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Effect of Phosphorus Enriched Vermicompost on Growth and Yield of Groundnut (*Arachis hypogaea* L.) as Influenced by Soil Phosphorus use Efficiency

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Abstract

The experiment was carried out at the farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal from August to October of 2011-12 and 2012-13, respectively. To investigate the effect of phosphorus enriched vermicompost on yield of ground nut under irrigated conditions. The experiment was laid out in a RBD design with 14 treatments which replicated thrice. Highest pod yield was obtained from T_7, that receiving 150% phosphorus through rockphosphate enriched vermicompost grade-I) (2400.50 kg ha-^{1}) whereas, the treatment receiving 100% recommended dose through sole application of chemical fertiliser (T_1) (1479.00 kg ha-1) was lowest yield. Dry matter accumulation increased significantly with crop age. Pooled data revealed that T_7 (4402.86 g m^{-2}) performed better in all sampling days. The lowest Dry matter accumulation was observed in T_1 (1096.66 g m^{-2}). The treatment T_7 recorded the highest value (4.02) of LAI at 75DAS and thereafter declined towards maturity. The highest value of 100-pod weight ,100-kernel weights and harvest index were recorded in T_7 respectively (93.22 gm) (63.56 gm) and. (44.04%).It was observed that haulm yield of T_4 recorded highest value of haulm yield (3541.10 kg ha^{-1})and T_8 recorded lowest value of haulm yield (3159.00 kg ha^{-1}) . Pooled data revealed that T_7 has highest (86.43%) shelling out and T_1 has the lowest value (57.84%). Among the Phosphorus use efficiency, Highest Partial factor of productivity and Agronomic efficiency were observed in T_5 respectively (55.21 kg ha^{-1}) and (29.99 kg ha^{-1}). Apparent recovery was highest in T_7 (306.46%) and maximum value of Physiological use efficiency was noticed in T_3 (26.23 kg ha^{-1}).

Keywords: 100-pod Weight, 100-Kernel Weight, Dry Matter Accumulation, Groundnut, Haulm Yield, LAI, Phosphorus Enriched Vermicompost, Phosphorus use Efficiency, Pod Yield

1. Introduction

The agro-climatic condition of terai zone is very much conducive for groundnut cultivation but soil constraints are there which prevent the farmers from taking some positive outlook about cultivation of this crop. Soil of North Bengal is mostly acidic which aggravates the problem of fixation of phosphorus and lower availability of micro-nutrients like zinc, boron etc. (Mandal, 1989), which leads to improper nodulation and poor yield of number of pulse and oilseed crops under the Fabaceae family. The efficiency of utilization of phosphatic fertilizer is very low (20-25 %) due to chemical fixation in soil. Besides, native soil phosphorus is mostly unavailable to crops because of its low solubility. Further there is build up of insoluble phosphates in soil where phosphatic

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fertilizers have been applied over long periods. Hence, to reduce the phosphorus fixation in soil and to enhance the efficiency of the applied phosphatic fertilizer and to keep phosphorus more timely available to crops, organic matter plays a great role. Increasing plant biomass production per unit cropped area, increasing biomass return per unit to cropped area and decreasing soil organic matter loss have been identified as the major considerations to maintain the soil organic matter balance. Therefore, there is a need to develop viable technology to increases the Phosphorus use efficiency of inorganic P-fertilizer and yield through of enriched vermicompost.

2. Materials and Methods

The experiment was carried out at the farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal from August to October of 2011-12 and 2012-13, respectively. To investigate the effect of phosphorus enriched vermicompost on yield of ground nut under irrigated conditions.

