vermicompost, bio-fertilizer and chemical fertilizers alone or in combination were showed it's superiority in increasing available nitrogen over control (Sharma *et al.,* 2009) [21]. The increase may be attributed to higher microbial activity in the integrated nutrient management treatments which favored the conversion of the organically bound nitrogen into inorganic form (Panwar, 2008) [17].

Table 2: Effect of INM on available nitrogen content (kg N ha^{-1}) in soil at various stage of rapeseed

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T_0	362.84^d	360.40^c	356.08^c	351.78^c
T_1	446.14^a	429.77^{ab}	409.59^{ab}	406.54^{ab}
T_2	423.35^{bc}	423.32^{ab}	404.47^{ab}	404.21^{ab}
T_3	415.82^e	414.84^b	398.64^b	397.95^b
T_4	438.81^{ab}	429.89^{ab}	410.11^{ab}	409.29^{ab}
T_5	451.12^a	439.27^a	422.25^a	421.26^a
T_6	443.44^{ab}	434.30^{ab}	415.25^{ab}	413.76^{ab}
T_7	442.27^{ab}	429.42^{ab}	410.78^{ab}	408.71^{ab}
T_8	436.34^{abc}	427.26^{ab}	407.63^{ab}	406.60^{ab}
T_9	444.54^{ab}	433.40^{ab}	414.48^{ab}	411.52^{ab}
T_{10}	436.43^{abc}	426.86^{ab}	408.15^{ab}	406.90^{ab}
T_{11}	449.83^a	435.86^{ab}	418.76^{ab}	414.23^{ab}
SE d (±)	9.30	9.12	8.76	8072
CD (p=0.05)	19.29	18.92	18.16	18.08

Interaction means followed by the different letters in each column are significantly different at $p< 0.05$ according to Duncan's Multiple Range Test.

2. Available Phosphorus (P_2O_5)

Data concerning to the effect of different treatments on available phosphorus content in the soil at various growing stages of rapeseed are presented in Table 3. Irrespective of different sources of nitrogen, the amount of available phosphorus increased up to 60th DAS followed by a gradual decline till harvest. More or less similar trend of available phosphorus accumulation at different stages of rapeseed growth was reported by Hadis *et al*. (2019) [6]. The decrease in soil available phosphorus with crop growth might be due to its utilization by the growing mustard crop (Bahl and Singh, 1997) [2]. Result further revealed that there was significantly higher accumulation of available phosphorus in soil treated with combined application of different nitrogen sources over control. These results were in conformity with Sharma *et al.* (2009) [21]. In general at all growth stages of rapeseed crop, available phosphorus content was observed to be the highest as a result of application of 75% RDN using chemical fertilizer + 25% RDN through vermicompost + *Azotobacter* (T_5) which remained at par with T_{11}, T_9, T_7, and T_6. This might be due to the fact that incorporation of organic manures increased phosphorus availability and this was attributed to the enhanced solubilization of native phosphorus and added phosphorus by the decomposition products of organic manures (Dotaniya and Datta, 2014 and Majumder *et al*., 2017) [4, 13]. Similar results were also reported by Bhardwaj and Omanwar (1994) [3]. In addition to this the increase in available phosphorus content in soil might be due to higher phosphorus content of vermicompost (Reddy *et al.*, 1999) [19]. The release of organic acids during the decomposition process of vermicompost could be another reason for increase in phosphorus content in the soil (Raju and Reddy, 2000 and Meena *et al*., 2015) [18, 14]. The increase in available phosphorus may be due to chelating effect of organic matter and organic matter lowered the Al-P and Fe-P in soil (Snehal *et al.*, 2019) [23].

Table 3: Effect of INM on available phosphorus content (kg P_2O_5 ha^{-1}) in soil at various growth stages of rapeseed

