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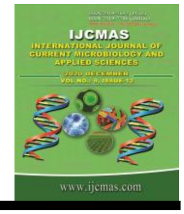

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Effect of Zeolite on Nutrient Use Efficiency in Soil and Nutrient Uptake of *Kharif* Upland Paddy Grown on Inceptisol

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A B S T R A C T

A field experiment was conducted in kharif-2019 at Agronomy Farm, Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur. An experiment was laid out in randomized block design with three replications and seven treatments comprising five levels of zeolite (60, 80, 100, 120 and 140 kg ha^{-1}). The total uptake of N, P, K and micronutrients (Fe, Mn, Zn and Cu) in paddy increased significantly due to zeolite application. Significantly the highest N (66.97 kg ha^{-1}), P (20.17 kg ha^{-1}), K (67.57 kg ha^{-1}) and micronutrients viz. Fe (1790 g ha^{-1}), Mn (990 g ha^{-1}), Zn (155 g ha^{-1}) and Cu (120 g ha^{-1}) were recorded in treatment T7 (GRDF + Zeolite @ 140 kg ha^{-1}) and these were at par with the treatment T5 (GRDF + Zeolite @ 100 kg ha^{-1}) and T6 (GRDF + Zeolite @ 120 kg ha^{-1}). The application of different levels of zeolite along with GRDF increased the N, P and K use efficiency of paddy. The highest nitrogen use efficiency (51.66 %), phosphorus use efficiency (53.80 %) and potassium use efficiency (96.25 %) recorded in the treatment T7 (GRDF + Zeolite @ 140 kg ha^{-1}), but these values were at par with the values recorded in treatment T5 (GRDF + Zeolite @ 100 kg ha^{-1}) and T6 (GRDF + Zeolite @ 120 kg ha^{-1}). The results of the present investigation indicated that the application of zeolite @ 100 kg ha^{-1} along with GRDF was found effective in increasing nutrient uptake of paddy and nutrient use efficiency in soil.

Keywords

Nutrient uptake, Nutrient use efficiency, Yield, paddy, Clinoptilolite zeolite

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Introduction

The zeolites are hydrated aluminosilicate minerals made from interlinked tetrahedral of alumina (AlO_4) and silica (SiO_4). The zeolites are composed of pores and corner sharing aluminosilicate (AlO_4 and SiO_4) tetrahedrons, joined into 3 dimensional frameworks. The pore structure is characterized by cages approximately 12 Å in diameter, which are interlinked through channels about 8 Å in diameter, composed of rings of 12 linked tetrahedrons (Kaduk and Faber, 1995). The zeolite has an ability to gain or lose water reversibly, without the change of crystal structure. They could be used as fertilizers, stabilizers and natural chelates (Perez-Caballero *et al.*, 2008). The zeolite enables both inorganic and organic fertilizers to slowly release their nutrients (Perez-Caballero *et al.*, 2008).

Materials and Methods

Field experiment was conducted in *kharif-2019* on sandy clay loam soil at Agronomy Farm, Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur located at latitude of $16^0$42' North and longitude $74^0$14' East. The field experiment site climatically belongs to Sub-Montane zone of Maharashtra with an average rainfall of 1057 mm, with 77 rainy days which are received mostly from south-west monsoon. Minimum and maximum mean temperature ranged from 11.83 to 20.9 ^{0}C and 24.9 to 33.1 ^{0}C, respectively. The soil of experimental plot was alkaline in reaction (pH 7.83), normal in electrical conductivity (0.17 dS m^{-1}), moderately high in organic carbon content (0.63%) and high in $CaCO_3$ content (9.86 %), and have bulk density 1.27 g cm^{-3}, CEC 16.91 cmol (p+) kg^{-1}. Soil was low in available nitrogen (171.29 kg ha^{-1}), medium in available phosphorous (16.29 kg ha^{-1}) and high in available potassium (160.31 kg ha^{-1}) content sufficient in available Fe (4.52 mg kg^{-1}), available Mn (2.04 mg kg^{-1}), available Zn (1.54 mg kg^{-1}) and available Cu (1.63 mg kg^{-1}). The experiment was laid out in randomized block design with seven treatments and three replications. The treatments consisted of T_1: Absolute control, T_2: GRDF (100:50:50 kg ha^{-1} $N:P_2O_5:K_2O$ + FYM 10 t ha^{-1}), T_3: GRDF+ Zeolite @ 60 kg ha^{-1}, T_4: GRDF+ Zeolite @ 80 kg ha^{-1}, T_5: GRDF+ Zeolite @ 100 kg ha^{-1}, T_6: GRDF+ Zeolite @ 120 kg ha^{-1}, T_7: GRDF+ Zeolite @ 140 kg ha^{-1}.

