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Different organic manures and inorganic sources of phosphorus as influenced on nutrient availability in calcareous soil

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Abstract
A laboratory incubation experiment of 90 days was carried out at Division of Soil Science and Agricultural Chemistry, RCSM College of agriculture, Kolhapur under MPKV, Rahuri, during 2021-22 to study the effect of organic manures on chemical properties *viz*. pH, EC, Organic carbon, $CaCO_3$, Available N, Available P, Available K and micronutrients DTPA Fe, Zn, Mn and Cu. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications and fifteen treatments combination of organic and inorganic fertilizers. The treatment comprised of Control, FYM, VC, POL, PMC, SSP, DAP, SSP+ FYM, SSP +VC, SSP + POL, SSP + PMC, DAP+ FYM, DAP+VC, DAP+ POL, DAP+ PMC. The results indicated that incorporation of organic manures and inorganic fertilizers to soil significantly influenced soil properties. Among organic manures the treatment receiving PMC recorded significantly lowest pH (8.20). However, it was at par with POL (8.22). The significantly highest EC was recorded with the application of all organic manures. The soil pH decreases whereas, the electrical conductivity increases due to application of organic manure alone or in combination with inorganic fertilizer. The organic carbon content in soil remains unaffected while the calcium carbonate level decreases gradually due to soil treatment with organic, inorganic or in combination. The soil nutrient status including major (N, P and K) and micronutrients (Fe, Zn, Mn and Cu) improved due to organic manure and combination treatments. DAP as an inorganic source of phosphorus was beneficial in increasing availability of nitrogen, potassium, zinc and manganese, iron alone or in combination with PMC and POL.

Keywords: Organic manures, inorganic fertilizers, phosphorus, calcareous soil

Introduction
The estimated area of calcareous soils in India is about 228.8 m ha, contributing over 69.4% of total geographical area of the country which covers around 38 out of 60 agro-ecological subregions. Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and part of Madhya Pradesh and Bihar are the major states occurring calcareous soils (Pal *et al*. 2000) [14]. Calcareous soil in different agro-ecological subregions indicates that $CaCO_3$ is present not only in the soils of arid and semi-arid climatic regions but also in soils of humid and per humid regions (Pal *et al*. 2000) [14]. In the regions having dry climates, presence of $CaCO_3$ is very common. The formation of calcium carbonate in soils is a vital pedogenic process in many arid and semi-arid parts of the world and in the sub-continent of India (Pal *et al*. 2000) [14]. However, presence of $CaCO_3$ in arid soil of Rajasthan is predominantly attributed to a pedogenic process that redistributed the calcareous material in soils (Choudhari, 1994) [3]. Calcareous soils have mostly often more than 15% $CaCO_3$ in various forms viz; powdery, nodules, crusts etc. Soil organic amendments can also indirectly increase in soil P availability by increasing P mobilisation and decreasing P fixation through the production and release of organic acids during decomposition, stimulation of microbial activity or blocking of P fixing sites on soil particles. Organic acids released from crop residues or organic matter 3 can increase P concentration by competing for P sorption sites (Iyamuremye *et al*. 1996) [7] reduces the precipitation of P. Organic manures like FYM, vermicompost, press mud, poultry manure not only solubilisation of added inorganic fertilizers single superphosphate, diammonium phosphate, but also improve soil aggregation, increase microbial biomass, its activity and

formation of crumby soil structure and maximise the water holding capacity of soil. The application of organic material is fundamentally important which supply various kinds of plant nutrients including micronutrient, improve soil physical and chemical properties and hence maintain nutrient holding and buffering capacity and consequently enhance microbial activity. Soil application of organic amendments is management strategy to counteract the progressive loss of organic matter. The addition of organic amendments may improve soil physico-chemical, biochemical and microbiological properties involved in biogeochemical cycles and thus positively influence plant productivity parameters. Among the main benefits attributed to the use of organic amendments are an improved soil aggregation and reduced bulk density, greater water holding capacity, stabilization of pH, increased CEC and organic matter. Manures have long been considered a desirable soil amendment and report of its effect on soil properties are numerous. To meet crop nutrient requirements, knowledge of soil characteristics following organic manure application is needed. Thus, it is pertinent to observe some changes in soil properties with time due to application of organic material. Hence, study will be carried out to observe the changes in pH, electrical conductivity, organic carbon content and N, P, K content of soil incorporated with FYM, poultry manure, vermicompost, goat manure, press mud compost and urban compost in laboratory incubation condition.

