Nutrient Release Pattern and Soil Enzyme Activities of Calcareous Soil As Influenced by PROM

ABSTRACT

A study was conducted at Post Graduate Laboratory, Division of Soil Science, College of Agriculture, Pune to study the nutrient release pattern and soil enzyme activities of calcareous soil as influenced by various levels of phosphorus using organic and inorganic sources. The experiment was conducted in randomized block design with seven treatments replicated three times. The treatments comprised as T_1- Absolute control, T_2 - RDF (50:75:45 N: P_2O_5:K_2O kg ha^{-1}) through DAP, T_3 - RDF (50:75:45 N: P_2O_5: K_2O kg ha^{-1}) through SSP, T_4- 25 % P_2O_5 through PROM, T_5- 50% P_2O_5 through PROM, T_6 -75% P_2O_5 through PROM and T_7 -100% P_2O_5 through PROM and RDF of soybean was used for incubation. This research aimed to understand performance of varying levels of P_2O_5 influencing nutrient cycling and soil properties in calcareous soils. The study demonstrated that applying 100% P_2O_5 through Phosphate Rich Organic Manure (PROM) significantly improved soil poperties, by reducing soil pH and calcium carbonate, increasing organic carbon, and enhancing the availability of macronutrients (nitrogen, phosphorus, potassium) and micronutrients (iron, manganese, zinc, copper). Enzyme activities, including urease, dehydrogenase and alkaline phosphatase were improved in calcareous soils, correlating positively with nutrient availability, particularly with phosphorus and micronutrients such as iron and manganese. PROM application was more effective than chemical fertilizers in promoting nutrient mobilization and improving soil enzyme activity over a 120-day incubation period. Strong correlations were observed between enzyme activity and micronutrient availability, especially in treatments receiving 100% P_2O_5 through PROM, indicating its potential to enhance both nutrient cycling and soil fertility.

Keywords: PROM, incubation, nutrient release, enzyme activities and correlation

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1. INTRODUCTION

Phosphorus (P) is the second most essential macronutrient for plants, after nitrogen (Reddy *et al*.,2004)., and is crucial for root development, nodulation, nitrogen fixation, and various physiological functions such as energy transfer, cell division, and photosynthesis. However, in calcareous and alkaline soils, phosphorus availability is limited due to its fixation with calcium, iron, and aluminium, leading to poor plant uptake. Lack of phosphorus in calcareous and alkaline soils is a major global problem. In calcareous/alkaline soils, phosphorus availability to plant roots is restricted by its reduced mobility in soils and higher fixation (Shen *et al*., 2011). Phosphorus solubilizing microorganisms (PSB) and soil enzymes like phosphatases play a critical role in converting immobilized P into plant-available forms, especially in phosphorus-deficient soils. Non-traditional phosphorus fertilizers like Phosphate Rock (PR) and Phosphate Rich Organic Manure (PROM) offer sustainable alternatives to conventional chemical fertilizers by maintaining phosphorus availability for longer periods and enhancing crop productivity. PROM, in particular, has been recognized as an eco-friendly solution, approved by the Government of India, to improve phosphorus availability in calcareous soils. Despite India's significant rock phosphate reserves, only a fraction is suitable for fertilizer production. Therefore, further research on optimizing PROM's production and its effects on phosphorus availability in different soil types is essential for improving phosphorus use efficiency and sustainable agriculture.

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2. MATERIALS METHODS

An incubation study was conducted in PG Laboratory, Division of Soil Science, College of Agriculture, Pune. The soil samples for the incubation study were obtained from the PG Instructional Farm at the College of Agriculture, Pune. The soil samples were analyzed for their chemical properties using standard analytical methods.

