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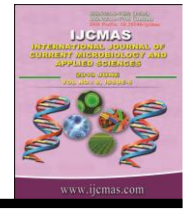

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Effect of Different Levels of Zeolite and Nitrogen on Grain Yield and Nutrient Uptake of Maize Grown in Red Soil

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A B S T R A C T

The present study entitled "Influence of zeolite and nitrogen levels on grain yield and nutrient uptake of maize grown in red soils," was a pot culture study carried out in Green House of Soil Science department, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana state during *kharif*, 2018-19. The treatments consists of combinations of 3 levels of nitrogen (100, 150, 200 kg ha^{-1}) and 4 levels of zeolite (0, 2.5, 5, 7.5 t ha^{-1}) along with a control in which only P and K were applied and they were replicated thrice in a factorial completely randomized design. The results revealed that application of 200 kg ha^{-1} nitrogen in combination with 7.5 t ha^{-1} zeolite ($Z_{7.5}$ N_{200}) increased grain yield of maize which was on par with the treatment receiving 200 kg ha^{-1} nitrogen in combination with 5 t ha^{-1} zeolite ($Z_{5.0}$ N_{200}). The combination of 7.5 t ha^{-1} zeolite with 200 kg ha^{-1} nitrogen ($Z_{7.5}$ N_{200}) have significantly increased N, P, K uptake of maize compared to rest of the treatments.

Introduction

Zeolites are among the most common minerals present in sedimentary rocks. They are natural crystalline tectosilicates (Szerement *et al.,* 2014) exhibiting an open three-dimensional structure containing cations needed to balance the electrostatic charge of the framework of silica and alumina tetrahedral units. Pores and voids are the key characteristics of zeolite materials (Ramesh *et al.*, 2011). Amendment of clinoptilolite zeolite to sandy soils has been reported to lower nitrogen concentration in the leachate and to increase moisture and nutrients in the soil due to increased soil surface area and cation exchange capacity (He *et al.*, 2002). So, in order to improve nitrogen uptake in maize, zeolite can be used along with inorganic fertilizers.

Clinoptilolite promote better plant growth by improving the use efficiency of fertilizers due to its high adsorption rate, cation exchange, catalysis and dehydration capacities. It has a very high CEC (from 100 to 230 cmol kg^{-1}). Therefore, its application to the soil increases the CEC of soils 2-3 times greater than other types of minerals found in soils. Keeping this in view, the mix of zeolite (Z) and nitrogen

(N) has been investigated to enhance soil fertility and improve crop production.

Materials and Methods

The present investigation was carried out at Professor Jayashankar Telangana State Agricultural University (PJTSAU), College Of Agriculture, and Rajendranagar which is located in Ranga Reddy district of Telangana state. The soil required for the present experiment has been collected from B block of student farm, College Of Agriculture, Rajendranagar. The red soil required for the experiment was collected from B-Block of Student farm, College of Agriculture, Rajendranagar. The clods in the soil were broken down and the soil is sieved through 2 mm sieve and was mixed with zeolite as per the treatments and after mixing of zeolite, the pot is filled with soil @ 8 kg pot^{-1}.

The test crop used in this experiment was maize (DHM 117). 4 levels of Zeolite (0, 2.5, 5, 7.5 t ha^{-1} *i.e.*, 0, 8.93, 17.26, 26.79 g pot^{-1} respectively) and 3 levels of nitrogen (100, 150, 200 kg N ha^{-1} *i.e.,* 357.14, 535.71, 714.28 mg pot^{-1}respectively) were applied in different treatments which were replicated thrice. Phosphorous (P_2O_5) and Potassium (K_2O) were applied @ 60-60 kg ha^{-1} (24.29 - 24.29 mg pot^{-1}) uniformly to all the treatments including control (Z_0N_0). At the end of the maturity stage, cob from each plant from pot was harvested. Grains were separated from the cobs and grain yield was calculated. The soil collected from B block of student farm, College of Agriculture, Rajendranagar is sieved through 2 mm sieve and is analyzed for initial physical, physico-chemical and chemical properties which are presented in the Table 1.

Plant nutrient analysis

Plant samples collected at 30, 60, 90 DAS and at harvest were shade dried and kept in the hot air oven at 60ºC - 80ºC until constant weight is attained. The dried plant samples were then powdered separately treatment wise and were used for analyzing the nutrient contents.

