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Effect of Different Levels of Phosphorus and Zeolite on Yield, Nutrient Uptake and Phosphorus Use Efficiency of Rabi Onion Grown on an Inceptisols

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Abstract: A field experiment was conducted at Post Graduate Institute Instructional Farm of Mahatma Phule Krishi Vidyapeeth, Rahuri, during *rabi* 2017-2018 to study the effect of different levels of phosphorus and zeolite on yield and its use efficiency and availability of nutrients. There were eight treatments replicated thrice in RBD. The significantly highest bulb with 150% of the recommended dose of P_2O_5 175 kg along with 120 kg ha^{-1} of zeolite application followed by the zeolite @ 120 kg ha^{-1} + 125% $P_2O_5$of RDF. However, the highest phosphorus use efficiency was observed in the treatment with 75% P_2O_5 of RDF and recommended dose of nitrogen and potassium fertilizers along with 120 kg ha^{-1}zeolite and 20 t ha^{-1} farm yard manure. The available nitrogen, phosphorus and potassium were significantly higher in treatment with zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF. Thus recommended dose of phosphatic fertilizer can be reduced by 25% when used along with 120 kg ha^{-1}zeolite and recommended dose of nitrogen and potassium fertilizers for obtaining optimum yield of onion.

Key words: *Zeolite, onion, phosphorus use efficiency*

Introduction

Fertilizer application is one of the most important factors in onion production because it directly affects growth, development and yields (Kurtz *et al.* 2013). Phosphorus (P) deficiency is one of the biggest constraints to crop production in many tropical soils, due to low native content and high P immobilization within the soil (Fairhust *et al.* 1999). Onion plant extracts low amount of P from the soil because the root hairs are mostly shorter than the length of phosphate diffusion. This requires a special care from growers with respect to the levels of this nutrient in the soil as well as the sources and forms of application of phosphate-based fertilizers (Brewester 1994). The response of onion to phosphorus fertilization depends on the genotype used, P level in the soil, P source, soil and weather conditions (Grant *et al.* 2005). Application of zeolite has been found to improve the phosphorus uptake in different crops (Pickering *et al*. 2002; Ramesh *et al*. 2011). The present study highlights the influence of different levels of recommended disc if fertilizers with and without zeolite on yield, P-use efficiency, nutrient uptake by onion crop and availability of nutrients in post harvest soil.

Materials and Methods

Study area

The experiment was conducted during the *rabi* season of 2017-18 at the Post Graduate Institute Instructional Farm of Mahatma Phule Krishi Vidyapeeth, Rahuri and the soil samples were collected and analyzed

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The medium deep black (Inceptisols) had holding capacity. Bulk density 1.40 Mg m^{-3}, pH-8.04, EC-0.32 dSm^{-1},organic carbon-0.49%, calcium carbonate 6.08%, cation exchange capacity 48.56 cmol p(+) kg^{-1} of soil, available nitrogen 197.56 kg ha^{-1}, available phosphorus 16.40 kg ha^{-1}, available potassium 495.2 kg ha^{-1}. The DTPA micronutrient Fe, Mn, Zn and Cu was 3.15, 6.48, 0.40 and 0.32 mg kg^{-1} respectively. The zeolite powder had pH 6.67, EC 0.09 dSm^{-1}, CEC 160 Cmol (p^+) kg^{-1}, organic carbon 4.83 %, NH_4-N 0.06 (mg kg^{-1} soil), NO_3-N 0.021 (mg kg^{-1} soil), Available micronutrients Fe, Mn, Zn and Cu 580.8, 121.2, 9.660 and 0.557 mg kg^{-1} respectively.

