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Effect of zeolite application on soil properties and primary nutrient uptake of green gram (*Vigna radiata*) on inceptisol

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Abstract
The experiment was carried out during the *summer* 2018-19 at Post Graduate Institute Research Farm, Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri on “Effect of zeolite application on soil properties and primary nutrient uptake of green gram (*Vigna radiata*) on Inceptisol” The experiment was laid out in Randomized Block Design with three replications comprising of twelve treatments (1 control treatment,1 GRDF treatment, 5 treatments of GRDF+Zeolite @ 20, 40, 60, 80, 100 kg/ha and 5 treatments of only Zeolite @ 20, 40, 60, 80, 100 kg/ha). It was observed that the effect of treatments of zeolite on soil pH and soil bulk density was non-significant, however EC, Organic carbon, calcium carbonate and CEC increased in all the treatments of zeolite. The uptake of NPK was also observed to be higher in the only zeolite treatment over the Absolute control and general recommended dose. It was observed that application of zeolite @ 80 kg ha^{-1} along with GRDF was observed to be the best treatment to improved the soil properties and primary nutrient uptake of green gram.

Keywords: Zeolite, GRDF, Soil properties, Nutrient uptake

Introduction
The large scale production through application of mineral fertilizers is the base of green revolution. But now a days increase in cost of fertilizer and growing energy crises have created considerable interest for search a alternative cheap sources of plant nutrients.

Green gram (*Vigna radiata*) is one of the pulse crop grown across the nation. It is locally known as moong or mungbean and belongs to the family Leguminacea. The crop is grown for its grains which are consumed either whole or in split form (dal). Its nutritive value is due to its high protein content, varying from 23.4 to 33%. It also contains 56.7% carbohydrates, 1.3% fats, 4.1% fibers, 3.5% minerals and various amino acids *viz*., lysine, thiamine, cysteine, methionine, etc.

Being a pulse crop, green gram has a mechanism of fixing atmospheric nitrogen into their root nodules and maintain soil fertility and thus play vital role in sustainable agriculture. But in recent times, concern about unbalanced use of fertilizers leading to environment pollution have been globally expressed. As a result studies on how to use efficient methods to reduce nutrient application at the same time increasing or maintaining the crop yield, increasing nutrient use efficiency are imperative. In this regard, inclusion of zeolites in fertilizers management for agriculture is essential as besides serving as soil conditioner these minerals have three main properties, which are of great interest for agricultural purposes: high cation exchange capacity, high water holding capacity in the free channels, and high adsorption capacity (Mumpton, 1999) [4].

Zeolite
Zeolites are hydrated aluminosilicate minerals made from interlinked tetrahedra of alumina (AlO_4) and silica (SiO_4). In simpler words, they are solids with a relatively open, three - dimensional crystal structure built from the elements aluminum, oxygen, and silicon, with alkali or alkaline Earth metals (such as sodium, potassium, and magnesium) plus water molecules trapped in the gaps between them. Zeolites form with many different crystalline structures, which have large open pores (sometimes referred to as cavities) in a very regular arrangement and roughly the same size as small molecules.

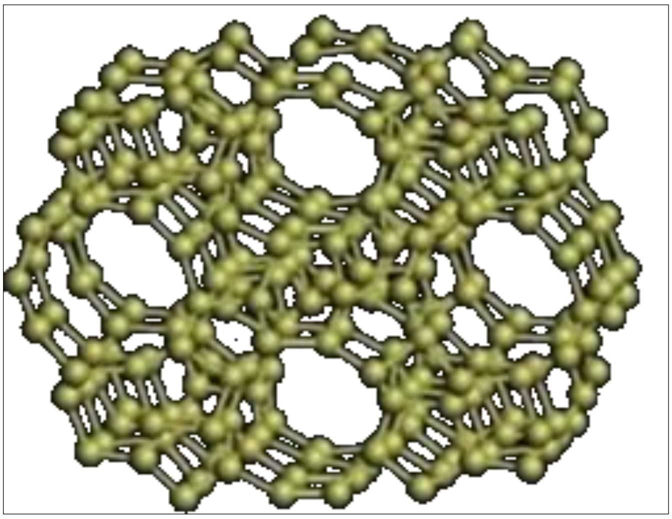

Fig 1: Structure of Zeolite

Structure of Zeolite

They are becoming the subject of interesting investigation in various agricultural issues (Ramesh *et al.*, 2011) [6] particularly the ion-exchange properties as they can serve the dual role of carrier and dispenser of plant nutrients.

