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Effect of organic and inorganic sources of nutrients on soil macronutrient status of garden pea (*Pisum sativum* L.)

Yogesh Pawar, LR Varma, P Verma and BM Nandre

Abstract
An experiment was conducted to examine the response of four different organic manures *viz.* farmyard manure, vermicompost, castor cake and poultry manure as a source of nitrogen with or without chemical fertilizers, phosphorus and potassium and biofertilizer *i.e.* PSB in a Randomized Block Design with three replications during the *rabi* season of the year 2012 and 2013. The results revealed that, the significantly maximum available nitrogen after crop harvesting (216.84 kg/ha) was recorded with T_2 (Farm yard manure 15 t/ha + Recommended dose of NPK) in pooled data. The maximum available phosphorus after crop harvesting (39.75 kg/ha and 38.19 kg/ha) was recorded with T_{15} (Recommended dose of N as vermicompost + P and K + PSB) during the year 2013 and in pooled data, respectively. Whereas, maximum available potassium after crop harvesting (192.38 kg/ha) was recorded with T_2 (Farm yard manure 15 t/ha + Recommended dose of NPK) in pooled data. Maximum increase in available nitrogen (6.55 %) in soil was noted with T_6 (Recommended dose of N as poultry manure). The significantly maximum increase in available phosphorus (9.17 %) in soil was recorded with T_{17} (Recommended dose of N as Castor Cake + P and K + PSB) during the year 2012, whereas, (12.61 % and 10.42 %) was noted with T_{18} (Recommended dose of N as poultry manure + P and K + PSB) during the year 2013 and in pooled data, respectively.

Keywords: bonneville, garden pea, macronutrient and soil

Introduction
Garden pea (*Pisum sativum* L. var. hortense) is a second important food legume of the world. The green and dry foliage are used as cattle fodder and green pods of vegetable pea are highly nutritive so, preferred for culinary purpose. The high percentage of digestible protein (7.2 g), carbohydrates (15.8 g), Vitamin A (139 I.U.), Vitamin C (9 mg), magnesium (34 mg) and phosphorus (139 mg) per 100 g of edible portion (Gopalkrishnan, 2007) [5].

The food legumes restorer of soil fertility has long been recognized due to their unique ability of symbiotic nitrogen fixation. This also makes them the most important and useful component of a cropping system in the present context of energy crisis (Rana *et al*. 1999) [14]. To eradicate the low yield of pea, success of Indian agriculture depends heavily on use of fertilizers. To compensate the short supply and to mitigate recent price hike in inorganic fertilizers, use of indigenous sources helps to sustain crop yields but also plays a key role in improving the physical, chemical and biological properties and also increases the efficiency of applied fertilizers (Singh and Biswas, 2000) [18].

To sustain soil health and benign environment there is a need for standardization the conjunctive use of organic and inorganic sources of nutrition in order to increase the productivity and alternately improving the soil health (Sharma and Chauhan, 2011; Rajput and Kushwah, 2005) [16, 13]. The concept of nutrient management is gaining considerable momentum today but negligible study has been conducted so, the present investigation was planned and executed on garden pea.

Materials and Methods
The investigation was conducted at Department of Vegetable Science, College of Horticulture, S. D. Agricultural University, Sardarkrushinagar. The four different organic manures *viz.* farmyard manure, vermicompost, castor cake and poultry manure as a source of nitrogen with or without chemical fertilizers like phosphorus and potassium and biofertilizer *i.e.* PSB were tested during the *rabi* season of the year 2012 and 2013. The promising variety of garden pea

i.e. Bonneville was taken for investigation. The experiment was laid out in a Randomized Block Design with eighteen treatments and replicated thrice.