Materials and Methods

Soil

The bulk soil samples were collected having depth 0-30 cm belongs to calcareous soil from Block No. 47 of Horticulture Farm, Division of Horticulture, Rajarshee Chhatrapati Shahu Maharaj, College of Agriculture, Kolhapur (M.S.). The soil samples were collected, air dried, grounded with wooden mortar and pestle to passed through 2.0 mm sieve. The initial soil chemical properties were analysed by adopting standard methods of soil analysis. The initial soil chemical properties are given in table 1.

Organic manures

The organic sources FYM, poultry manure and vermicompost were collected from Dairy Farm, Division of Dairy Science and Agronomy Farm, Division of Agronomy of Rajarshee Chhatrapati Shahu Maharaj, College of Agriculture, Kolhapur. While press mud compost was collected from Shree Datta Shetkari Sahakari Sugar factory, Shirol, Tal. Hatkanagale, Kolhapur District (M.S.).

Soil analysis

The collected soil samples were analysed for initial physio-chemical properties by adopting standard analytical methods. Standard methods were used for chemical analysis pH (1:2.5) Potentiometry by Jackson (1973) [8], EC (1:2.5) Conductometry by Jackson (1973) [8], Organic carbon by Wet oxidation method Nelson and Sommer (1982) [13], $CaCO_3$ Acid neutralization by Piper (1966) [15], Available Nitrogen Alkaline Permanganate by Subbiah and Asija (1956) [20], Available Phosphorous 0.5M $NaHCO_3$ (pH 8.5) by Olsen *et al*. (1954) [21], Available Potassium N- NH_4OAc extractant (Flame photometry) by Hanway and Heidal (1952) [6], DTPA extractable Micronutrient (Fe, Mn, Zn, Cu) Atomic absorption Spectrophotometry by Lindsay and Norvell (1978) [9].

Table 1: Initial chemical properties of experimental of soil

Sr. No	Parameters	Values
1.	pH (1:2.5)	8.3
2.	EC (dS m^{-1})	0.52
3.	Organic carbon (%)	0.48
4.	$CaCO_3$ (%)	12.2
5.	Available N (kg ha^{-1})	157
6.	Available P (kg ha^{-1})	14.8
7.	Available K (kg ha^{-1})	361
8.	Fe (mg ha^{-1})	3.40
9.	Zn (mg ha^{-1})	0.48
10.	Mn (mg ha^{-1})	5.20
11.	Cu (mg ha^{-1})	6.40

Organic Manure Analysis

The well decomposed organic manures i.e. FYM, vermicompost, poultry manure and press mud compost were air dried under shed. Gently grounded organic manures were passed through 2.0 mm sieve and analysed for pH, EC, total N, P, K, micronutrients (Fe, Mn, Cu, Zn) and organic carbon by adopting appropriate standard methods.

Results and Discussion

Effect of organic manures on soil pH

The soil pH as influenced by application of different organic manures is presented in table 3. Among organic manures the treatment receiving PMC recorded significantly lowest pH (8.20) over all the other organic sources however, it was at par with POL (8.22) after completion of incubation period The reduction in soil pH was found in either organic or combine treatment of organic and inorganic. This decrease in soil pH could be attributed to release of weak acid during decomposition. Naim *et al.* (2015) [12] reported reduction in soil pH due to application of chemical fertilizer with organic amendments. They attributed the reduction in soil pH to development of acidity due to decomposition of organic manure and consequently increases the P mineralization during incubation period. Abbasi *et al.* (2015) [1] indicated reduction in soil pH due to combine treatments of SSP and DAP with organic manures. The soil pH reduction due to organic amendment was also reported by Roy and Kashem (2014) [16]. Similar results are also in agreement to Dinesh *et al.* (2010) [4].