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Or applied treatments individually …………

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The PROM was prepared at Vermicompost Yard, Division of Soil Science, College of Agriculture, Pune. The recommended dose of fertilizer for soybean (50:75:45 kg ha^{-1} of N, P_2O_5 and K_2O) was applied except to absolute control. The recommended dose of phosphorus was supplied through various sources such as PROM as an organic source and DAP and SSP as an inorganic source. The nitrogen and potassium were supplied through urea and muriate of potash, respectively. The proximate analysis of PROM was done before start of incubation. Plastic bowls of 2 kg capacity were filled with 1 kg (2 mm sieved) soil in one hundred twenty six bowls for seven treatments, three replications and six stages of sampling. The moisture was maintained at field capacity. The soil was mixed thoroughly with PROM, DAP and SSP as per treatments. The set of experiment was incubated for 0, 15, 30, 60, 90 and 120 days in three replications each. The incubation study was conducted by using factorial completely randomized design. (Panse and Sukhatme, 1985).

Table 1 Proximate analysis of PROM

Sr. No	Parameters	Unit	PROM

1	pH (1:10)	-	7.18
2	EC	(dS m^{-1})	1.74
3	Moisture	(%)	24.02
4	Organic Carbon	(%)	21.06
5	Total N	(%)	0.78
6	Total P	(%)	14.57
7	Total K	(%)	0.37
8	Total Fe	(mg kg^{-1})	12.70
9	Total Mn	(mg kg^{-1})	0.67
10	Total Zn	(mg kg^{-1})	2.69
11	Total Cu	(mg kg^{-1})	0.46
12	C:N ratio	-	24:1
13	C:P ratio	-	1.44:1

3. RESULTS AND DISCUSSION

3.1 Chemical properties of soil as influenced by levels of PROM

Soil calcareousness influenced pH, which decreased from 8.22 at 0 days to 8.13 over 120 days. Treatments with 100% and 75% P_2O_5 through PROM significantly lowered soil pH, with 100% P_2O_5 showing the greatest reduction. Organic matter played an important role in reducing the pH of both soils as negative correlation between pH and organic matter is reported by Talashilkar *et al*. (2000). Soil calcareousness increased EC at 0 and 15 days (0.39 dS m^{-1}), with no significant impact from P_2O_5 levels initially. By 30 days, RDF through SSP and 100% P_2O_5 recorded higher EC (0.38 dS m^{-1}). At 60 days, RDF through DAP and SSP reported the higher EC (0.46 dS m^{-1}), followed by 100% and 75% P_2O_5 through PROM. At 90 and 120 days, RDF through DAP maintained the highest EC (0.49 and 0.51 dS m^{-1}).

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At 0 days, P_2O_5 levels had no effect on soil organic carbon. From 15 days onward, 100% P_2O_5 through PROM significantly increased organic carbon, peaking at 0.75% by 120 days, comparable to 75% P_2O_5 through PROM throughout and 50% P_2O_5 at 15 and 90 days.

Table: 2 Influence of soil calcareousness and PROM on periodical changes in pH and Electrical Conductivity of soil

	Days After Incubation											
	pH						EC (dSm^{-1})					
Levels	0	15	30	60	90	120	0	15	30	60	90	120

of P_2O_5												
B_1	8.23	8.22	8.21	8.17	8.17	8.15	0.39	0.38	0.35	0.39	0.40	0.41
B_2	8.21	8.20	8.18	8.16	8.15	8.13	0.40	0.41	0.37	0.46	0.49	0.51
B_3	8.22	8.21	8.19	8.17	8.17	8.14	0.39	0.41	0.38	0.46	0.48	0.49
B_4	8.24	8.23	8.21	8.19	8.16	8.15	0.38	0.38	0.36	0.40	0.41	0.43
B_5	8.21	8.20	8.19	8.16	8.14	8.13	0.39	0.39	0.37	0.41	0.43	0.44
B_6	8.20	8.19	8.18	8.13	8.13	8.12	0.39	0.39	0.37	0.43	0.44	0.46
B_7	8.20	8.19	8.17	8.12	8.12	8.10	0.38	0.40	0.38	0.44	0.46	0.48
Mean	**8.22**	**8.20**	**8.19**	**8.16**	**8.15**	**8.13**	**0.39**	**0.39**	**0.37**	**0.43**	**0.44**	**0.46**
C.D. at (5%)	NS	0.009	0.012	0.013	0.009	0.015	NS	NS	0.033	0.033	0.033	0.03
SE(m)$\pm$	0.007	0.003	0.004	0.004	0.003	0.005	0.005	0.01	0.01	0.01	0.011	0.01

