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Effect of integrated nutrient management on chemical properties of soil under mustard crop (*Brassica juncea* L.) on Alfisols of Konkan (M.S.)

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Abstract
The field experiment was conducted to assess the "Effect of integrated nutrient management on chemical properties of soil under mustard (*Brassica juncea* L.) crop on Alfisols of Konkan (M.S.)" at Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.) during the month of December to March, 2017-18. The experiment was laid out in Randomized Block Design (RBD) comprising eleven treatment combinations replicated thrice. The different treatment combinations did not show any significant effect on soil reaction, electrical conductivity and organic carbon content of soil, While, the treatment (T_3) receiving application of 100 per cent RDN through poultry manure along with seed inoculations of Azotobacter and PSB recorded the highest values of available nitrogen (278.06 kg ha^{-1}), available phosphorus (15.57 kg ha^{-1}), available potassium (271.79 kg ha^{-1}) and DTPA extractable micronutrients *viz.* iron (51.70 mg kg^{-1}), manganese (91.57 mg kg^{-1}), zinc (1.39 mg kg^{-1}), copper (7.37 mg kg^{-1}) content of soil after harvest of mustard crop.

Keywords: Mustard, sulphur, boron, poultry manure, Konkan

1. Introduction
The global production of mustard and it's oil is around 38-42 MT & 12-14 MT respectively. India contributes 28.3 per cent and 12.0 per cent in world acreage and production. India produces around 6.9 MT of rapeseed-mustard next to China (11-12 MT) and Europe (10-13 MT) with significant contribution in world mustard industry (Anonymous, 2014) [3]. In India the mustard crop accounts for nearly one-third of the total oil produced, making it the country's key edible oilseed crop. In India, it is third most important edible oilseed crop after soybean and groundnut sharing 27.8 per cent in the India's oilseed economy. The seed and mustard oil have a peculiar pungency due to presence of a glycoside "sinigrin" ($C_{10}H_{16}O_9NS_2K$) thus making it suitable as condiments used in the preparation of pickles, curries and vegetables. Mustard seed, in general, contains 30-33 per cent oil, 17-25 per cent proteins, 8-10 per cent fibers, 6-10 per cent moisture, and 10-12 per cent extractable substances (Pandey *et al*., 2013) [7].

The intensive cultivation and use of imbalanced and inadequate fertilizers accompanied by restricted use of organic manures have made the soils not only deficient in the nutrients, but also deteriorated the soil health. Integrated nutrient management is very essential which is not only sustains high crop production over the years (Verma *et al*. 2010) [13] but also improves soil health and ensures safer environment. Balanced nutrient management through conjunctive use of organic, inorganic and bio-fertilizers facilitate profitable and sustainable crop production and also maintain soil health (Singh and Sinsinwar, 2006) [10]. In order to bring the soil well supplied with all the essential plant nutrients and also to maintain it in good health, it is necessary to use organic source like farmyard manure, vermicompost, neemcake and poultry manure are good source of nutrients required by plants for quality produce.

In light of the meagre available information and sparse related research, especially on the mustard the present investigation entitled, "Effect of integrated nutrient management on chemical properties of soil under mustard crop (*Brassica juncea* L.) on Alfisols of Konkan (M.S.)'' was undertaken The details regarding the material used and the methods followed during the course.

2. Material and methods

The present investigation entitled "Effect of integrated nutrient management on chemical properties of soil under mustard (*Brassica juncea* L.) crop on Alfisols of Konkan (M.S.)" was conducted at Department of Agronomy, College of Agriculture, Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.) during the month of December to March, 2017-18. The experimental soil was sandy loam in texture, moderately acidic in reaction and having very low electrical conductivity, very high in organic carbon, low in available nitrogen, very low in available phosphorus, high in available potassium. In general, soil properties of experimental plot represented a typical lateritic soil of the Konkan region.