Experimental details

The test crop *rabi* onion (Cv. N-2-4-1) was raised in net plot size of 2.40 m x 2.90 m under 15 x 10 cm^2 spacing. The experiment was laid out in Randomized Block Design (RBD) with eight treatments *viz*., T_1: Control, T_2 : GRDF – 100:50:50 N, P_2O_5, K_2O kg ha^{-1} + 20t ha^{-1} FYM, T_3: zeolite @ 120 kg ha^{-1}, T_4: zeolite @ 120 kg ha^{-1} + 50% P_2O_5 of RDF (25 kg $ha^{-1}P_2O_5$), T_5: zeolite @ 120kg ha^{-1} + 75% P_2O_5 of RDF (37.5 kg ha^{-1} P_2O_5), T_6 : zeolite @ 120 kg ha^{-1} + 100% P_2O_5 of RDF (50 kg ha^{-1} P_2O_5), T_7: zeolite @ 120 kg ha^{-1} + 125% $P_2O_5$of RDF (62.5 kg ha^{-1} P_2O_5) and T_8: zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF (75 kg ha^{-1} P_2O_5). The recommended dose of fertilizer 100:50:50 (N:P_2O_5:K_2O) kg ha^{-1} was applied to onion. The recommended dose of N and K_2O were common to treatments T_3 to T_8 and FYM 20 t ha^{-1} common to all treatments except T_1. At harvest, bulb and straw yields were recorded. The processed (powdered) bulb and straw samples were analysed for N, P and K content and total uptake of these nutrients were calculated. Similarly at harvest, plot –wise soil samples were collected, processed and analysed.

Results and Discussion

The significantly higher bulb yield (51.55 t ha^{-1}) and straw yield (42.52 q ha^{-1}) of onion was observed in the treatment 100:75:50 (N, P_2O_5, K_2O kg ha^{-1}) with 150% of the recommended dose of P_2O_5 along with 120 kg ha^{-1} of zeolite application followed by the treatment zeolite having @ 120 kg ha^{-1} + 125% P_2O_5 of RDF. The results indicated that 75% P_2O_5 along with 120 kg ha^{-1} zeolite recorded yield at par with treatment 100% P_2O_5 + zeolite 120 kg ha^{-1}(Table 1)

Table 1. Effect of different levels of phosphorus and zeolite on bulb and straw yield of onion

	Treatments	**Bulb yield (t ha^{-1})**	**Straw yield (q ha^{-1})**
T_1	Control	24.35	33.14
T_2	GRDF- 100:50:50 N, P_2O_5,K_2O kg ha^{-1} + 20t ha^{-1} FYM	44.15	35.53
T_3	Zeolite @ 120 kg ha^{-1}	33.31	35.82
T_4	Zeolite @ 120 kg ha^{-1} + 50% P_2O_5 of RDF (25 kg $P_2O_5ha^{-1}$)	40.80	36.77
T_5	Zeolite @ 120kg ha^{-1} + 75% P_2O_5 of RDF (37.5 kg $P_2O_5ha^{-1}$)	45.54	37.83
T_6	Zeolite @ 120 kg ha^{-1} + 100% P_2O_5 of RDF (50 kg $P_2O_5ha^{-1}$)	47.28	38.55
T_7	Zeolite @ 120 kg ha^{-1} + 125% P_2O_5 of RDF (62.5 kg $P_2O_5ha^{-1}$)	49.27	40.37
T_8	Zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF (75 kg P_2O_5 ha^{-1})	51.55	42.52
	SEm±	**0.65**	**0.52**
	CD at 5%	**1.97**	**1.57**

Phosphorus fixation in swelling clay soil and release of phosphorus from the fixed form to available form is a matter of great concern. Zeolite in presence of inorganic fertilizers influenced the uptake of N, P, K and other micro elements and in turn onion by altering the microbial population. The inclusion of FYM might have also enhanced the use efficiency of chemical fertilizers.

The significantly highest N (116.32 kg ha^{-1}) uptake was observed in treatment with zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF followed by the treatment zeolite @ 120 kg ha^{-1} + 125% P_2O_5 of RDF (109.01 kg ha^{-1}) and zeolite @ 120 kg ha^{-1} + 100% P_2O_5 of RDF and the lowest was observed in control. Latifah *et al*. (2016) observed a positive relationship between zeolite application and nitrogen uptake. The highest total P uptake was observed in treatment zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF (31.78 kg ha^{-1}) followed by zeolite @ 120 kg ha^{-1} + 125% P_2O_5 of RDF (29.53 kg ha^{-1}) and zeolite @ 120 kg ha^{-1} + 100% P_2O_5 of RDF (27.45 kg ha^{-1}). However, total phosphorus uptake was recorded minimum (10.75 kg ha^{-1}) in treatment control (Table 2).