The treatment wise application of zeolite and fertilizers mixture was done before sowing of paddy seed and covered with soil. The FYM was applied @ 10 t ha^{-1}.The general recommended dose of fertilizer (100 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1}) were applied per hectare at the time of sowing as per the treatments. The paddy variety *Indrayani* was sown by adopting standard package of practices. After the harvest rain and stover samples were collected separately, dried and powdered. The powdered 0.5 g plant samples was digested with concentrated H_2SO_4 (5 mL) and H_2O_2 (5 mL) digestion mixture ($CuSO_4$ + K_2SO_4 + selenium powder). The volume was made water to 100 mL after digestion of sample. A suitable aliquot was taken for nitrogen distillation and nitrogen was determined by Micro Kjeldahl method (Parkinson and Allen, 1975). The total phosphorous determined by using known quantity of triacid extract and the yellow colour was developed with combined HNO_3 vanadomolybdate reagent. Phosphorous was determined colorimetrical by using spectrophotometer at 470 nm wavelength (Jackson, 1973). The total potassium was determined from known quantity of triacid digested extract by flame photometer (Chapman and Pratt, 1961). The plant samples (0.5 g each) were wet digested with nitric acid and perchloric acid. The volume was made to 100 mL with distilled water after digestion and was used for determination of micronutrient by using atomic absorption spectrophotometer (Zososki and Burau, 1977). The uptake of nutrients was calculated by multiplying dry matter with nutrient content.

Results and Discussion

The data pertaining to total uptake of N, P and K by paddy crop is presented in Table 1. The data clearly indicated that there was significant increase in total uptake of N, P and K with GRDF alone and in combinations with different levels of zeolite.

The significantly highest total N uptake of paddy (66.97 kg ha^{-1}) crop was recorded with the treatment T_7 (GRDF+ Zeolite @ 140 kg ha^{-1}), however it was at par with the treatment T_5 (GRDF + Zeolite @ 100 kg ha^{-1}) and T_6 (GRDF + Zeolite @ 120 kg ha^{-1}. Similar trend was observed with total P and K uptake of paddy. The phosphorus uptake of paddy crop was significantly highest (20.17 kg ha^{-1}) with the treatment T_7 (GRDF+ Zeolite @ 140 kg ha^{-1}) but it was at par with T_5 (GRDF + Zeolite @ 100 kg ha^{-1}) and T_6 (GRDF + Zeolite @ 120 kg ha^{-1}). The total K uptake of paddy was significantly highest (67.57 kg ha^{-1}) with the treatment T_7 (GRDF+ Zeolite @ 140 kg ha^{-1}), however it was at par with T_5 (GRDF + Zeolite @ 100 kg ha^{-1}) and T_6 (GRDF + Zeolite @ 120 kg ha^{-1}). The increase in total nutrient uptake of paddy crop registered due to combined effect of GRDF and with different zeolite levels is attributed to the unique character of zeolite that influenced soil CEC and in turn increased the NH_4^+ absorption and decreased N loss induced by leaching. This increase in uptake of nitrogen may be due to the initial fixation of NH_4^+ ions during nitrification of nitrogenous fertilizer and subsequent release and oxidation to nitrates which were made available for uptake by paddy. The zeolite possibly acted as an exchange fertilizer, with Ca^{2+} exchanging onto the zeolite in response to plant uptake of uptake of nutrient cations (NH_4^+ or K^+). Similar beneficial effect of zeolite on increasing the availability and uptake of nutrients by different crops reported by Pickering *et al.*, (2002), Ahmed *et al.*, (2010) and Ozbahce *et al.*, (2015).

The data pertaining to total uptake Fe, Mn, Zn and Cu by paddy as influenced by GRDF alone and in combination with different levels of zeolite presented in Table 2. The data clearly indicated that the total uptake Fe, Mn, Zn and Cu by paddy increased significantly with application of GRDF alone and in combination with different levels of zeolite. The significantly highest total uptake of Fe (1790 g ha^{-1}) by paddy was recorded with treatment T_7 (GRDF+ Zeolite @ 140 kg ha^{-1}) but it was at par with the treatment T_5 (GRDF + Zeolite @ 100 kg ha^{-1}) and T_6 (GRDF + Zeolite @ 120 kg ha^{-1}). The increase in total Fe uptake with zeolite application might be due to honeycomb like structure of zeolite entrapped cations and increases the iron uptake. The total Mn uptake of paddy crop was significantly highest (990 g ha^{-1}) with the treatment T_7 (GRDF + Zeolite @ 140 kg ha^{-1}) but it was at par with the treatment T_5 (GRDF + Zeolite @ 100 kg ha^{-1}) and T_6 (GRDF + Zeolite @ 120 kg ha^{-1}). Higher porosity of zeolite might have led to increase Mn uptake. The total Zn uptake of paddy was significantly highest (155 g ha^{-1}) with the treatment T_7 (GRDF + Zeolite @ 140 kg ha^{-1}) but on par with T_5 (GRDF + Zeolite @ 100 kg ha^{-1}) and T_6 (GRDF + Zeolite @ 120 kg ha^{-1}) which might be attributed to the ability of zeolite to hold nutrients and release as per the plant requirement. These results are in confirmity with those reported by Ozbahce *et al.*, (2015). The treatment T_7 (GRDF + Zeolite @ 140 kg ha^{-1}) recorded significantly highest uptake of total copper (120 g ha^{-1}) by paddy however it was at par with the treatment T_5 (GRDF + Zeolite @ 100 kg ha^{-1}) and T_6 (GRDF + Zeolite @ 120 kg ha^{-1}). The increase in total uptake of copper might be attributed to the properties of zeolite such as cation exchange capacity, adsorption capacity and porosity of zeolite which led to increase the micronutrient uptake. Similar results were also noticed by Ozbahce *et al.*, (2015). Similar results were reported by Ozbahce *et al.*, (2015).