The nitrogen content in the plant and grain samples was determined by micro Kjeldal distillation (Piper, 1966). For estimation of phosphorous and potassium in plant and grain samples were first digested in diacid mixture (HNO_3 and $HClO_4$ in 9:4 ratio). In digested extract the phosphorous content is determined by Vanado-Molybdo phosphate yellow colour method in Spectrophotometer at 420 nm and potassium by Flame photometer as described by Piper (1966).

Nutrient uptake

The dry matter obtained from each treatment and their respective nutrient contents were used to compute nutrient uptake at 30, 60, 90 DAS and at harvest.

$$\text{N/ P/K Uptake (mg pot}^{-1}\text{)} = \frac{\text{N/P/K content (\%) X Dry matter (g pot}^{-1}\text{)}}{100}$$

The data recorded from the pot culture experiment was statistically computed by adopting factorial completely randomized design using standard procedures (Rao, 1983). The critical difference was used to evaluate the effects of treatments.

Results and Discussion

Grain yield

The grain yield of maize ranged from 14.86 to 46.80 g pot^{-1}(Table 2 and Fig. 1). The grain yield of maize was significantly improved by application of different combinations of nitrogen and zeolite levels. Among all the treatments, N_{200} $Z_{7.5}$ (Nitrogen @ 200 kg ha^{-1} + Zeolite @ 7.5 t ha^{-1}) resulted in higher grain yield (46.80 g pot^{-1}) which is on par with $N_{200}Z_5$ (Nitrogen @ 200 kg ha^{-1} + Zeolite @ 5 t ha^{-1}) where the grain yield recorded was 45.35 g pot^{-1}. The lowest grain yield was observed in control (14.86 g pot^{-1}). Among the three nitrogen levels, N_{200} produced significantly higher grain yield (42.79 g pot^{-1} mean value) compared to other levels of nitrogen. Among four zeolite levels, $Z_{7.5}$ produced higher grain yield (36.62 g pot^{-1}) which is significantly superior over other zeolite levels and control (14.86 g pot^{-1}).

Nitrogen uptake

N uptake was significantly affected by the levels of zeolite and nitrogen at 30, 60, 90 DAS and at harvest (Table 3, 4, 5, 6, 7 respectively). Increasing the zeolite dose have significantly improved N uptake from 179.30 mg pot^{-1} to 231.27 mg pot^{-1} and nitrogen levels also significantly improved N uptake. Highest N uptake was registered in N_{200} (275.86 mg pot^{-1}), followed by N_{150} (204.50 mg pot^{-1}) and N_{100} (136.30 mg pot^{-1}), while the interaction effect of zeolite and nitrogen on N uptake at 30 DAS was non significant, but it was significant at 60 and 90 DAS, by stover. At 60 DAS, (465.37 mg pot^{-1}) and 90 DAS, (1066.06 mg pot^{-1}) significantly higher N uptake was recorded with the treatment $Z_{7.5}N_{200}$, followed by Z_5N_{200} (442.22 mg pot^{-1}, 1015.53 mg pot^{-1} respectively) while the lowest N uptake at 60 and 90 DAS was obtained from control (90.17 mg pot^{-1}, 199.04 mg pot^{-1} respectively). At harvest, the highest N uptake in grain (425.83 mg pot^{-1}) and stover (278.45 mg pot^{-1}) was observed in $Z_{7.5}N_{200}$, which was significantly superior over all other treatments and the lowest N uptake was found in control (26.91 mg pot^{-1}).

Phosphorous uptake

P uptake by maize at 30, 60, 90 DAS and at harvest in grain and stover were represented in table 8, 9, 10, 11, 12 respectively. Higher P uptake at 30, 60, 90 DAS (75.09, 108.63, 180.88 mg pot^{-1} respectively) and at harvest (118.53, 92.84 mg pot^{-1} by grain and stover respectively table 11, 12) was observed in $Z_{7.5}N_{200}$ treatment, but at 90 DAS, the P uptake in $Z_{7.5}N_{200}$ treatment was on par with $Z_{5.0}N_{200}$ (173.21 mg pot^{-1}) which were significantly superior over rest of the treatments and control (11.84, 14.29, 31.57, 27.23, 12.12 mg pot^{-1} respectively).