Treat. No.	Treatments
T_1	Recommended dose of NPK (25:70:50 kg/ha)
T_2	Farm Yard Manure 15 t/hectare+ Recommended dose of NPK
T_3	Recommended dose of N as Vermicompost
T_4	Recommended dose of N as Farm Yard Manure
T_5	Recommended dose of N as Castor Cake
T_6	Recommended dose of N as Poultry Manure
T_7	Recommended dose of N as Vermicompost + PSB
T_8	Recommended dose of N as Farm Yard Manure + PSB
T_9	Recommended dose of N as Castor Cake + PSB
T_{10}	Recommended dose of N as Poultry Manure + PSB
T_{11}	Recommended dose of N as Vermicompost + P and K
T_{12}	Recommended dose of N as Farm Yard Manure + P and K
T_{13}	Recommended dose of N as Castor Cake + P and K
T_{14}	Recommended dose of N as Poultry Manure + P and K
T_{15}	Recommended dose of N as Vermicompost + P and K + PSB
T_{16}	Recommended dose of N as Farm Yard Manure + P and K + PSB
T_{17}	Recommended dose of N as Castor Cake + P and K + PSB
T_{18}	Recommended dose of N as Poultry Manure + P and K + PSB

Note

Biofertilizers (Seed treatment) : @20 ml per kg seed

Biofertilizers (Soil treatment) : @1.25 liter per hectare

The soil status of experimental field as follows-

Table 1: Physico-chemical properties of the experimental soil

S. No.	Properties	Status	Methods employed
1	Textural class	Sandy loam	International pipette method (Piper, 1966)
2	Soil pH	7.5	Potentiometric method (Jackson, 1973) [7]
3	Organic carbon (%)	0.15	Walkley and Black's rapid titration method (Jackson, 1973) [7]
4	Available N (kg ha^{-1})	138	Alkaline permanganate method (Jackson, 1973) [7]
5	Available P_2O_5 (kg ha^{-1})	31.20	Olsen's method (Jackson, 1973) [7]
6	Available K_2O (kg ha^{-1})	281	Flame photometer method (Jackson, 1973) [7]

Table 2: Nitrogen content (%) of organic manures used

Sr. No.	Organic manures	Nitrogen content (%) of organic manures
1.	FYM	0.64
2.	Vermicompost	1.14
3.	Poultry manure	2.35
4.	Castor cake	4.11

To raise the crop recommended package of practices were followed. The treatments were evaluated on the basis of available nitrogen, phosphorus and potassium (kg/ha) in soil before crop sowing and after harvesting, increase in available nitrogen (%), phosphorus (%) and potassium (%) in soil. The available nitrogen were analyzed by Alkaline permanganate method (Jackson, 1973) [7], available phosphorus by Olsen's method (Jackson, 1973) [7] and available potassium by Flame photometer method (Jackson, 1973) [7]. The mean data were subjected to statistical analysis following analysis of variance technique (Gomez and Gomez, 1984) [4].

Results and Discussion

a. Effect of organic and inorganic sources of nutrients on macronutrient status *viz*., available nitrogen, phosphorus and potassium (kg/ha) of soil before crop sowing

The soil analysis data on available nitrogen, phosphorus and potassium (kg/ha) before crop sowing are presented in Table 1. The data furnished in table revealed that the available nitrogen, phosphorus and potassium (kg/ha) contents in soil before crop sowing were not influenced significantly due to various treatments during the year 2012 and 2013.

b. Effect of organic and inorganic sources of nutrients on macronutrient status of soil after crop harvesting
    1. Effect of organic and inorganic sources of nutrients on macronutrient status of soil after crop harvesting on available nitrogen (kg/ha) after crop harvesting

The data furnished in Table 2 revealed that the effect of various treatments on available nitrogen after crop harvesting was found to be non-significant during both the years of experimentation (2012 and 2013) whereas, significant in pooled data. However, the maximum available nitrogen after crop harvesting (213.90 kg/ha) was recorded with T_6 (Recommended dose of N as poultry manure) during the year 2012 and minimum (206.10 kg/ha) was recorded with T_{10} (Recommended dose of N as poultry manure + PSB). During the year 2013, maximum available nitrogen after crop harvesting (221.10 kg/ha and 216.84 kg/ha) was observed with T_2 (Farm yard manure 15 t/ha + Recommended dose of NPK) during the year 2013 and in pooled data, respectively and it was found statistically at par with all other treatments except T_{10}, T_{11} and T_{18} in pooled data.

The minimum available nitrogen after crop harvesting (211.11 kg/ha) was recorded with T_{11} (Recommended dose of N as vermicompost + P and K) in the year 2013 and in pooled analysis T_{10} (Recommended dose of N as poultry manure + PSB) showed similar trend with 208.67 kg/ha.