Materials and Methods

The experiment was conducted during *summer* 2018-19 at PGI Research Farm, Department of Soil Science and Agril. Chemistry, M.P.K.V., Rahuri. The experimental field soils was medium deep black belonging to Inceptisol order and chemical properties of experimental soil showed moderately in alkaline reaction (pH 8.10), normal in electrical conductivity (0.33dSm^{-1}), medium in organic carbon content (0.54%) and medium in $CaCO_3$ content (6.58%), and have bulk density 1.38 g/cm^3, CEC 42.08 cmol (p+) kg^{-1}. Soil fertility was low in available nitrogen (175.6 kg ha^{-1}), medium in available phosphorous (18.09 kg ha^{-1}) and very high in available potassium (477 kg ha^{-1}) content. However, deficient in available Fe (3.94 mg kg^{-1}) and available Zn (0.37 mg kg^{-1}), and sufficient in available Mn (5.73 mg kg^{-1}), and available Cu (1.5 mg kg^{-1}).The experiment was laid out in a randomized block design with 12 treatments and 3 replications. The recommended spacing of 30 cm x 10 cm was adopted for dibbling of green gram. The general recommended dose of nutrients (20:40:00 kg ha^{-1} N, P_2O_5 and K_2O, respectively + FYM @ 5 t ha^{-1}) were given to green gram as per treatment details except contol treatment at the time of dibbling of green gram. The fertilizer, farm yard manure and zeolite as per treatment (GRDF+zeolite @ 20,40,60,80,100 kg/ha and only zeolite@ 20, 40, 60, 80, 100 kg/ha) were thoroughly mixed together and were applied in band placement by opening small furrows with a marker. The added dose of fertilizer, farm yard manure and zeolite were coverd with soil and the sowing of seed was done above the band placement of fertilizer.

Results and Discussion

Effect of zeolite application on soil properties after harvest of green gram

The pH of the soil in the experimental plot was observed to increase slightly, but this increase was not significant. A slight increase in electrical conductivity with increasing levels of zeolite was observed due to increase in the total soluble salts by release of nutrient cations and anions in the solution. The significant increase in the organic carbon content was registered with increasing levels of zeolite and was the highest (0.69%) in the 80 kg ha^{-1} zeolite + GRDF treatment which may be due to increased availability of nutrients resulting in increased root growth and a consequent increase in organic carbon of the soil. A slight increase (0.61%) in the calcium carbonate in treatment (80 kg ha^{-1} zeolite + GRDF) was also observed due to the release of free calcium ions by zeolite in the solution leading to precipitation reaction forming calcium carbonate. The cation exchange capacity of soil was observed to increase significantly with increasing levels of zeolite which may be attributed to the adsorption and release of cations on the negatively charged honey comb structure of zeolite. The highest cation exchange capacity was observed in treatment (80 kg ha^{-1} zeolite + GRDF) (52.60 cmol (p$^+$) kg^{-1} of soil). A slight numerical decrease in bulk density of the soil was observed due to zeolite treatments however, it was non-significant.

Table 1: Effect of zeolite application on soil properties after harvest of green gram

Tr. No.	Treatment	pH (1:2.5)	EC (dSm^{-1})	Organic carbon (%)	Calcium Carbonate (%)	Bulk Density (gm/cm^3)	CEC cmol (p+) kg^{-1} of soil
T_1	Absolute control	8.07	0.26	0.46	6.12	1.37	42.37
T_2	GRDF (20:40:00 kg ha^{-1} N:P_2O_5:K_2O + FYM@ 5 t ha^{-1})	8.10	0.28	0.52	6.31	1.38	47.40
T_3	T_2 + Zeoilte @ 20 kg ha^{-1}	8.12	0.31	0.57	6.53	1.36	48.10
T_4	T_2 + Zeoilte @ 40 kg ha^{-1}	8.12	0.33	0.62	6.54	1.35	48.73
T_5	T_2 + Zeoilte @ 60 kg ha^{-1}	8.12	0.35	0.67	6.79	1.37	51.30
T_6	T_2 + Zeoilte @ 80 kg ha^{-1}	8.09	0.36	0.69	6.92	1.35	52.60
T_7	T_2 + Zeoilte @ 100 kg ha^{-1}	8.13	0.34	0.66	6.61	1.36	51.77
T_8	Zeoilte @ 20 kg ha^{-1}	8.10	0.28	0.44	5.89	1.35	42.53
T_9	Zeoilte @ 40 kg ha^{-1}	8.10	0.29	0.50	6.07	1.34	43.67
T_{10}	Zeoilte @ 60 kg ha^{-1}	8.07	0.31	0.53	6.18	1.35	44.24
T_{11}	Zeoilte @ 80 kg ha^{-1}	8.12	0.34	0.59	6.37	1.31	45.43
T_{12}	Zeoilte @ 100 kg ha^{-1}	8.10	0.32	0.55	6.28	1.33	44.49
	SE+	0.017	0.007	0.012	0.03	0.003	0.09
	CD at 5%	NS	0.22	0.03	0.09	NS	0.28
	Initil status	8.10	0.33	0.54	6.58	1.38	33.09