Potassium uptake

Increasing the zeolite dose have significantly improved K uptake by maize from 208.42 mg pot^{-1} in Z_0 level to 268.05 mg pot^{-1} and nitrogen levels also significantly improved K uptake at 30 DAS. The zeolite level, $Z_{7.5}$ (268.05 mg pot^{-1}) recorded significantly higher K uptake at 30 DAS compared to all other zeolite levels while the lowest K uptake was noticed in control (72.11 mg pot^{-1}). Among the nitrogen levels, highest K uptake was registered in N_{200} (320.39 mg pot^{-1}), followed by N_{150} (235.79 mg pot^{-1}) while the interaction effect of zeolite and nitrogen on K uptake at 30 DAS was non significant. K uptake was significantly influenced by both the levels of zeolite and nitrogen at 60, 90 DAS and at harvest (Table 13, 14, 15, 16, 17 respectively). $N_{200}Z_{7.5}$ showed highest K uptake at 60, 90 DAS (549.23, 773.17 mg pot^{-1} respectively) while the lowest K uptake was observed in control (112.30, 160.45 mg pot^{-1} respectively). At harvest, the highest K uptake in grain (210.59 mg pot^{-1}) was observed in $Z_{7.5}N_{200}$, which was significantly superior over all other treatments followed by Z_5N_{200} (191.97 mg pot^{-1}) while the lowest K uptake by grain was observed in control (26.75 mg pot^{-1}). In stover highest K uptake was observed in $Z_{7.5}N_{200}$ (591.72 mg pot^{-1}) followed by Z_5N_{200} (566.98 mg pot^{-1}) and the lowest K uptake was found in control (162.04 mg pot^{-1}).

Table.1 Properties of the experimental soil (Initial) and zeolite used in the experiment

Initial soil properties				
S. No.	**Property**	**Values**	**Property**	**Values**
1.	Sand (%)	87.36	8.Available P (kg ha^{-1})	15.48
2.	Silt (%)	4.40	9. Available K (kg ha^{-1})	380.66
3.	Clay (%)	8.24	**Zeolite properties**	
4.	Soil Texture	Loamy sand	1.Water Absorption	**90-100%**
	pH	7.08	2.Bulk Density (Mg m^{-3})	**0.35-0.45**
5	EC (dSm^{-1})	0.45	3. pH	**8.0 - 9.0**
6	Organic Carbon (%)	0.57	4. EC (dS m^{-1})	**5.5**
7	Available N (kg ha^{-1})	177.00	5. CEC (cmol (p+) kg^{-1})	**130-135**

Table.2 Effect of different levels of nitrogen and zeolite on grain yield (g pot^{-1}) of maize

Levels	**Grain yield of maize (g pot^{-1})**				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	19.50	22.87	25.35	27.20	**23.73**
N_{150}	29.73	33.30	34.67	35.86	**33.39**
N_{200}	38.10	40.89	45.35	46.80	**42.79**
Mean (Z)	**29.11**	**32.36**	**35.12**	**36.62**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	0.26	0.78	N X Z	0.53	1.55
Z	0.31	0.90			

*****Control – 14.86 g pot^{-1}

Table.3 Effect of different levels of nitrogen and zeolite on Nitrogen uptake (mg pot^{-1}) of maize at 30 DAS

Levels	**Nitrogen uptake (mg pot^{-1})**				
	Z_0	**$Z_{2.5}$**	**Z_5**	**$Z_{7.5}$**	**Mean (N)**
N_{100}	**116.57**	**126.53**	**138.33**	**163.77**	**136.30**
N_{150}	**178.50**	**198.13**	**213.23**	**228.13**	**204.50**
N_{200}	**242.83**	**273.03**	**285.67**	**301.92**	**275.86**
Mean (Z)	**179.30**	**199.23**	**212.41**	**231.27**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	**2.64**	**7.76**	**N X Z**	**5.29**	**NS**
Z	**3.05**	**8.97**			

*Control – 60.69 mg pot^{-1}

Table.4 Effect of different levels of nitrogen and zeolite on Nitrogen uptake (mg pot^{-1}) of maize at 60 DAS