The application of rock phosphate with organic materials in gypsiferous soils increased the organic carbon and phosphorous status of soil. (Muhawish and Al-Kafaje, 2017). At 0 and 15 days, calcareous soil recorded high $CaCO_3$ (12.44% and 12.25%), which was remained unaffected by PROM treatments. From 30 days onward, 100% P_2O_5 through PROM significantly reduced $CaCO_3$ levels, reaching 11.42% at 30 days and 11.25% at 60 days, and at par with 75% and 50% P_2O_5 through PROM treatments. During 90 and 120 days, $CaCO_3$ content was reduced, with 100% P_2O_5 through PROM achieving the lower levels (10.58% and 9.80%), comparable to the 75% and 50% treatments. The reactivity of rock phosphate increases as carbonates are converted into mineral apatite was recorded by Qureshi *et al*. (1999).

Table: 3 Influence of soil calcareousness and PROM on periodical changes in Organic Carbon and Calcium Carbonate Content of soil

	Days After Incubation											
	Organic carbon (%)						**Calcium carbonate (%)**					
Levels of P_2O_5	**0**	**15**	**30**	**60**	**90**	**120**	**0**	**15**	**30**	**60**	**90**	**120**
B_1	0.55	0.55	0.55	0.58	0.63	0.64	12.42	12.42	12.45	12.37	12.30	12.24
B_2	0.55	0.56	0.67	0.59	0.65	0.66	12.46	12.42	12.33	12.23	11.81	10.75
B_3	0.57	0.57	0.65	0.62	0.66	0.68	12.44	12.33	12.36	12.08	11.75	10.58
B_4	0.57	0.57	0.56	0.64	0.68	0.69	12.44	12.30	12.28	11.82	11.33	10.50
B_5	0.56	0.58	0.59	0.66	0.70	0.71	12.42	12.17	12.15	11.33	11.00	10.08
B_6	0.56	0.59	0.61	0.69	0.71	0.73	12.46	12.08	11.91	11.31	10.75	10.07
B_7	0.57	0.60	0.63	0.70	0.73	0.75	12.42	12.00	11.42	11.25	10.58	9.80

Mean	0.56	0.58	0.61	0.64	0.68	0.70	12.44	12.25	12.13	11.77	11.36	10.58
C.D. at (5%)	NS	0.03	0.032	0.023	0.021	0.027	NS	NS	0.472	0.48	0.455	0.615
SE(m)±	0.008	0.01	0.01	0.007	0.007	0.009	0.149	0.176	0.151	0.154	0.146	0.197

3.2 Macronutrient and Micronutrient release in calcareous soil as influenced by levels of PROM

3.2.1 Macronutrients

The available nitrogen from 0 to 120 days was increased to 145.42 kg ha^{-1} from 112.81 kg ha^{-1}. Application of RDF through DAP consistently recorded higher nitrogen, rising from 143.76 kg ha^{-1} at 15 days to 158.97 kg ha^{-1} at 120 days. Pandey *et al.* (2024) reported that ammonical nitrogen, the first available organic form of nitrogen for plants and microorganisms, was significantly higher over the incubation study compared to the control.

At 0 days, calcareous soil recorded available phosphorus 11.89 kg ha^{-1}, with no significant treatment effects. By 15 days, RDF through DAP showed the highest phosphorus (12.18 kg ha^{-1}). From 30 to 120 days, 100% P_2O_5 through PROM consistently achieved the highest phosphorus levels, peaking at 16.33 kg ha^{-1}, similar to 75% P_2O_5 through PROM. Kumar *et al.* (2015) reported that the increased availability of phosphorus in organically amended soils results from a large reduction in phosphorus sorption.