Effect of zeolite application on total uptake of N, P, K by green gram crop

Total Uptake of Nitrogen

A significant increase in the total N uptake by green gram was observed with the increasing levels of zeolite along with GRDF and was also observed to increase with increasing levels of only zeolite treatments (Zeolite @ 20, 40, 60, 80, 100 kg/ha). The significantly the highest N uptake was observed in treatmentT_6 (GRDF+ Zeoilte @ 80 kg ha^{-1}) (59.22 kg ha^{-1}) over all the treatments and the lowest N uptake was observed in control treatment (21.31 kg ha^{-1}). This significant uptake of nitrogen may be attributed to the initial fixation of NH_4^+ ions during nitrification of the nitrogenous fertilizer and subsequent release and oxidation to nitrates which were made available for the uptake by green gram. The positive impact of zeolite application on the nitrogen uptake was reported by Latifah *et al*. (2016) [3]. Ahmed *et al*. (2010) [1] reported that application of inorganic fertilizers mixed with zeolite significantly improved nitrogen uptake compared with treatment without zeolite addition.

Total uptake of phosphorus: The significantly highest total P uptake (16.81 kg ha^{-1}) by green gram plant was observed in T_6 (GRDF+ Zeoilte @ 80 kg ha^{-1}) over all the treatments and the least (6.31 kg ha^{-1}) in treatment T_1 (Absolute control). The results showed that greatly enhanced plant uptake of P from single superphosphate when applied in combination with zeolite. The zeolite and single superphosphate offers the considerable advantage of P release in response to plant demand and is unique in this regard.The positive impact of zeolite application on the phosphorus uptake was reported by Pickering *et al.* (2002) [5], Barbarick *et al.* (1990) [2] and Ramesh *et al*. (2011) [6].

Total uptake of potassium

The significantly highest total K uptake (30.66 kg ha^{-1}) by green gram plant was observed in T_6 (GRDF+ Zeoilte @ 80 kg ha^{-1}) over all the treatments and least (23.26 kg ha^{-1}) in treatment T_1 (Absolute control). The zeolite possibly acted as an exchange fertilizer, with Ca^{2+} exchanging onto the zeolite in response to plant uptake of nutrient cations (NH_4^+ or K^+).

Table 2: Effect of zeolite application on total uptake of N, P, K by green gram crop after harvest

Tr. No.	Treatment	Total nutrient uptake (kg ha^{-1})		
		N	P	K
T_1	Absolute control	21.31	6.31	-
T_2	GRDF (20:40:00 kg ha^{-1} $N:P_2O_5:K_2O$ + FYM @ 5 t ha^{-1})	42.23	11.98	-
T_3	T_2 + Zeoilte @ 20 kg ha^{-1}	50.67	14.38	-
T_4	T_2 + Zeoilte @ 40 kg ha^{-1}	53.21	15.10	-
T_5	T_2 + Zeoilte @ 60 kg ha^{-1}	55.87	15.86	-
T_6	T_2 + Zeoilte @ 80 kg ha^{-1}	59.22	16.81	-
T_7	T_2 + Zeoilte @ 100 kg ha^{-1}	53.30	15.13	-
T_8	Zeoilte @ 20 kg ha^{-1}	22.76	6.68	-
T_9	Zeoilte @ 40 kg ha^{-1}	25.04	7.34	-
T_{10}	Zeoilte @ 60 kg ha^{-1}	27.53	8.08	-
T_{11}	Zeoilte @ 80 kg ha^{-1}	29.45	8.64	-
T_{12}	Zeoilte @ 100 kg ha^{-1}	26.51	7.78	-
	SE+	0.01	1.17	-
	CD at 5%	0.03	3.44	-

It was observed that primary nutrient uptake was significantly influenced by increase in the levels of zeolite.The dose of 80 kg ha^{-1} zeolite along with recommended dose of green gram (20:40:00 kg ha^{-1} $N:P_2O_5:K_2O$ + FYM @ 5 t ha^{-1})was found beneficial to improve soil properties and observed to be the best treatment to improved the available primary nutrient status of the soil and also increased the nitrogen and phosphorus uptake.

Conclusion

It was observed that the effect of treatments of zeolite on soil pH and soil bulk density was non-significant, however EC, Organic carbon, calcium carbonate and CEC increased in all the treatments of zeolite. The uptake of NPK was also observed to be higher in the only zeolite treatment over the Absolute control and general recommended dose. It was observed that application of zeolite @ 80 kg ha^{-1} alongwith GRDF was observed to be the best treatment to improved the soil properties and primary nutrient uptake of green gram.

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