Levels	Nitrogen uptake (mg pot^{-1})				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	Mean (N)
N_{100}	163.67	184.63	199.43	212.73	190.12
N_{150}	241.03	267.27	311.53	337.47	289.33
N_{200}	364.67	402.20	442.22	465.37	418.61
Mean (Z)	256.46	284.70	317.73	338.52	
	SE(m) ±	CD (0.05)		SE(m) ±	CD (0.05)
N	3.04	8.93	N X Z	6.09	17.87
Z	3.51	10.32			

*Control – 90.17 mg pot^{-1}

Table.5 Effect of different levels of nitrogen and zeolite on Nitrogen uptake (mg pot^{-1}) of maize at 90 DAS.

Levels	Nitrogen uptake (mg pot^{-1})				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	Mean (N)
N_{100}	299.96	358.89	430.19	495.74	396.19
N_{150}	539.74	597.81	669.29	727.69	633.63
N_{200}	783.35	861.16	1015.53	1066.06	931.52
Mean (Z)	541.02	605.95	705.00	763.17	
	SE(m) ±	CD (0.05)		SE(m) ±	CD (0.05)
N	5.19	15.22	N X Z	10.37	30.45
Z	5.99	17.58			

*Control – 199.04 mg pot^{-1}

Table.6 Effect of different levels of nitrogen and zeolite on Nitrogen uptake (mg pot-1) by maize grain at harvest

Levels	Nitrogen uptake (mg pot^{-1})				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	Mean (N)
N_{100}	117.61	151.67	176.67	197.61	160.89
N_{150}	220.11	259.70	281.98	298.79	265.14
N_{200}	320.01	351.66	408.21	425.83	376.43
Mean (Z)	219.24	254.34	288.96	307.41	
	SE(m) ±	CD (0.05)		SE(m) ±	CD (0.05)
N	2.39	7.03	N X Z	4.79	14.06
Z	2.76	8.12			

*Control – 67.42 mg pot^{-1}

Table.7 Effect of different levels of nitrogen and zeolite on Nitrogen uptake (mg pot^{-1}) by maize stover at harvest

Levels	**Nitrogen uptake (mg pot^{-1})**				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	36.90	51.38	67.66	86.85	**60.70**
N_{150}	104.11	124.60	146.65	178.80	**138.54**
N_{200}	205.07	221.74	265.05	278.45	**242.58**
Mean (Z)	**115.36**	**132.57**	**159.79**	**181.37**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	1.70	5.00	N X Z	3.41	10.00
Z	1.97	5.77			

*****Control – 26.91 mg pot^{-1}

Table.8 Effect of different levels of nitrogen and zeolite on phosphorous uptake (mg pot^{-1}) by maize at 30 DAS

Levels	**P uptake (mg pot^{-1})**				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	22.94	25.45	28.15	34.25	**27.70**
N_{150}	32.77	43.56	48.29	53.66	**44.57**
N_{200}	46.56	66.57	69.86	75.09	**64.52**
Mean (Z)	**34.09**	**45.20**	**48.76**	**54.33**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	0.69	2.03	N X Z	1.38	4.06
Z	0.80	2.35			

*****Control – 11.84 mg pot^{-1}

Table.9 Effect of different levels of nitrogen and zeolite on phosphorous uptake (mg pot^{-1}) by maize at 60 DAS

Levels	**P uptake (mg pot^{-1})**				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	27.65	30.67	33.57	40.02	**32.98**
N_{150}	38.09	51.99	61.18	68.74	**55.00**
N_{200}	61.29	90.71	103.10	108.63	**90.93**
Mean (Z)	**42.35**	**57.79**	**65.95**	**72.46**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	0.67	1.98	N X Z	1.35	3.95
Z	0.78	2.28			

***** Control – 14.29 mg pot^{-1}

Table.10 Effect of different levels of nitrogen and zeolite on phosphorous uptake (mg pot^{-1}) by maize at 90 DAS

Levels	**P uptake (mg pot^{-1})**				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	50.45	58.40	68.25	78.19	**63.82**
N_{150}	79.83	96.56	113.03	122.44	**102.97**
N_{200}	121.49	146.17	173.21	180.88	**155.44**
Mean (Z)	**83.92**	**100.38**	**118.16**	**127.17**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	1.48	4.36	N X Z	2.97	8.72
Z	1.71	5.03			