The data pertaining to nutrient use efficiency are presented in Table 3. The data clearly indicated that there was increase in N, P and K use efficiency of paddy with increase in levels of zeolite along with GRDF. The highest N (51.66%), P (53.80%) and K (96.25%) use efficiency was found with treatment T_7 (GRDF + Zeolite @ 140 kg ha^{-1}) followed by T_6, T_5, T_4 and T_3.

Table.1 Total uptake of N, P and K by paddy as influenced by different levels of zeolite

Tr. No.	Treatment details	Total uptake of nutrients (kg ha^{-1})		
		N	**P**	**K**
T_1	**Absolute control**	15.31	8.43	27.62
T_2	**GRDF (100:50:50 kg ha^{-1} N : P_2O_5 : K_2O + FYM 10 t ha^{-1})**	41.43	10.76	42.30
T_3	**GRDF+ Zeolite @ 60 kg ha^{-1}**	48.15	12.68	48.69
T_4	**GRDF+ Zeolite @ 80 kg ha^{-1}**	54.79	15.95	54.66
T_5	**GRDF+ Zeolite @ 100 kg ha^{-1}**	60.33	18.74	60.48
T_6	**GRDF + Zeolite @ 120 kg ha^{-1}**	63.64	19.03	64.89
T_7	**GRDF + Zeolite @ 140 kg ha^{-1}**	66.97	20.17	67.57
SE±		**1.54**	**0.47**	**1.64**
CD (0.05)		**4.74**	**1.45**	**5.04**

Table.2 Total uptake of micronutrients by paddy as influenced by different levels of zeolite

Tr. No.	Treatment details	Total uptake of micronutrients (g ha^{-1})			
		Fe	**Mn**	**Zn**	**Cu**
T_1	**Absolute control**	610	640	84	50
T_2	**GRDF (100:50:50 kg ha^{-1} N : P_2O_5 : K_2O + FYM 10 t ha^{-1})**	1230	720	96	70
T_3	**GRDF+ Zeolite @ 60 kg ha^{-1}**	1360	810	108	80
T_4	**GRDF+ Zeolite @ 80 kg ha^{-1}**	1530	890	120	90
T_5	**GRDF+ Zeolite @ 100 kg ha^{-1}**	1670	970	131	100
T_6	**GRDF + Zeolite @ 120 kg ha^{-1}**	1710	980	140	110
T_7	**GRDF + Zeolite @ 140 kg ha^{-1}**	1790	990	155	120
SE±		**0.04**	**0.03**	**0.003**	**0.003**
CD (0.05)		**0.13**	**0.08**	**0.01**	**0.01**

Table.3 Effect of different levels of zeolite application on nutrient use efficiency of paddy

Tr. No.	Treatment details	Nutrient Use Efficiency (%)		
		N	P	K
T_1	Absolute control	-	-	-
T_2	GRDF (100:50:50 kg ha^{-1} N : P_2O_5 : K_2O + FYM 10 t ha^{-1})	26.12	10.68	35.37
T_3	GRDF+ Zeolite @ 60 kg ha^{-1}	32.84	19.47	50.76
T_4	GRDF+ Zeolite @ 80 kg ha^{-1}	39.48	34.46	65.15
T_5	GRDF+ Zeolite @ 100 kg ha^{-1}	45.02	47.24	79.16
T_6	GRDF + Zeolite @ 120 kg ha^{-1}	48.33	48.57	89.79
T_7	GRDF + Zeolite @ 140 kg ha^{-1}	51.66	53.80	96.25

The higher nutrient use efficiency of paddy is attributed to the properties of zeolite such as high cation exchange, larger surface area, dehydration-rehydration and adsorption and slow release of nutrients during the growth of crop. The positive role of natural zeolite in reducing nitrogen leaching provides an opportunity for the crop to uptake more nitrogen and thus increases its grain yield. These could be related to enhance NUE at the presence of zeolite. These might be due to initial adsorption of NH_4^+ during nitrification thereby retarding the nitrification rate and arresting the nitrogen losses. Increase in the use efficiency of added nitrogenous fertilizers due to steady release of NH_4^+ ions resulted in constant nitrogen supply to the crop. Zeolite had capacity to adsorb phosphorus chemical fertilizer and reduce phosphorus from leakage in the soil. The calcium from the monocalcium phosphate (SSP) is adsorbed on the exchange sites of zeolite and the phosphate ions remains in the soil solution. It resulted into higher phosphorus use efficiency by increasing the absorption by paddy crop. These results are in confirmity with those reported by Hua *et al.,* (2006), Kavoosi (2007) and Majid *et al.*, (2012).

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