At 0 and 15 days, calcareous soil had high potassium (483.06–483.89 kg ha^{-1}), which was unaffected by PROM treatments. From 30 to 120 days, potassium levels increased, with RDF through DAP consistently achieving the highest values, peaking at 502.44 kg ha^{-1} by 120 days. K content is more readily available in manured soil than in unmanured soil was also observed by Brar *et al.* (2015).

Table: 4 Influence of soil calcareousness and PROM on release of Nitrogen and Phosphorus in soil

	Days After Incubation	
	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})

Levels of P_2O_5	0	15	30	60	90	120	0	15	30	60	90	120
B_1	112.89	122.36	116.63	118.99	120.38	123.61	11.92	11.71	11.95	12.17	12.43	12.68
B_2	113.71	143.76	145.53	146.28	152.23	158.97	11.90	12.18	12.67	13.02	15.71	16.11
B_3	112.59	136.31	142.57	143.29	147.77	152.55	11.91	12.14	12.37	12.48	14.97	15.28
B_4	112.89	123.52	126.29	137.81	139.35	140.38	11.91	11.74	12.22	12.25	12.97	14.03
B_5	112.49	125.73	137.81	139.35	140.38	142.80	11.92	11.85	12.27	12.37	13.34	14.78
B_6	112.94	128.23	139.35	140.38	142.80	143.29	11.91	11.95	12.99	14.28	15.76	16.31
B_7	112.13	129.93	140.29	142.80	150.22	156.34	11.76	12.12	13.00	14.30	15.84	16.33
Mean	**112.81**	**129.98**	**135.50**	**138.42**	**141.87**	**145.42**	**11.89**	**11.95**	**12.50**	**12.98**	**14.43**	**15.07**
C.D. at (5%)	NS	3.952	5.203	0.532	1.049	0.503	NS	0.029	0.02	0.038	0.193	0.052
SE(m)$\pm$	3.831	1.268	1.67	0.171	0.337	0.162	0.148	0.009	0.006	0.012	0.062	0.017

3.2.2 Micronutrients

The iron at 0 days of incubation was 2.90 mg kg^{-1} and from 15 days onward, application of 100% P_2O_5 through PROM improved it to 4.02 mg kg^{-1} by 120 days, which was at par with 75% P_2O_5 through PROM. Safarzadeh *et al.* (2018) reported that the release of iron from soil samples following the addition of organic compounds increased over time. The manganese in calcareous soil increased from 1.99 mg kg^{-1} at 0 days to 2.54 mg kg^{-1} at 120 days with 100% P_2O_5 through PROM, and at par with 75% P_2O_5 through PROM at all stages. The increased in available manganese after first week of incubation period might be due to reduction of Mn^{3+} to Mn^{2+} ion because decrease in organic and oxide surfaces during this period with advancement of incubation period (Mandal and Mitra, 1982). Zinc content in calcareous soil increased from 0.41 mg kg^{-1} at 0 days to 0.93 mg kg^{-1} at 120 days with 100% P_2O_5 through PROM, consistently higher than other treatments. The increased in available zinc supplying capacity was significantly higher in organic manure treated soil compared to untreated soil was also reported by Motaghian and Hosseinpur (2017).

Table: 5 Influence of soil calcareousness and PROM on Potassium and Iron in soil

	Days After Incubation											
	Potassium (kg ha^{-1})						**Iron (mg kg^{-1})**					
Levels of P_2O_5	**0**	**15**	**30**	**60**	**90**	**120**	**0**	**15**	**30**	**60**	**90**	**120**