The interaction between year and treatment was found significant and showed inconsistency of treatments in respect of available nitrogen after crop harvesting (kg/ha).

Supplementation of chemical fertilizers along with various organic sources is capable of sustaining higher crop productivity, improving soil quality, and productivity on long-term basis (Chhonkar, 2002) [2]. Increase in available nitrogen because the favourable soil conditions might have helped in greater multiplication of microbes which could convert organically bound nitrogen to inorganic form leading to build up of higher available nitrogen. Several researchers all over the world have shown various benefits of the application of FYM on soil properties and productivity of leguminous crops (Bhardwaj *et al.,* 2010 and Prabhakar *et al.,* 2010) [1, 12]. The results are also in line with the findings of Jaipaul *et al.* (2011) [8], Khanday *et al*. (2012) [10], Sepehya *et al.* (2012) [15] in garden pea.

2. Effect of organic and inorganic sources of nutrients on macronutrient status of soil after crop harvesting on available phosphorus (kg/ha) after crop harvesting

It is quite apparent from the data presented in Table 2 that the effect of various treatments on available phosphorus after crop harvesting was found to be non-significant during the year of 2012 while significant in 2013 and in pooled data. However, the maximum available phosphorus after crop harvesting (36.63 kg/ha, 39.75 kg/ha and 38.19 kg/ha) was recorded with T_{15} (Recommended dose of N as vermicompost + P and K + PSB) during the year 2012, 2013 and in pooled data, respectively and which was statistically at par with T_{17} and T_7 during 2013, whereas, $T_{17,}$ $T_{7,}$ T_2 and T_{12} in pooled data. The minimum available phosphorus after crop harvesting (32.48 kg/ha) was recorded with T_{16} (Recommended dose of N as farm yard manure + P and K + PSB) during the year 2012, whereas, T_4 (Recommended dose of N as farm yard manure) showed 33.00 kg/ha and 32.86 kg/ha during the year 2013 and in pooled data, respectively. The interaction between year and treatment failed to exert any significant influence on available phosphorus (kg/ha) after crop harvesting.

Buildup of available phosphorus with the application of NPK fertilizers in conjunction with organic manures might be due to the release of organic acids during decomposition which in turn helped in releasing phosphorus through solubilizing action of native phosphorus in the soil (Bhardwaj *et al.,* 2010) [1]. These results are in conformity with those of Jaipaul *et al.* (2011) [8], Khanday *et al*. (2012) [10], Sepehya *et al.* (2012) [15] in garden pea and Singh *et al*. (2014) [17] in field pea.

3. Effect of organic and inorganic sources of nutrients on macronutrient status of soil after crop harvesting on available potassium (kg/ha) after crop harvesting

The data (Table 2) revealed that the effect of various treatments on available potassium after crop harvesting was found to be non-significant during the year of 2012 and 2013 whereas, significant in pooled data.

The maximum available potassium after crop harvesting (189.75 kg/ha, 195.00 kg/ha and 192.38 kg/ha) was recorded with T_2 (Farm yard manure 15 t/ha + Recommended dose of NPK) during the year 2012, 2013 and in pooled data, respectively and it was found statistically at par with treatments T_{18}, $T_{4,}$ T_{12}, $T_{9,}$ T_8, $T_{3,}$ T_{10}, T_{17}, T_{13} and T_{16} in pooled data.

The minimum available potassium after crop harvesting (182.49 kg/ha) was recorded with T_{14} (Recommended dose of N as poultry manure + P and K) during the year 2012, whereas, similar trend (186.89 kg/ha) was observed with T_5 (Recommended dose of N as castor cake) during the year 2013 and in pooled data, T_7 (Recommended dose of N as vermicompost + PSB) with 180.05 kg/ha.

The interaction between year and treatment failed to exert any significant influence on available potassium (kg/ha) after crop harvesting.

Increase in the content of available potassium due to addition of organic manures along with chemical fertilizers may be ascribed to the reduction of potassium fixation and release of Potassium. Such increase in the content of available potassium with the use of organics and chemical fertilizers was also reported by Bhardwaj *et al.* (2010) [1].