Table 2: pH of soil after completion of incubation period

pH (1:2.5)						
Sources	Control	FYM	VC	POL	PMC	Chem. fert
Control	8.30	8.24	8.26	8.25	8.22	8.25
SSP	8.29	8.28	8.21	8.23	8.22	8.25
DAP	8.18	8.17	8.22	8.20	8.16	8.19
Org. manures	8.26	8.23	8.23	8.22	8.20	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.004	0.01				
Organic Manure	0.006	0.02				
Chem. fert. x OM	0.011	0.03				
Initial value-8.3						

Effect of organic manures on soil EC

Unlike soil pH the EC of soil was found to be increased over initial value due to different organic amendments, chemical fertilizer and in combination treatment as given in table 4.10. Among chemical fertilizers and organic manures despite numerical increase the electrical conductivity did not differ significantly due to application of different phosphorus sources. Among the combination of chemical fertilizer and organic manure SSP+VC and DAP + FYM i.e (0.54 dS m-1) showed significant increase in soil EC however, is at par over all other combinations. This could be attributed to release of salt from chemical as well as organic fertilizer during mineralization/decomposition process. The results are in close agreement with Naim *et al.* (2015) [12]. Increase in EC due to organic sources is also reported by Roy and Kashem (2014) [16] and Diwale *et al.* (2020) [5].

Table 3: Electrical conductivity of soil after completion of incubation period

EC (dS m^{-1})						
Sources	**Control**	**FYM**	**VC**	**POL**	**PMC**	**Chem. fert.**
Control	0.52	0.53	0.53	0.53	0.53	0.53
SSP	0.52	0.52	0.54	0.53	0.53	0.53
DAP	0.53	0.54	0.53	0.53	0.53	0.53
Org. manures	0.53	0.53	0.53	0.53	0.53	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.001	NS				
Organic Manure	0.001	NS				
Chem. fert. x OM	0.002	0.06				
Initial value-0.52						

Organic Carbon of Soil after Completion of Incubation Period

The soil organic carbon did not differ significantly due to application of different phosphorus sources and its combinations. Nonetheless, the soil organic carbon was found to be numerically higher in treatment receiving organic and combination treatments of organic and inorganic as compared to control and only inorganic treatment. The evidently show the role of organic in enhancing soil carbon due to microbial decomposition. The Similar results were observed by Roy and Kashem (2014) [16] and Soremi *et al.* (2017) [18].

Table 4: Organic carbon of soil after completion of incubation period

Organic carbon (%)						
Sources	**Control**	**FYM**	**VC**	**POL**	**PMC**	**Chem. fert.**
Control	0.47	0.51	0.48	0.48	0.51	0.49
SSP	0.48	0.48	0.52	0.48	0.49	0.49
DAP	0.53	0.53	0.49	0.49	0.54	0.52
Org. manures	0.49	0.51	0.50	0.48	0.51	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.014	NS				
Organic Manure	0.017	NS				
Chem. fert. x OM	0.030	NS				
Initial value-0.48						

Calcium Carbonate of Soil after Completion of Incubation Period

Among organic manures the treatment receiving calcium carbonate is significantly lowest in PMC (11.74%) over all other treatments. The interaction effect between the organic and inorganic sources was found to be significant after completion of incubation period. Among the different combination treatment, the treatment application of DAP+PMC showed significantly lowest calcium carbonate (11.20%) over all the other combination treatment. The reduction in calcium carbonate content due to organic and integrated treatments of organic and inorganic could be attributed to release of organic acid as the result of decomposition. In case of inorganic fertilizer acidification might be higher in case of DAP as compared to SSP. The strong relation between native $CaCO_3$ content and P mineralization has been exemplified by Asif *et al.* (2013) [2]. They stated that P adsorption increases with increase in $CaCO_3$ content in calcareous soil.

Table 5: Calcium carbonate of soil after completion of incubation period

$CaCO_3$ (%)						
Sources	**Control**	**FYM**	**VC**	**POL**	**PMC**	**Chem. fert.**
Control	12.15	11.89	12.11	12.12	11.81	12.02
SSP	12.26	12.10	12.15	12.19	12.21	12.18
DAP	12.09	11.75	11.88	11.80	11.20	11.74
Org. manures	12.17	11.91	12.04	12.04	11.74	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.04	0.12				
Organic Manure	0.05	0.15				
Chem. fert. x OM	0.09	0.26				
Initial value-12.2						

Available Nitrogen in Soil after Completion of Incubation Period

The available nitrogen was observed to be significantly affected by use of different organic manures. The significantly highest available nitrogen content was recorded in treatment of POL (163.01 kg ha^{-1}) followed by VC (161.97 kg ha^{-1}). The lowest nitrogen content in soil was observed in PMC (160.68 kg ha^{-1}). The combine effect of inorganic and organic sources of N was found to be significantly affecting the available nitrogen content in soil. The significant highest available N content was observed due to conjunct use of DAP+POL (171.49 kg ha^{-1}) over rest of the combinations however, it was followed by application of DAP+VC (168.85 kg ha^{-1}).