B_1	482.05	480.60	482.21	483.30	486.34	486.23	2.90	2.89	2.89	2.89	2.89	2.92
B_2	484.65	488.83	490.36	493.89	499.02	502.44	2.92	2.90	2.91	2.92	2.93	2.94
B_3	484.17	486.34	489.76	493.76	496.13	500.09	2.91	2.90	2.90	2.90	2.91	2.92
B_4	481.73	481.73	484.41	486.34	487.43	488.83	2.91	2.90	2.95	3.01	3.11	3.47
B_5	482.31	482.21	486.34	487.43	488.83	490.12	2.91	2.91	2.99	3.05	3.18	3.68
B_6	482.31	483.24	487.43	488.83	491.03	491.26	2.90	2.93	3.04	3.15	3.35	4.01
B_7	484.17	484.29	488.83	491.26	495.74	498.44	2.90	2.94	3.05	3.16	3.36	4.02
Mean	**483.06**	**483.89**	**487.05**	**489.26**	**492.08**	**493.92**	**2.91**	**2.91**	**2.96**	**3.01**	**3.11**	**3.42**
C.D. at (5%)	NS	NS	0.896	0.89	1.022	0.871	NS	0.029	0.034	0.016	0.011	0.009
SE(m) ±	4.803	3.423	0.287	0.286	0.328	0.28	0.023	0.009	0.011	0.005	0.003	0.003

Table: 6 Influence of soil calcareousness and PROM on Manganese and Zinc in soil

	Days After Incubation											
	Manganese (mg kg^{-1})						**Zinc (mg kg^{-1})**					
Levels of P_2O_5	**0**	**15**	**30**	**60**	**90**	**120**	**0**	**15**	**30**	**60**	**90**	**120**
B_1	1.99	1.98	1.99	1.99	2.00	2.03	0.41	0.41	0.40	0.41	0.42	0.41
B_2	2.01	2.00	2.00	2.00	2.01	2.01	0.42	0.43	0.42	0.43	0.43	0.43
B_3	2.01	1.98	2.01	2.01	1.99	2.01	0.41	0.42	0.41	0.42	0.42	0.42
B_4	1.97	1.98	2.02	2.03	2.06	2.24	0.41	0.46	0.47	0.52	0.62	0.75
B_5	1.98	1.99	2.03	2.06	2.25	2.50	0.41	0.49	0.48	0.57	0.78	0.90
B_6	1.99	2.02	2.04	2.07	2.34	2.53	0.41	0.51	0.55	0.68	0.79	0.91
B_7	2.00	2.03	2.05	2.08	2.35	2.54	0.40	0.52	0.56	0.69	0.80	0.93
Mean	**1.99**	**2.00**	**2.02**	**2.04**	**2.20**	**2.27**	**0.41**	**0.46**	**0.47**	**0.53**	**0.61**	**0.68**
C.D. at (5%)	NS	0.007	0.008	0.007	0.011	0.01	NS	0.026	0.019	0.063	0.061	0.035
SE(m)±	0.008	0.002	0.002	0.002	0.004	0.003	0.005	0.008	0.006	0.02	0.02	0.011

Copper content in calcareous soil increased from 1.99 mg kg^{-1} at 0 days to 3.02 mg kg^{-1} at 120 days with 100% P_2O_5 through PROM, showing higher levels than other treatments. Copper release through the mineralization of organic carbon from organic waste was responsible for the increase in copper availability in soil was reported by Tella *et al.* (2016).

Table 7 Influence of soil calcareousness and PROM on copper in soil

Days After Incubation						
	Copper (mg kg^{-1})					
Levels of P_2O_5	**0**	**15**	**30**	**60**	**90**	**120**
B_1	2.10	2.09	2.10	2.11	2.10	2.10
B_2	2.10	2.15	2.12	2.10	2.13	2.11
B_3	2.10	2.12	2.11	2.10	2.12	2.10
B_4	2.09	2.08	2.14	2.22	2.28	2.41
B_5	2.10	2.09	2.14	2.28	2.94	2.86
B_6	2.09	2.13	2.20	2.74	2.96	2.99
B_7	2.10	2.14	2.22	2.75	2.97	3.02
Mean	**1.99**	**2.11**	**2.15**	**2.33**	**2.50**	**2.51**
C.D. at (5%)	NS	0.021	0.06	0.105	0.075	0.111
SE(m)$\pm$	0.019	0.007	0.019	0.034	0.024	0.036