Table 2. Effect of different levels of phosphorus and zeolite on total uptake of N, P and K at harvest of onion

	Treatment	Total nutrient uptake (kg ha^{-1})		
		N	P	K
T_1	Control	47.10	10.75	43.79
T_2	GRDF- 100:50:50 N, P_2O_5,K_2O kg ha^{-1} + 20t ha^{-1} FYM	98.85	25.82	71.36
T_3	Zeolite @ 120 kg ha^{-1}	73.29	16.85	63.47
T_4	Zeolite @ 120 kg ha^{-1} + 50% P_2O_5 of RDF (25 kg P_2O_5 ha^{-1})	80.26	19.22	69.10
T_5	Zeolite @ 120kg ha^{-1} + 75% P_2O_5 of RDF (37.5 kg P_2O_5 ha^{-1})	95.46	24.60	72.98
T_6	Zeolite @ 120 kg ha^{-1} + 100% P_2O_5 of RDF (50 kg P_2O_5ha^{-1})	103.24	27.45	74.87
T_7	Zeolite @ 120 kg ha^{-1} + 125% P_2O_5 of RDF (62.5 kg P_2O_5ha^{-1})	109.01	29.53	75.85
T_8	Zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF (75 kg P_2O_5ha^{-1})	116.32	31.78	98.59
	SEm±	**1.47**	**0.32**	**1.59**
	CD at 5%	**4.45**	**0.97**	**4.82**

The zeolite with single superphosphate possibly acted as an exchange fertilizer, with Ca^{2+} exchanging onto the zeolite and thereby enhancing the dissolution of the single superphosphate. The positive impact of zeolite application on the phosphorus uptake was reported by Barbarick *et al*. (1990)

Total K uptake was highest in treatment with zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF (98.59 kg ha^{-1}) followed by treatments with zeolite @ 120 kg ha^{-1} + 125% P_2O_5 of RDF (75.85 kg ha^{-1}) and zeolite @ 120 kg ha^{-1} + 100% P_2O_5 of RDF (74.87 kg ha^{-1}). This increase in the total uptake of K by onion may be attributed to the sorption and release of added K fertilizer to onion by zeolite. The content of N, P and K in onion was found to increase gradually with increasing levels of P, which might be attributed to the synergistic effect of P on N and K absorption by plants (Singh *et al.* 1987).

Phosphorususe efficiency was significantly highest (37.43%) in zeolite @ 120 kg ha^{-1} + 75% $P_2O_5$of RDF and significantly low phosphorus use efficiency (28.03%) was found in zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF. Due to increase in the phosphorus use efficiency, decrease in phosphorus dose by 25 per cent is possible (Table 3). Similar results were also reported by (Allen *et al.* 1993).

Table 3. Effect of different levels of phosphorus and zeolite application on phosphorus use efficiency by onion

	Treatments	P-use efficiency (%)
T_1	Control	-
T_2	GRDF- 100:50:50 N, P_2O_5,K_2O kg ha^{-1} + 20t ha^{-1} FYM	30.13
T_3	Zeolite @ 120 kg ha^{-1}	-
T_4	Zeolite @ 120 kg ha^{-1} + 50% P_2O_5 of RDF (25 kg $P_2O_5ha^{-1}$)	33.85
T_5	Zeolite @ 120kg ha^{-1} + 75% P_2O_5 of RDF (37.5 kg $P_2O_5ha^{-1}$)	37.43
T_6	Zeolite @ 120 kg ha^{-1} + 100% P_2O_5 of RDF (50 kg $P_2O_5ha^{-1}$)	33.39
T_7	Zeolite @ 120 kg ha^{-1} + 125% P_2O_5 of RDF (62.5 kg $P_2O_5ha^{-1}$)	30.04
T_8	Zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF (75 kg P_2O_5 ha^{-1})	28.03
	SEm±	**0.64**
	CD at 5%	**1.94**