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T_0	43.14^{f}	44.00^{f}	41.53^{f}	41.27^{f}
T_1	51.06^{bcde}	51.84^{bcde}	48.39^{cde}	45.49^{de}
T_2	49.01^{de}	50.27^{de}	48.03^{de}	45.32^{de}
T_3	48.61^{e}	49.63^{e}	47.56^{e}	44.69^{e}
T_4	51.67^{bc}	52.82^{bcd}	50.83^{abc}	47.39^{cd}
T_5	55.51^{a}	55.86^{a}	52.86^{a}	51.43^{a}
T_6	51.21^{bcd}	53.01^{bc}	50.08^{bcd}	49.41^{abc}
T_7	51.70^{bc}	52.99^{bc}	50.90^{ab}	49.72^{abc}
T_8	50.53^{bcde}	51.19^{cde}	49.65^{bcde}	47.63^{cd}
T_9	52.20^{bc}	53.20^{bc}	51.11^{ab}	50.44^{ab}
T_{10}	50.09^{cde}	51.68^{bcde}	49.90^{bcde}	48.71^{bc}
T_{11}	52.76^{b}	54.02^{ab}	52.01^{ab}	50.70^{ab}
SE d (±)	1.09	1.11	1.06	1.02
CD (p=0.05)	2.26	2.31	2.20	2.13

Interaction means followed by the different letters in each column are significantly different at $p < 0.05$ according to Duncan's Multiple Range Test.

3. Available Potassium (K_2O)

Scrutiny of the data in Table 4 showed the effect of integrated nutrient management on available potassium content in soil at various stages of rapeseed. Irrespective of different treatments, result revealed that available potassium content gradually increase up to 30th DAS followed by a decline till harvest. Similar trend of potassium availability was also reported earlier by Majumder *et al*. (2017) [13]. Further study of the data revealed that combined application of inorganic and organic sources of nitrogen significantly influenced available potassium content over control at different stages of crop growth. The higher availability of K in soil may be due to beneficial effect of organic manures on the reduction of potassium fixation; added organic matter interacted with K clay to release K from non-exchangeable fraction to the available pool. The reason attributed could be the organic and inorganic acids produced during decomposition of vermicompost which might have helped in the release of mineral bound insoluble potassium and also reduced the potassium fixation (Mohankumar and Gowda, 2010) [15]. This is also in corroboration with the findings of Lal *et al*. (1990) [11]. Comparing among the different treatments, higher available potassium was recorded in T_{11} which was statistically at par with T_5, T_6, T_7 and T_{10} on 30th, 60th DAS, 90th DAS and at harvest stage too. Harikesh *et al*. (2017) [9] also notified that INM treatments got the highest nutrient availability as compared to inorganic fertilizer application treatment.

Table 4: Effect of INM on available potassium content (kg K_2O ha^{-1}) in soil at various growth stages of rapeseed

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T_0	215.00^{d}	210.27^{d}	204.89^{d}	203.50^{e}
T_1	275.64^{a}	261.91^{ab}	252.72^{abc}	245.97^{cd}
T_2	254.35^{c}	251.16^{bc}	250.17^{bc}	248.88^{bcd}
T_3	251.32^{c}	246.95^{c}	244.76^{c}	243.02^{d}
T_4	268.35^{ab}	261.47^{ab}	252.82^{abc}	250.60^{bcd}
T_5	276.49^{a}	267.33^{a}	264.43^{a}	263.63^{a}
T_6	269.83^{ab}	262.50^{ab}	259.01^{ab}	256.93^{abc}
T_7	269.30^{ab}	261.66^{ab}	256.48^{abc}	254.58^{abcd}
T_8	262.34^{bc}	257.62^{abc}	255.08^{abc}	252.95^{abcd}
T_9	269.00^{ab}	264.31^{ab}	257.16^{abc}	254.92^{abcd}
T_{10}	259.44^{bc}	255.70^{abc}	253.54^{abc}	250.67^{bcd}
T_{11}	276.30^{a}	267.14^{a}	264.24^{a}	260.15^{ab}
SE d (±)	5.64	5.50	5.41	5.36
CD (p=0.05)	11.69	11.40	11.23	11.12

Interaction means followed by the different letters in each column are significantly different at $p < 0.05$ according to Duncan's Multiple Range Test.

Conclusion

The treatment receiving combined application of organic manure, chemical fertilizers and bio-fertilizers increased N, P and K content over the untreated control. This is due to the fact that addition of nutrient from chemical fertilizer and mineralization of organic fertilizer and with the help of bio-fertilizer (*Azotobacter*). So, highest accumulation of available macronutrient content in soil was recorded in T_5 which is at par with T_6, T_7, T_9 and T_{11}. Therefore, the integrated use of inorganic fertilizer with organic manures and bio-fertilizer could be the better option in view of the above findings as well as the additional advantage of creating a favourable environment thereby improved physical and biological properties of soil.

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