3.3 Soil enzyme activities as influenced by levels of PROM in highly calcareous and low calcareous soils.

3.3.1 Urease Activity

Urease activity at 120 days was observed higher with application of 100% P_2O_5 through PROM (47.28 µg NH_4^+-N g^{-1} hr^{-1}), and at par with application of 75% and 50% P_2O_5 through PROM treatments. Srinivasan *et al.* (2016) reported that the addition of organic material is good source of energy and carbon to heterotrophs causing an increase in enzymatic activity and a rise in population.

3.3.2 Dehydrogenase Activity

At 120 days, 100% P_2O_5 through PROM showed the higher dehydrogenase activity (16.26 µg TPF g^{-1} 24 hr^{-1}), which was at par with 75% P_2O_5 through PROM and RDF through DAP. These results were in close confirmation with Rai and Yadav (2011).

Table 8 Influence of soil calcareousness and PROM on Urease, dehydrogenase and Alkaline Phosphatase activity of soil

Days After Incubation						
	urease		Dehydrogenase		Alkaline phosphatase	
Levels of P_2O_5	**0**	**120**	**0**	**120**	**0**	**120**

B_1	33.06	33.01	14.34	14.52	9.63	12.11
B_2	33.07	35.21	14.36	16.06	9.69	14.24
B_3	33.09	36.16	14.46	15.99	9.69	14.66
B_4	33.08	39.77	14.34	15.84	9.63	15.35
B_5	33.06	46.97	14.31	15.95	9.67	17.03
B_6	33.05	47.05	14.24	16.19	9.61	17.70
B_7	33.09	47.28	14.35	16.26	9.67	17.72
Mean	**33.07**	**40.78**	**14.34**	**15.83**	**9.66**	**15.55**
C.D. at (5%)	NS	1.439	NS	0.209	NS	0.406
SE(m)±	0.067	0.462	0.114	0.067	0.09	0.13

3.3.3 Alkaline Phosphatase Activity

Alkaline phosphatase activity at 120 days was highest with 100% P_2O_5 through PROM (17.72 µg PNP g^{-1} hr^{-1}), comparable to 75% P_2O_5 through PROM. Waldrip *et al.* (2012) reported that organic manure may enhance phosphatase activity by providing soil microbes with carbon, nitrogen, and phosphorus.

4. CONCLUSION

The study revealed that application of 100 % P_2O_5 using PROM is beneficial for improving the release of macro and micronutrients in calcareous soil with significant reduction in calcium carbonate and higher enzymatic activities as urease, dehydrogenase and alkaline phosphatase.

Comment [D7]: Add one or two more sentences in conclusion

References

Comment [D8]: Arrange and check all the references according to journal requirement ....

1. Brar, B.S., Singh, J., Singh, G. and Kaur, G. (2015). Effects of long-term application of inorganic and organic fertilizers on soil organic carbon and physical properties in maize–wheat rotation. Agronomy, 5(2), 220-238.
2. Hapse, D.G. (1993). Organic farming in the light of reduction in use of chemical fertilizers. Proceedings of 43rd Annual Deccan Sugar Technology Association, Pune, Part, 1.
3. Kaptanoğlu Berber, A.S., Farasat, S. and Namli, A. (2014). Afforestation effects on soil biochemical properties. Eurasian Journal of Forest Science, 1,25-34.
4. Kumar, S., Srivastava, A. and Gupta, A. (2015). Effect of organic amendments on availability of different chemical fractions of phosphorus. Agricultural Science Digest-A Research Journal, 35(2), 83-88.