Table 4. Effect of different levels of phosphorus and zeolite application on available nitrogen, phosphorus and potassium in soil after harvest of onion crop

	Treatments	Available nutrients (kg ha^{-1})		
		N	P	K
T_1	Control	172.48	11.38	470.40
T_2	GRDF- 100:50:50 N, P_2O_5,K_2O kg ha^{-1} + 20t ha^{-1} FYM	198.61	19.50	507.73
T_3	Zeolite @ 120 kg ha^{-1}	202.79	13.40	520.80
T_4	Zeolite @ 120 kg ha^{-1} + 50% P_2O_5 of RDF (25 kg $P_2O_5ha^{-1}$)	208.61	15.20	532.00
T_5	Zeolite @ 120kg ha^{-1} + 75% P_2O_5 of RDF (37.5 kg $P_2O_5ha^{-1}$)	209.82	17.20	537.60
T_6	Zeolite @ 120 kg ha^{-1} + 100% P_2O_5 of RDF (50 kg $P_2O_5ha^{-1}$)	210.11	18.31	543.20
T_7	Zeolite @ 120 kg ha^{-1} + 125% P_2O_5 of RDF (62.5 kg $P_2O_5ha^{-1}$)	211.15	21.16	543.71
T_8	Zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF (75 kg P_2O_5 ha^{-1})	212.20	22.84	553.16
	SEm±	**1.68**	**0.19**	**5.78**
	CD at 5%	**5.10**	**0.57**	**17.56**

The application of zeolite in combination with phosphorus fertilizer found to increase the phosphorus uptake, phosphorus use efficiency and yield of crops as (Ramesh *et al.* 2011; Latifah *et al.* 2016 and Mirzakhani *et al.* 2016).

The highest available nitrogen was observed in treatment having 150% of P_2O_5 along with 120 kg ha^{-1} zeolite (212.20 kg ha^{-1}) and the lowest was observed in control (172.48 kg ha^{-1}). MacKown and Tucker (1985) reported that zeolite applications decreased nitrification and leaching losses and thereby increased available N.

The highest available phosphorus was observed with 150% of P_2O_5 along with 120 kg ha^{-1} zeolite (22.84 kg ha^{-1}) and the lowest was observed in control (11.38 kg ha^{-1}). Similar results were reported by Latifah *et al.* (2016).

The available potassium was maximum (553.16 kg ha^{-1}) in the treatment associated with zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF which was at par with treatment having zeolite @ 120 kg ha^{-1} + 75% P_2O_5 of RDF (537.60

kg ha^{-1}), zeolite @ 120 kg ha^{-1} + 100% P_2O_5 of RDF (543.20 kg ha^{-1}) and zeolite @ 120 kg ha^{-1} + 125% P_2O_5 of RDF (543.71 kg ha^{-1}). Polat *et al.* (2004) reported that clinoptilolite zeolite can be used to improve fertilizer nutrient use efficiency as zeolite has high cation exchange capacity.

Conclusion

The onion bulb yield was highest in the treatment having 150% P_2O_5 of RDF, along with120 kg ha^{-1}zeolite and recommended dose of N and K fertilizers. However, the highest phosphorus use efficiency was observed in the treatment. 75% P_2O_5 of RDF and recommended dose of N and K fertilizers along with 120 kg ha^{-1} zeolite and 20 t ha^{-1} farm yard manure. The available phosphorus (22.84 kg ha^{-1}) was significantly higher in the treatment associated with zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF. The available potassium (553.16 kg ha^{-1}) was significantly higher in treatment having zeolite @ 120 kg ha^{-1} + 150% P_2O_5 of RDF. The recommended dose of phosphatic fertilizer for *rabi* onion crop can be reduced by 25% when used along with 120 kg ha^{-1} zeolite and recommended dose of nitrogen and potassium fertilizers.

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