*****Control – 31.57 mg pot^{-1}

Table.11 Effect of different levels of nitrogen and zeolite on phosphorous uptake (mg pot^{-1}) by maize grains

Levels	**P uptake (mg pot^{-1})**				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	39.65	45.00	54.13	57.02	**48.95**
N_{150}	60.42	74.36	77.45	81.28	**73.38**
N_{200}	83.82	99.50	111.89	118.53	**103.44**
Mean (Z)	**61.30**	**72.95**	**81.16**	**85.61**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	0.98	2.87	N X Z	1.97	5.77
Z	1.13	3.33			

*****Control – 27.23 mg pot^{-1}

Table.12 Effect of different levels of nitrogen and zeolite on phosphorous uptake (mg pot^{-1}) by maize Stover

Levels	**P uptake (mg pot^{-1})**				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	17.41	22.03	27.45	31.30	**24.55**
N_{150}	30.32	46.36	52.67	57.42	**46.69**
N_{200}	52.72	73.91	85.15	92.84	**76.16**
Mean (Z)	**33.48**	**47.43**	**55.09**	**60.52**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	0.96	2.45	N X Z	1.67	4.90
Z	0.83	2.83			

*****Control – 12.12 mg pot^{-1}

Table.13 Effect of different levels of nitrogen and zeolite on potassium uptake (mg pot^{-1}) by maize at 30 DAS

Levels	**K uptake (mg pot^{-1})**				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	136.86	147.70	160.60	188.72	**158.47**
N_{150}	206.57	227.39	246.91	262.31	**235.79**
N_{200}	281.81	315.47	331.17	353.13	**320.39**
Mean (Z)	**208.42**	**230.19**	**246.22**	**268.05**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	2.95	8.67	N X Z	5.90	NS
Z	3.41	10.01			

*****Control – 72.11 mg pot^{-1}

Table.14 Effect of different levels of nitrogen and zeolite on potassium uptake (mg pot^{-1}) by maize at 60 DAS

Levels	**K uptake (mg pot^{-1})**				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	198.94	210.38	224.07	240.59	**218.50**
N_{150}	275.28	308.40	359.47	393.06	**334.05**
N_{200}	423.81	472.49	523.58	549.77	**492.41**
Mean (Z)	**299.34**	**330.42**	**369.04**	**394.47**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	3.69	10.83	N X Z	7.37	21.65
Z	4.26	12.50			

*****Control – 112.30 mg pot^{-1}

Table.15 Effect of different levels of nitrogen and zeolite on potassium uptake (mg pot^{-1}) I by maize at 90 DAS

Levels	**K uptake (mg pot^{-1})**				
	Z_0	**$Z_{2.5}$**	**Z_5**	**$Z_{7.5}$**	**Mean (N)**
N_{100}	**240.60**	**274.01**	**320.49**	**366.02**	**300.28**
N_{150}	**400.35**	**446.11**	**492.00**	**532.22**	**467.67**
N_{200}	**567.74**	**619.20**	**735.71**	**773.17**	**673.95**
Mean (Z)	**402.90**	**446.44**	**516.07**	**557.13**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	**3.53**	**10.35**	**N X Z**	**7.05**	**20.70**
Z	**4.07**	**11.96**			

*Control – 160.45 mg pot^{-1}

Table.16 Effect of different levels of nitrogen and zeolite on potassium uptake (mg pot^{-1}) by maize grain

Levels	K uptake (mg pot^{-1})				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	38.99	53.39	63.38	73.43	**57.30**
N_{150}	83.28	104.40	115.55	129.08	**108.08**
N_{200}	144.82	167.66	191.97	210.59	**178.76**
Mean (Z)	**89.03**	**108.48**	**123.64**	**137.70**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	1.07	3.15	N X Z	2.14	6.93
Z	1.24	3.63			