5. Mandal, L.N. and Mitra, R.R. (1982). Transformation of iron and manganese in rice soils under different moisture regimes and organic matter applications. Plant and Soil, 69,45-56.
6. Manjaiah, K.M., Singh, D. (2001). Soil organic matter and biological properties after 26 years of maize-wheat-cowpea cropping as affected by manure and fertilization in a cambisol in semiarid region of India. Agriculture Ecosystem and Environment. 86,155-162.
7. Motaghian, H.R. and Hosseinpur, A.R. (2017). The effects of cow manure and vermicompost on availability and desorption characteristics of zinc in a loamy calcareous soil. Communications in Soil Science and Plant Analysis, 48(18),2126-2136.
8. Muhawish, N.M. and Al-Kafaje, R.K. (2017). Soil organic carbon and phosphorus status after combined application of phosphate rock and organic materials in a gypsiferous soil. Iraqi Journal of Agricultural Sciences, 48.
9. Pandey, R., Bargali, S.S., Bargali, K., Karki, H. and Chaturvedi, R.K. (2024). Dynamics of nitrogen mineralization and fine root decomposition in sub-tropical Shorea robusta Gaertner f. forests of Central Himalaya, India. Science of The Total Environment, 921,170896.
10. Panse V.G., Sukhatme P.V. (1985). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi, India. 1967,272-279.
11. Qureshi, A.A., Narayanasamy, G., Chhonkar, P.K. and Balasundaram, V.R. (2005). Direct and residual effect of phosphate rocks in presence of phosphate solubilizers and FYM on the available P, organic carbon and viable counts of phosphate solubilizers in soil after soybean, mustard and wheat crops. **53**(1),97-100.
12. R. Srinivasan, K. Jeevan Rao, S. K. Reza, Shelton Padua, D. Dinesh and S. Dharumarajan. (2016). Influence of Inorganic Fertilizers and Organic Amendments on Plant Nutrients and Soil Enzyme Activities under Incubation. International Journal of Bio-resource and Stress Management, 7(4), 924-932.
13. Rai, T.N. and Yadav, J. (2011). Influence of inorganic and organic nutrient sources on soil enzyme activities. *Journal of the Indian society of Soil Science*, 59(1),54-59.
14. Reddy, A.R., Chaitanya, K.V. and Vivekanandan, M. (2004). Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. Journal of plant physiology, 161(11),1189-1202.

15. Roy, S. and Kashem, M.A., (2014). Effects of organic manures in changes of some soil properties at different incubation periods. *Open Journal of Soil Science,* 4(3),6.
16. Safarzadeh, S., Kasmaei, S.L. and Ahmad, A.Z. (2018). Effect of organic substances on iron-release kinetics in a calcareous soil after basil harvesting. Journal of the Serbian Chemical Society, 83(7-8),941-952.
17. Shen, J., Yuan, L., Zhang, J., Li, H., Bai, Z., Chen, X., Zhang, W. and Zhang, F. (2011). Phosphorus dynamics: from soil to plant. Plant physiology, 156(3),997-1005.
18. Talashilkar, S.C., Sawant, D.S., Dhamapurkar, V.B. and Savant, N.K. (2000). Yield and nutrient uptake by rice as influenced by integrated use of calcium silicate slag and UB-DAP in acid lateritic soil. Journal of the Indian Society of Soil Science, 48(4),847-849.
19. Tarafdar, J.C. and Jungk, A. (1987). Phosphatase activity in the rhizosphere and its relation to the depletion of soil organic phosphorus. Biology and Fertility of Soils, 3,199-204.
20. Tella, M., Bravin, M.N., Thuriès, L., Cazevieille, P., Chevassus-Rosset, C., Collin, B., Chaurand, P., Legros, S. and Doelsch, E. (2016). Increased zinc and copper availability in organic waste amended soil potentially involving distinct release mechanisms. Environmental pollution, 212,299-306.
21. Waldrip, H.M., He, Z. and Griffin, T.S. (2012). Effects of organic dairy manure on soil phosphatase activity, available soil phosphorus, and growth of sorghum-sudangrass. Soil science, 177(11),629-637.