The experiment was laid out in a RBD design with 14 treatments which replicated thrice viz., Grade-I = 2% rockphosphate and Grade-II = 3% rock phosphate; T_1 = 100% Phosphorus through SSP, T_2 = 75% Phosphorus through SSP + 25% Phosphorus through enriched vermicompost (Grade I), T_3 = 50% Phosphorus through SSP + 50% Phosphorus through enriched vermicompost (Grade I), T_4 = 25% Phosphorus through SSP + 75% Phosphorus through enriched vermicompost (Grade I), T_5 = 100% Phosphorus through enriched vermicompost (Grade I), T_6 = 125% Phosphorus through enriched vermicompost (Grade I), T_7 = 150% Phosphorus through enriched vermicompost (Grade I), T_8 = 75% Phosphorus through SSP + 25% Phosphorus through enriched vermicompost (Grade II), T_9 = 50% Phosphorus through SSP + 50% Phosphorus through enriched vermicompost (Grade II), T_{10} =25% Phosphorus through SSP + 75% Phosphorus through enriched vermicompost (Grade II), T_{11} =100% Phosphorus through enriched vermicompost (Grade II), T_{12} = 125% Phosphorus through enriched vermicompost (Grade II), T_{13} = 150% Phosphorus through enriched vermicompost (Grade II), T_{14} = control plot.

The total content in the selected vermicompost were determined and the calculated quantity of each enriched vermicompost was taken separately and mixed well with single superphosphate to make exactly the double the quantity of phosphorus in each vermicompost. Single superphosphate mixed vermicompost was filled separately in polyethylene bag and required quantity of water was added to each bag to maintain moist condition (50% of maximum water retention capacity of the manure). These bags were kept for a period of one month by adding water as per the requirement to maintain uniform moisture level in the entire incubated time. After the incubation period of 30 days all these vermicompost were dried and applied to soil.

3. Results and Discussion

The ground nut yield in control plot was 1008.85 kg ha-[1] (Table 1) (Figure1). Addition of P-enriched vermicompost increased the grain yield significantly to 2400.50 kg ha-[1].

Highest pod yield was obtained from T_7, that receiving 150% phosphorus through rockphosphate enriched vermicompost grade-I (2400.50 kg ha-[1]) whereas, the treatment receiving 100% recommended dose through sole application of chemical fertiliser (T_1) (1479.00 kg ha-[1]) was lowest yield. T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) was followed by T_6 (125% phosphorus through rockphosphate enriched vermicompost grade-I) and T_5 (100% phosphorus through rockphosphate enriched vermicompost grade-I) which were at par with each other Rasal et al.[12], Raj et al.[11], Ghosh et al.[7], Saha and Hajra[15] and a number of authors experienced the higher pod yield of groundnut and other crops due to application of rockphosphate enriched compost over chemical fertiliser alone.

Dry matter accumulation (Table 2) (Figure 2) increased significantly with crop age. Sastry et al.[16] also recorded progressive increase in dry matter up to harvest of groundnut. From the destructive samplings at all the stages it was noticed that, treatment T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) recorded higher dry matter accumulation than T_{13} (150% rockphosphate enriched vermicompost grade-II). Treatment T_1 (100% phosphorus through SSP) i.e., sole application of chemical fertiliser at recommended dose recorded lowest values of dry matter accumulation in almost all sampling. The higher vegetative growth might be achieved by greater amount of available phosphorus in soil at important stages of growth, i.e., at 45 and 60 DAS (Table 4) which probably enabled the plant to grab higher amount of nutrient from the soil with greater root rhizosphere. Bhawalkar[3] experienced that vermicompost contains more number of N-fixing, P-solubilizing

Table 1. Effect of rockphosphate enriched vermicompost on yield of groundnut at harvest