The experiment was laid out in Randomized Block Design with eleven treatments and replicated thrice. The treatment comprised *viz*.,T_1 (Absolute control), T_2 100% RDF through Inorganics (90:45:00 kg ha^{-1}), T_3 100% RDN through poultry manure (PM) + Azotobacter + PSB, T_4 100% RDN through vermicompost (VC) + Azotobacter + PSB, T_5 75% RDF + 25% RDN through poultry manure + 40 kg Sulphur (S), T_6 75% RDF + 25% RDN through vermicompost + 40 kg Sulphur, T_7 50% RDF + 50% RDN through poultry manure + 60 kg Sulphur + 1 kg Boron (B), T_8 50% RDF + 50% RDN through vermicompost + 60 kg Sulphur + 1 kg Boron, T_9 50% RDN through poultry manure + 50% RDN through vermicompost + 60 kg Sulphur + 1 kg Boron, T_{10} 75% RDN through poultry manure + 25% RDN through vermicompost + Azotobacter, T_{11} 75% RDN through vermicompost + 25% RDN through poultry manure + PSB. A well decomposed vermicompost and poultry manure was applied 30 days before sowing as a broadcast in single dose as per the treatment plan. Nitrogen @ 90 kg ha^{-1} was applied in two splits doses viz., first dose of 50 per cent N at the time of sowing, second dose of 30 per cent N after 30 days of sowing. Phosphorus was applied @ 45 kg ha^{-1}. The mustard variety Varuna was sown on 15th December 2015 with the spacing 0.45 m x 0.10 m.

The pH and EC of soil was estimated by potentiometric and conductometric method as described by Jackson (1973). The organic carbon content of soil was determined by Walkley and Black's wet oxidation method (Black, 1965). Available nitrogen content was determined by Alkaline potassium permanganate method as described by Subbaiah and Asija (1956), Available phosphorous content was determined by Bray's No. 1 method (Bray and Kurtz, 1945), available potassium content was determined by 1 N NH_4OAC (pH_7) extraction with flame photometry method as given by Jackson (1973) and DTPA extractable micronutrients were determined by extraction with DTPA-$CaCl_2$-TEA solution and determination with AAS as given by Lindsay and Norvell (1978).

3. Results and discussions

3.1 Chemical properties

3.1.1 Soil Reaction (pH)

The data presented in Table 1 when studied revealed that the soil pH after harvest was ranged between 5.71 and 5.80 with an average value of 5.76. Different treatment combinations did not show any significant effect on pH of soil after harvest of mustard crop. The application of 100 per cent RDN through poultry manure in combination with Azotobacter and PSB (T_3) recorded the highest value of pH (5.80). The effect of organic amendments on soil pH might be due to the release of base cations especially Ca and Mg which resulted in acid neutralization during microbial decarboxylation (Tang & Yu, 1999) [12], the neutralizing effect of poultry manure was due to the presence of substantial quantity (2.49%) of calcium which replaces the hydrogen ion on clay complex resulted in improvement in soil pH.

3.1.2 Electrical Conductivity (EC)

The EC of soil after harvest of mustard crop varied from 0.038 to 0.058 dSm^{-1} with a mean value of 0.051 dSm^{-1}. The treatment (T_7) receiving equal integration of RDN through inorganics and RDN through poultry manure along with seed inoculations of Azotobacter and PSB recorded the highest (0.058 dSm^{-1}) value of EC. Data further indicated that the effect of different treatment combinations on EC of soil was found to be statistically non significant (Table 1).

3.1.3 Organic Carbon (OC)

The organic carbon content after harvest of mustard ranged from 14.47 to 15.30 g kg^{-1} with a mean value of 14.93 g kg^{-1}. Different treatment combinations did not show any significant effect on pH of soil after harvest of mustard crop (Table 1). All the treatment combinations showed built up in organic carbon content over control treatment. Confirming that most of the organic manures are effective building up the organic carbon status of soil since microbial abundance helped in sequestering the mineralized carbon from organic manures and loading in to the soil carbon pool. These observations are in close conformity with observations made by Sanyal (2001) [9], who observed build-up in soil organic matter following the application of organic manures. As the organic manures contained high amount of total organic carbon, their continuous use might have resulted in significant increase in soil organic carbon status.