Soil Available Phosphorus after Completion of Incubation Period

The soil available phosphorus content due to application of only organic sources varied significantly with significantly highest available P content in PMC (15.12 kg ha^{-1}) over all the other sources however, it was followed by POL (14.82 kg ha^{-1}). The phosphorus was also found to be significantly influenced by conjunct use of inorganic and organic sources of phosphorus i n DAP + PMC (1 5. 3 2 kg ha^{-1}) followed by DAP + vermicompost (15.22 kg ha^{-1}).

Table 6: Available nitrogen of soil after completion of incubation period

		Avail. N	(kg ha^{-1})			
Sources	**Control**	**FYM**	**VC**	**POL**	**PMC**	**Chem. fert.**
Control	156.00	158.22	158.36	159.30	158.63	158.10
SSP	157.57	159.70	158.71	158.24	159.02	158.65
DAP	160.79	167.92	168.85	171.49	164.38	166.69
Org. manures	158.12	161.95	161.97	163.01	160.68	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.61	1.79				
Organic Manure	0.79	2.30				
Chem. fert. x OM	1.38	3.99				
Initial value-157						

Table 7: Available phosphorus of soil after completion of incubation period

Avail. P (kg ha^{-1})						
Sources	**Control**	**FYM**	**VC**	**POL**	**PMC**	**Chem.fert.**
Control	14.70	14.55	13.96	14.95	15.15	14.66
SSP	12.83	15.23	14.77	14.55	14.89	14.46
DAP	15.22	14.85	15.22	14.95	15.32	15.11
Org. manures	14.25	14.88	14.65	14.82	15.12	14.74
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.104	0.30				
Organic Manure	0.134	0.39				
Chem. fert. x OM	0.232	0.67				
Initial value-14.8						

Soil Available Potassium after Completion of Incubation Period

The significant and highest available potassium content was recorded by treatment of only POL application (364.41 kg ha^{-1}) while it was at par with all the other organic sources. The interaction effect between the organic and inorganic sources was found to be non-significant after completion of incubation period. The integrated effect of organic and inorganic fertilizer was more prominent as compared to only organic or inorganic treatments. This indicate that sole application of organic or inorganic sources may not keep pace with time in maintaining soil nutrient status. However, the conjunct use of organic and inorganic has substantial effect on soil fertility. The higher N, P and K concentration in soil due to combine application of organic and inorganic treatments can be attributed to rate of decomposition and consequent change induced in soil chemical properties. The pattern of decomposition and mineralization of organic manures and the nutrient content therein. Similar results are reported by Subbaiah (2019) [19]. The results are in close corroboration with the findings of Muhammad *et al.* (2019) [11] and Diwale *et al.* (2020) [5] who found that use of press mud compost and poultry manure enhanced the soil available nutrient status.

Table 8: Soil available potassium after completion of incubation period

Avail. K (kg ha^{-1})						
Sources	**Control**	**FYM**	**VC**	**POL**	**PMC**	**Chem.fert.**
Control	360.70	361.61	362.19	362.69	362.01	361.84
SSP	361.26	361.29	361.58	362.13	362.92	361.83
DAP	361.81	365.56	366.91	368.42	365.09	365.56
Org. manures	361.26	362.82	363.56	364.41	363.34	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.44	1.27				
Organic Manure	0.56	1.64				
Chem. fert. x OM	0.98	NS				
Initial value-361						

DTPA Iron in Soil after Completion of Incubation Period

The DTPA Fe present in soil was non-significantly affected by chemical fertilizer however, the highest DTPA Fe was recorded in DAP (3.62 mg kg^{-1}). The available Fe of soil is significantly influenced by different organic amendments. The significantly highest DTPA Fe was recorded due to application of PMC (3.59 mg kg^{-1}) over all the other sources. This was followed by application of POL (3.55 mg kg^{-1}). The combine effect of organic and inorganic sources on DTPA Fe content in soil was found to be non-significant after completion of incubation period.