However, the data indicated that the nutrients status of soil slightly improved after crop harvesting in both the years 2012 and 2013 with respect to all treatments. Similar results were reported by Jaipaul *et al.* (2011) [8], Khanday *et al*. (2012) [10], Sepehya *et al.* (2012) [15] in garden pea.

c. Effect of organic and inorganic sources of nutrients on macronutrient status of soil after crop harvesting on increase in available nitrogen (%)

1. Effect of organic and inorganic sources of nutrients on macronutrient status of soil after crop harvesting on increase in available nitrogen (%)

The data furnished in Table 3 revealed that various treatments non-significantly influenced the increase in available nitrogen (%) in soil during the year 2012 and 2013 whereas, significant in pooled analysis. However, maximum increase in available nitrogen (4.72 % and 5.38 %) in soil was noted with T_2 (Farm yard manure 15 t/ha + Recommended dose of NPK) during the year 2012 and in pooled data, respectively and it was found statistically at par with all other treatments except T_{11}, T_{13}, T_{12} and T_{14} in pooled data. During the year 2013, maximum increase in available nitrogen (6.55 %) in soil was noted with T_6 (Recommended dose of N as poultry manure).

Minimum increase in available nitrogen (0.28 %) in soil was noted with T_{13} (Recommended dose of N as castor cake + P and K) in the year 2012, whereas, similar trend (0.84 % and 0.62 %) was noted with T_{11} (Recommended dose of N as vermicompost + P and K) during year 2013 and in pooled data, respectively.

The interaction between year and treatment was found significant and showed inconsistency of treatments on increase in available nitrogen (%) in soil.

The increase in available nitrogen could be due to better nodule anion and N - fixation as explained earlier. Seed inoculation with biofertilizers played a vital role in improving nodulation and thereby N_2 fixation and P_2O_5 solubilization. These results are in close harmony with Dadhich *et al.* (2006) [3] in soyabean. Similar results were obtained by Gopinath *et al*. (2008), Jaipaul *et al.* (2011) [8], Khanday *et al*. (2012) [10], Sepehya *et al.* (2012) [15] in garden pea and Singh *et al*. (2014) [17] in field pea.

2. Effect of organic and inorganic sources of nutrients on macronutrient status of soil after crop harvesting on increase in available phosphorus (%)

Significantly maximum increase in available phosphorus (9.17 %) in soil was noted with T_{17} (Recommended dose of N as Castor Cake + P and K + PSB) during the year 2012, whereas, (12.61 % and 10.42 %) was noted with T_{18} (Recommended dose of N as poultry manure + P and K + PSB) during the year 2013 and in pooled data, respectively

and which it was statistically at par with T_{18}, T_{10}, T_{15} and T_{16} during 2012; T_7, T_{15}, T_{17}, T_9, T_{16}, T_8 and T_{10} during 2013, whereas, T_{17}, T_{15}, T_7, T_{10}, T_{16}, T_9 and T_8 in pooled data.

Minimum increase in available phosphorus (1.76 %) in soil was noted with T_6 (Recommended dose of N as poultry manure) during the year 2012; T_4 (Recommended dose of N as farm yard manure) with 2.59 % during the year 2013 and T_3 (Recommended dose of N as vermicompost) with 2.42 % in pooled data.

The interaction between year and treatment was found non-significant and showed inconsistency of treatments with the respect to increase in available phosphorus (%) in soil.

Increase in available phosphorus is due to addition of poultry manure and increased solubility of phosphorus due to PSB by producing certain organic acids and thereby increased the soil available phosphorus (Jeon *et al.* 2003; Jaipaul *et al.* 2011) [9, 8]. Similarly, the increase in available phosphorus can be attributed to organic acids produced by root legumes which are capable of solubilizing of soil phosphorus. These results are in conformity with those of Gopinath *et al.* (2008), Khanday *et al.* (2012) [10], Sepehya *et al.* (2012) [15] in garden pea and Singh *et al.* (2014) [17] in field pea.

3. Effect of organic and inorganic sources of nutrients on macronutrient status of soil after crop harvesting on increase in available potassium (%)

Perusal of data (Table 3) revealed that various treatments were non-significantly influenced the increase in available potassium (%) in soil during the year 2012, 2013 and in pooled analysis. However, maximum increase in available potassium (1.91 %) in soil was noted with T_{17} (Recommended dose of N as castor cake + P and K + PSB) during the year 2012, whereas, during the year 2013 increase in available potassium (4.05 %) in soil was noted with T_{18} (Recommended dose of N as poultry manure + P and K + PSB) and in pooled data, T_2 (Farm yard manure 15 t/ha + Recommended dose of NPK) the value being 2.84 %.