Table 1: Effect of Integrated Nutrient Management on Chemical properties (pH, EC and Organic Carbon) of soil after harvest of mustard

Tr. No.	Treatments	pH (1:2.5)	EC (dSm^{-1})	OC (g kg^{-1})
T_1	Absolute control	5.71	0.038	14.47
T_2	100% RDF (Inorganics)	5.72	0.052	14.51
T_3	100% RDN (PM) + Azotobacter + PSB	5.80	0.052	15.03
T_4	100% RDN (VC) + Azotobacter + PSB	5.76	0.048	15.30
T_5	75% RDF + 25% RDN (PM) + 40 kg S	5.73	0.053	14.77
T_6	75% RDF + 25% RDN (VC) + 40 kg S	5.76	0.048	14.62
T_7	50% RDF + 50% RDN (PM) + 60 kg S + 1 kg B	5.77	0.058	15.00
T_8	50% RDF + 50% RDN (VC) + 60 kg S + 1 kg B	5.73	0.052	14.83
T_9	50% RDN (PM) + 50% RDN (VC) + 60 kg S + 1 kg B	5.76	0.050	15.28
T_{10}	75% RDN (PM) + 25% RDN (VC) + Azotobacter	5.79	0.055	15.20
T_{11}	75% RDN (VC) + 25% RDN (PM) + PSB	5.78	0.048	15.23
	Mean	5.76	0.051	14.93
	S.E.±	0.027	0.006	0.20
	C.D. (P=0.05)	NS	NS	NS

3.1.4 Available Nitrogen (N)

The data pertaining to the effect of integrated nutrient management on available nitrogen content in soil after harvest of mustard are presented in the Table 2 when studied revealed that the treatment (T_3) receiving application of 100 per cent RDN (PM) + Azotobacter + PSB exhibited significantly higher available nitrogen (278.06 kg ha^{-1}) which was statistically significant over all the treatment combinations with exception of the treatment (T_4) and (T_{10}). Amanullah (2007) [2] showed that poultry manure can increase the available N progressively and make it available to the plants for a longer period of time than the other manures. Dosani (1997) [5] reported that Poultry manure is not only a good source of nutrients, but also facilitates biological nitrogen fixation.

3.1.5 Available Phosphorus (P_2O_5)

The highest status of available phosphorus (15.57 kg ha^{-1}) was observed in the treatment (T_3) receiving the application of 100 per cent RDN through poultry manure with superimposition of Azotobacter and PSB inoculations. The treatments (T_3), (T_4) and (T_{11}) were found to be statistically at par with each other (Table 2). The increase in soil phosphorus in amended plots with poultry manure application suggested the ability of poultry manure in lowering the Al and Fe concentration in the soil which might have helped for reduction in phosphorus fixation in soil and also ability of PSB to solubilize native fixed P present in soil might have resulted in higher P availability of soil. Also poultry manure contains more stable mineral associated P than many types of manures and may act as long term P source. (Acharya *et al*., 2015) [1].

Table 2: Effect of Integrated Nutrient Management on chemical properties [N, P_2O_5, K_2O (kg ha^{-1})] of soil after harvest of mustard

Tr. No.	Treatments	N	P_2O_5	K_2O
T_1	Absolute control	224.75	6.91	252.75
T_2	100% RDF (Inorganics)	240.43	11.39	257.97
T_3	100% RDN (PM) + Azotobacter + PSB	278.06	15.57	271.79
T_4	100% RDN (VC) + Azotobacter + PSB	259.24	14.99	267.31
T_5	75% RDF + 25% RDN (PM) + 40 kg S	248.79	12.94	258.35
T_6	75% RDF + 25% RDN (VC) + 40 kg S	241.47	11.48	256.48
T_7	50% RDF + 50% RDN (PM) + 60 kg S + 1 kg B	250.88	13.95	261.33
T_8	50% RDF + 50% RDN (VC) + 60 kg S + 1 kg B	247.74	13.04	256.48
T_9	50% RDN (PM) + 50% RDN (VC) + 60 kg S + 1 kg B	238.34	12.55	261.59
T_{10}	75% RDN (PM) + 25% RDN (VC) + Azotobacter	258.20	13.14	265.81
T_{11}	75% RDN (VC) + 25% RDN (PM) + PSB	235.20	15.08	258.35
	Mean	247.55	12.85	260.65
	S.E.±	8.91	0.54	3.04
	C.D. (P=0.05)	26.30	1.60	8.98

3.1.6 Available Potassium (K_2O)

The data presented in Table 2 when studied revealed that the available potassium status was observed to be the lowest in the control treatment (252.75 kg ha^{-1}) and it was found to be the highest (271.79 kg ha^{-1}) in the (T_3) treatment receiving application of the 100 per cent RDN through poultry manure along with Azotobacter and PSB inoculations. Treatments (T_3), (T_4) and (T_{10}) were remained statistically at par with each other. The higher availability of potassium in soil might be attributed to the beneficial effect of organic manures in the reduction of potassium fixation; added organic matter interacted with potassium clay to release potassium from non-exchangeable fraction to the available pool.