Table 9: DTPA iron content in soil after completion of incubation period

DTPA Fe (mg kg^{-1})						
Sources	**Control**	**FYM**	**VC**	**POL**	**PMC**	**Chem. fert**
Control	3.42	3.45	3.49	3.50	3.54	3.48
SSP	3.41	3.43	3.49	3.51	3.57	3.48
DAP	3.60	3.58	3.61	3.64	3.67	3.62
Org. manures	3.48	3.48	3.53	3.55	3.59	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.012	NS				
Organic Manure	0.015	0.05				
Chem. fert. x OM	0.027	NS				
Initial value-3.40						

DTPA Zinc in Soil after Completion of Incubation Period

The highest DTPA Zn was recorded in DAP (0.53 mg kg^{-1}) over control however, it was at par with other organic treatments. The available Zn of soil is significantly influenced by different organic amendments. The significantly highest DTPA Zn was recorded due to application of POL (0.52 mg kg^{-1}) over all the other sources. The combine effect of organic and inorganic sources on DTPA Zn content in soil was found to be non-significant after completion of incubation period.

Table 10: DTPA zinc in soil after completion of incubation period

DTPA Zn (mg kg^{-1})						
Sources	**Control**	**FYM**	**VC**	**POL**	**PMC**	**Chem. fert**
Control	0.48	0.48	0.50	0.49	0.49	0.49
SSP	0.48	0.48	0.49	0.51	0.50	0.49
DAP	0.49	0.52	0.53	0.55	0.54	0.53
Org. manures	0.49	0.49	0.51	0.52	0.51	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.0049	0.01				
Organic Manure	0.0064	0.02				
Chem.fert. x OM	0.0111	NS				
Initial value-0.48						

DTPA Manganese in Soil after Completion of Incubation Period

The data pertaining to manganese content after incubation is presented in table 4.18. The DTPA Mn present in soil was significantly affected by chemical fertilizer however, the highest DTPA Mn was recorded in DAP (5.31 mg kg^{-1}) over control however, it was at par with other treatments. The organic sources on DTPA Mn content in soil was found to be non-significant after completion of incubation period. The combine effect of organic and inorganic sources on DTPA Mn content in soil was found to be non-significant after completion of incubation period.

Table 11: DTPA Mn in soil after completion of incubation period

Sources	Control	FYM	VC	POL	PMC	Chem. fert
Control	5.21	5.29	5.27	5.27	5.27	5.26
SSP	5.26	5.24	5.31	5.28	5.29	5.28
DAP	5.29	5.33	5.30	5.31	5.30	5.31
Org. manures	5.26	5.29	5.30	5.29	5.29	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.010	0.03				
Organic Manure	0.013	NS				
Chem. fert. x OM	0.022	NS				
Initial value-5.20						

DTPA Copper in Soil after Completion of Incubation Period

The organic sources were found to be significantly affecting the available micronutrient content. The increase in micronutrient content due to application of organic manures might be due to the inherent content of respective micronutrient in the particular manure. Singh *et al.* (2015) [17] studied the characteristics of different organic manure and reported that different organic manure varies substantially in their nutrient content. Similarly, Mishara *et al.* (2016) [10] reported that the mineralization of nutrient depends on the nutrient content of particular organic sources and C: N ratio.

Table 12: DTPA copper in soil after completion of incubation period

Sources	Control	FYM	VC	POL	PMC	Chem. fert
Control	6.43	6.50	6.51	6.54	6.48	6.49
SSP	6.43	6.47	6.54	6.56	6.61	6.52
DAP	6.50	6.60	6.63	6.67	6.57	6.59
Org. manures	6.45	6.52	6.56	6.59	6.56	
Factors	SE m ±	C.D @ 0.05				
Chem. fertilizers	0.017	0.05				
Organic Manure	0.023	0.07				
Chem. fert. x OM	0.040	NS				
Initial value-6.4						

Conclusion

The application of organic manure PMC and POL with DAP @ 75 kg P_2O_5 ha^{-1} to calcareous soil was increasing in availability of nitrogen, potassium, zinc and manganese, iron as compare to other remaining sources phosphorus.

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