Minimum increase in available potassium (0.22 % and 1.40 %) in soil was noted with T_1 (Recommended dose of NPK 25:70:50 kg/ha) during the year 2012 and in pooled data, respectively, whereas, similar trend was observed with T_5 (Recommended dose of N as castor cake) *i.e.* 1.94 % during the year 2013.

Table 3: Effect of organic and inorganic sources of nutrients on soil macronutrient status (available nitrogen, phosphorus and potassium) of garden pea before crop sowing

Treat. No.	Treatment name	Available Nitrogen (kg/ha)		Available Phosphorus (kg/ha)		Available Potassium (kg/ha)	
		2012	2013	2012	2013	2012	2013
T_1	RDF of NPK (25:70:50 kg/ha)	203.93	210.60	34.14	34.72	183.73	185.45
T_2	FYM 15 t/ha + RDF of NPK	203.08	208.52	33.93	34.81	186.22	187.92
T_3	RDN as vermicompost	204.49	208.23	32.48	34.94	185.81	187.51
T_4	RDN as farm yard manure	202.74	208.19	31.98	32.22	187.51	189.20
T_5	RDN as castor cake	204.17	210.02	34.37	34.59	181.58	183.35
T_6	RDN as poultry manure	206.97	206.32	33.49	34.81	181.47	182.84
T_7	RDN as vermicompost + PSB	207.59	207.09	33.58	33.74	180.54	182.25
T_8	RDN as farm yard manure + PSB	205.54	209.05	31.27	33.22	185.77	187.48
T_9	RDN as castor cake + PSB	207.59	207.09	31.87	32.19	185.98	187.78
T_{10}	RDN as poultry manure + PSB	200.91	205.49	31.81	33.54	185.07	186.85
T_{11}	RDN as vermicompost + P and K	206.31	209.36	33.33	33.40	181.45	183.25
T_{12}	RDN as farm yard manure + P and K	206.32	209.64	33.72	35.43	184.92	187.49
T_{13}	RDN as castor cake + P and K	209.98	205.49	32.60	33.59	182.22	183.98
T_{14}	RDN as poultry manure + P and K	207.43	209.45	32.93	32.80	179.96	181.73
T_{15}	RDN as vermicompost + P and K + PSB	201.99	208.98	34.13	35.61	181.50	183.27
T_{16}	RDN as farm yard manure + P and K + PSB	207.22	209.54	30.38	33.14	181.80	183.51
T_{17}	RDN as castor cake + P and K + PSB	201.62	210.74	32.18	33.93	183.41	186.11
T_{18}	RDN as poultry manure + P and K + PSB	199.85	205.06	31.01	32.00	185.84	187.61
S.Em±		2.05	1.59	0.89	0.86	1.69	1.73
C.D. at 5%		NS	NS	NS	NS	NS	NS
Interaction: YX T							
S.Em±							
C.D. at 5%							

Table 4: Effect of organic and inorganic sources of nutrients on soil macronutrient status (available nitrogen, phosphorus and potassium) of garden pea after crop harvesting

Treatments	Available nitrogen (kg/ha)			Available phosphorus (kg/ha)			Available potassium (kg/ha)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1	208.43	218.03	213.23	34.76	36.63	35.69	184.12	190.22	187.17
T_2	212.58	221.10	216.84	35.21	36.82	36.02	189.75	195.00	192.38
T_3	209.64	216.53	213.09	33.19	35.90	34.54	186.56	193.36	189.96
T_4	210.71	218.80	214.76	32.72	33.00	32.86	188.57	194.44	191.51
T_5	212.27	220.37	216.32	35.23	36.11	35.67	184.93	186.89	185.91
T_6	213.90	219.73	216.82	34.06	36.71	35.39	183.26	188.25	185.76
T_7	209.15	215.57	212.36	34.80	37.72	36.26	182.98	187.09	185.04
T_8	209.61	217.13	213.37	32.92	35.78	34.35	188.31	192.30	190.30
T_9	209.75	213.73	211.74	33.33	35.23	34.28	188.51	192.50	190.50
T_{10}	206.10	211.23	208.67	34.20	36.08	35.14	187.62	191.98	189.80
T_{11}	207.11	211.11	209.11	34.20	35.51	34.86	183.98	190.08	187.03
T_{12}	209.38	213.18	211.28	34.53	37.24	35.88	187.79	194.08	190.93