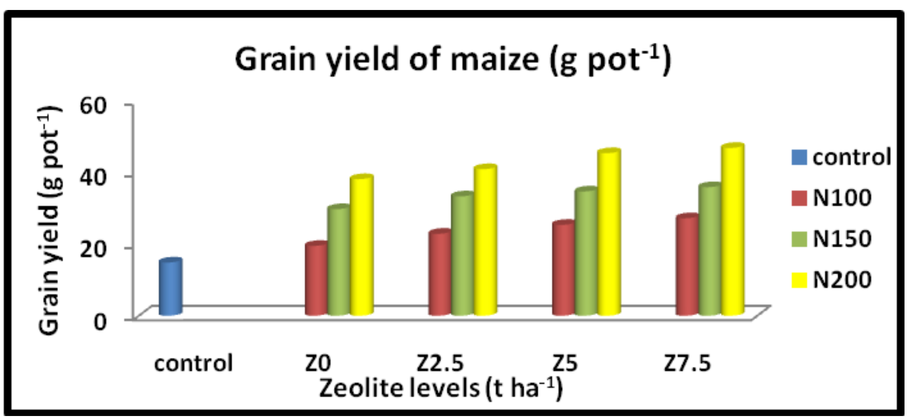
*****Control – 26.75 mg pot^{-1}

Table.17 Effect of different levels of nitrogen and zeolite on potassium uptake (mg pot^{-1}) by maize stover

Levels	K uptake (mg pot^{-1})				
	Z_0	$Z_{2.5}$	Z_5	$Z_{7.5}$	**Mean (N)**
N_{100}	209.50	249.63	284.58	315.84	**264.89**
N_{150}	344.75	387.15	416.33	439.87	**397.03**
N_{200}	488.28	503.00	566.98	591.72	**537.50**
Mean (Z)	**347.51**	**379.93**	**422.63**	**449.14**	
	SE(m) ±	**CD (0.05)**		**SE(m) ±**	**CD (0.05)**
N	2.82	8.29	N X Z	5.65	16.57
Z	3.26	9.57			

*****Control – 162.04 mg pot^{-1}

Fig.1 Effect of different levels of nitrogen and zeolite on grain yield (g pot^{-1}) of maize



The combined application of nitrogen with zeolite, increased the grain yield of maize due to the slow and controlled release of nitrogen from zeolite and thus making availability of nitrogen throughout the crop growth period which resulted in increased uptake, plant height, number of grains per row and test weight, which ultimately lead to increase in the grain yield. These results were comparable to results obtained by Manikandan and Subramanian (2016) where the grain yield of maize in alfisols was increased in zeourea treatment. The enhancement of maize yield with application of zeolite @ 200 kg ha^{-1} compared to without application of zeolite was also reported by Weaks *et al.,* (2011).

The slow release pattern of nitrogen by zeolite and reduction of leaching losses which resulted in increased N availability in the plant root zone might be the responsible factor for enhanced nitrogen uptake. The similar results were obtained by Lija *et al.,* (2014), who reported that combination of zeolite with compound fertilizer enhanced N uptake in maize. Ahmed *et al.,* (2008) (a) found that zeolite had significantly improved N uptake in maize and application of higher doses of zeolite along with nitrogen enhanced N uptake in rice grain and straw (Kavoosi, 2007).

The increase in the P uptake in maize at different stages with the addition of zeolite may be due to increase in the P content in the plant tissues and dry matter production. These results were in accordance with the findings of Ahmed *et al.,* (2010) (b) who concluded that irrespective of the treatments, addition of zeolite significantly improved P uptake in leaves, stems and roots of maize. P uptake in stems, maize was significantly higher in treatment with compound fertilizer mixed with clinoptilolite zeolite (Rabai *et al.,* (2013).

At 30 DAS there was no significant interaction between zeolite and nitrogen on K uptake in plants was observed which was in correspondence with the results obtained by Kavoosi (2007), where no significant interaction between zeolite and nitrogen on K uptake in rice plants was observed. There was a significant influence of both zeolite and nitrogen levels in increasing the K uptake at 60, 90 DAS and at harvest, due to less leaching of potassium. This is because when zeolites are mixed with soil, they help to retain nutrients from the applied fertilizers in the root zone. These results were in line with the findings of Rabai *et al.,* (2013), who concluded that treatments with clinoptilolite zeolite significantly increased K uptake in maize stem, roots and leaves. Similar results were also obtained by Ahmed *et al.,* (2010), who found that best K uptake from all plant tissues of maize from the treatments with zeolite.

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