Bamgude (2007) [4] also reported an increase in the available nitrogen, phosphorus and potassium in lateritic soils of Konkan with the application of 100 per cent RDN through poultry manure along with Biofertilizers as seed inoculation.

3.1.7 DTPA extractable micronutrients (Fe, Mn, Zn and Cu)

The data on DTPA extractable micronutrients content of soil as affected by various treatments of the integrated nutrient management after harvest of mustard are presented in the Table 3.

Table 3: Effect of Integrated Nutrient Management on available micronutrients [Fe, Mn, Zn and Cu (mg kg^{-1})] status of soil after harvest of mustard

Tr. No.	Treatments	Fe	Mn	Zn	Cu
T_1	Absolute control	43.72	77.82	1.19	6.01
T_2	100% RDF (Inorganics)	46.80	83.27	1.28	6.29
T_3	100% RDN (PM) + Azotobacter + PSB	51.70	91.57	1.39	7.37
T_4	100% RDN (VC) + Azotobacter + PSB	48.54	87.82	1.34	5.79
T_5	75% RDF + 25% RDN (PM) + 40 kg S	46.16	84.79	1.15	6.07
T_6	75% RDF + 25% RDN (VC) + 40 kg S	45.27	85.45	1.22	6.45
T_7	50% RDF + 50% RDN (PM) + 60 kg S + 1 kg B	44.16	84.82	1.25	6.52
T_8	50% RDF + 50% RDN (VC) + 60 kg S + 1 kg B	46.42	87.34	1.24	6.52
T_9	50% RDN (PM) + 50% RDN (VC) + 60 kg S + 1 kg B	48.01	84.66	1.32	6.96
T_{10}	75% RDN (PM) + 25% RDN (VC) + Azotobacter	48.82	86.26	1.36	7.12
T_{11}	75% RDN (VC) + 25% RDN (PM) + PSB	49.94	88.52	1.20	6.50
	Mean	47.11	85.66	1.27	6.51
	S.E.±	1.08	0.73	0.03	0.28
	C.D. (P=0.05)	3.20	2.15	0.09	0.82

The treatment (T_3) receiving application of 100 per cent RDN through poultry manure along with Azotobacter and PSB as seed inoculations recorded significantly higher values of iron (51.70 mg kg^{-1}), manganese (91.57 mg kg^{-1}), zinc (1.39 mg kg^{-1}) and copper (7.37 mg kg^{-1}) content of soil after harvest of mustard crop. The higher availability of micronutrients in soil with the application of organic manures might be attributed complexing properties of organic manures with the metal ions which prevents precipitation and fixation and also due to production of chelating agents during the decay of organic manures which have the ability to transform solid phase of micronutrient cations into the soluble metal complexes. Among manures, poultry manure recorded higher available micronutrients as compared to other organics which might be due to the fact that poultry manure, a potential source of micronutrient cations and as a complexing agent preventing precipitation, fixation and keep them in soluble form (Madhavi and Reddy, 1996) [6].

Talashilkar *et al*. (2002) [11] also observed an increase in the DTPA extractable micronutrients in the soil with the application of poultry manure in the lateritic soils of Konkan.

4. Conclusion

From the present investigation it can be concluded that the application of organic manures, inorganic fertilizers and biofertilizers did not show any significant effect on pH, EC and organic carbon content of soil. While, The treatment (T_3) receiving application of 100 per cent RDN through poultry manure along with seed inoculations of Azotobacter and PSB found to be beneficial for enhancing the available nitrogen, phosphorus, potassium and DTPA extractable micronutrient status of soil.

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