T_{13}	210.57	211.35	210.96	34.38	35.68	35.03	184.75	190.85	187.80
T_{14}	208.99	214.75	211.87	34.08	35.17	34.63	182.49	188.51	185.50
T_{15}	209.61	217.13	213.37	36.63	39.75	38.19	184.00	190.20	187.10
T_{16}	213.20	220.40	216.80	32.48	35.83	34.16	184.34	190.40	187.37
T_{17}	209.61	217.13	213.37	35.13	37.61	36.37	186.94	190.71	188.83
T_{18}	206.45	213.90	210.18	33.55	36.04	34.79	188.45	195.22	191.84
S.Em±	1.68	2.57	2.17	0.86	0.78	0.82	1.73	1.86	1.80
C.D. at 5%	NS	NS	6.12	NS	2.25	2.32	NS	NS	5.06
Interaction: YX T									
S.Em±			1.51			0.61			0.92
C.D. at 5%			4.28			NS			NS

Table 5: Effect of organic and inorganic sources of nutrients on increase in available nitrogen, phosphorus and potassium (%) of garden pea in soil

Treatments	Increase in available nitrogen (%) in soil			Increase in available phosphorus (%) in soil			Increase in available potassium (%) in soil		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1	2.22	3.53	2.87	1.83	5.76	3.79	0.22	2.58	1.40
T_2	4.72	6.05	5.38	3.79	5.76	4.78	1.90	3.77	2.84
T_3	2.52	3.98	3.25	2.16	2.69	2.42	0.43	3.13	1.78
T_4	3.92	5.08	4.50	2.32	2.59	2.46	0.58	2.78	1.68
T_5	3.99	4.94	4.47	2.53	4.45	3.49	1.85	1.94	1.89
T_6	3.42	6.55	4.98	1.76	5.44	3.60	0.98	2.96	1.97
T_7	0.72	4.15	2.43	3.59	11.90	7.75	1.35	2.65	2.00
T_8	1.98	3.87	2.93	5.35	7.74	6.54	1.36	2.58	1.97
T_9	1.04	3.24	2.14	4.60	9.46	7.03	1.36	2.50	1.93
T_{10}	2.59	2.85	2.72	7.48	7.68	7.58	1.38	2.76	2.07
T_{11}	0.40	0.84	0.62	2.69	6.35	4.52	1.39	3.72	2.56
T_{12}	1.49	1.69	1.59	2.41	5.12	3.77	1.56	3.52	2.54
T_{13}	0.28	2.86	1.57	5.51	6.26	5.89	1.39	3.74	2.56
T_{14}	0.75	2.51	1.63	3.50	7.23	5.36	1.41	3.73	2.57
T_{15}	3.87	3.94	3.90	7.39	11.68	9.53	1.38	3.79	2.58
T_{16}	3.03	5.22	4.13	6.93	8.14	7.53	1.40	3.76	2.58
T_{17}	4.01	3.04	3.53	9.17	10.88	10.03	1.91	2.50	2.21
T_{18}	3.32	4.31	3.81	8.23	12.61	10.42	1.40	4.05	2.73
S.Em±	1.14	1.24	1.19	1.09	1.75	1.46	0.60	0.77	0.69
C.D. at 5%	NS	NS	3.36	3.12	5.04	4.11	NS	NS	NS
Interaction: YX T									
S.Em±			0.79			1.44			0.51
C.D. at 5%			2.25			NS			NS

The interaction between year and treatment was found non-significant and showed inconsistency of treatments on increase in available potassium (%) in soil.

Similar results were obtained by Gopinath *et al*. (2008), Jaipaul *et al.* (2011) [8], Khanday *et al*. (2012) [10] in garden pea and Singh *et al*. (2014) [17] in field pea.

The judicious use of organic and inorganic sources of nutrients in garden pea leads to increase the macronutrient status of soil after harvesting and increase in available nitrogen, phosphorus and potassium of soil.

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