Treatments	Pod yield (kg ha^{-1})		
	2012	2013	Pooled
T_1= 100% Phosphorus through SSP	1384.00	1574.00	1479.00
T_2 =75% Phosphorus through SSP + 25%Phosphorus through enriched vermicompost (Grade I)	1620.00	1767.00	1693.50
T_3 =50% Phosphorus through SSP + 50% Phosphorus through enriched vermicompost (Grade I)	1908.00	2157.00	2032.50
T_4 =25% Phosphorus through SSP + 75% Phosphorus through enriched vermicompost (Grade I)	2150.00	2220.00	2185.00
T_5 =100% Phosphorus through enriched vermicompost (Grade I)	2154.00	2263.00	2208.50
T_6=125% Phosphorus through enriched vermicompost (Grade I)	2157.00	2300.00	2228.50
T_7 =150% Phosphorus through enriched vermicompost (Grade I)	2381.00	2420.00	2400.50
T_8 =75% Phosphorus through SSP + 25% Phosphorus through enriched vermicompost (Grade II)	1511.00	1675.00	1593.00
T_9 =50% Phosphorus through SSP + 50% Phosphorus through enriched vermicompost (Grade II)	1854.00	2077.00	1965.50
T_{10} =25% Phosphorus through SSP + 75% Phosphorus through enriched vermicompost (Grade II)	1897.00	2107.00	2002.00
T_{11} =100% Phosphorus through enriched vermicompost (Grade II)	2077.00	2174.00	2125.50
T_{12} =125% Phosphorus through enriched vermicompost (Grade II)	2078.00	2190.00	2134.00
T_{13} =150% Phosphorus through enriched vermicompost (Grade II)	2097.67	2210.00	2153.83
T_{14}=control plot	1027.70	990.00	1008.85
SEm.(±)	118.69	98.58	167.63
CD (0.05)	345.03	286.58	487.28
CV (%)	10.95	8.5	9.06

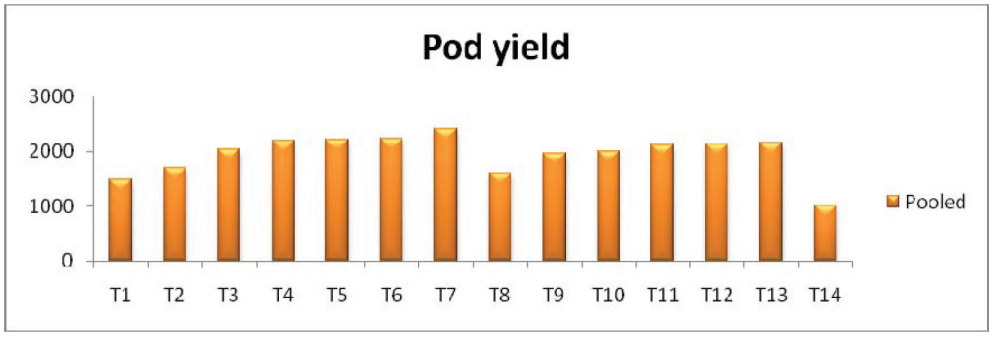

Figure 1. Effect of rockphosphate enriched vermicompost on pod yield (kg ha^{-1}) of ground nut.

and other beneficial microbes, antibiotics, vitamins, hormones, enzymes etc. which have better effects on growth and yield of plants. Gosh and Das Gupta[8], Roopadevi et al.[14] experienced similar result.

There was an increasing trend of LAI (Table 3) (Figure 3) values up to 75 DAS and thereafter declined towards maturity, probably due to senescence of lower leaves. Pooled analysis of data from each sampling showed that at 75 DAS the LAI was higher in T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) (4.02) and T_{13} (150% rockphosphate enriched vermicompost grade-II)(6.55) among organic treatment. Both the organic treatment T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) (4.02) and T_{13} (150% rockphosphate enriched vermicompost grade-II) had higher LAI than sole chemical treatment

Table 2. Effect of rockphosphate enriched vermicompost on dry matter accumulation (g m^{-2}) at different developmental stages of ground nut

Treatments	At 15 DAS			At 30 DAS			At 45 DAS			At 60 DAS			At 75DAS		
	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled
T_1	20.85	21.85	21.35	86.96	93.45	90.21	126.70	139.93	133.32	293.17	321.30	307.23	1007.63	1185.697	1096.663
T_2	22.14	23.17	22.65	89.86	96.55	93.21	130.46	154.90	142.68	315.50	328.90	322.20	1297.667	1328.497	1313.082
T_3	24.42	25.45	24.94	96.93	102.95	99.94	139.30	172.47	155.88	360.90	403.73	382.32	1397.697	1672.197	1534.947
T_4	25.91	27.25	26.58	113.52	119.37	116.45	150.42	192.50	171.46	390.50	448.60	419.55	1472.297	1687.597	1579.947
T_5	28.64	29.79	29.21	125.09	131.98	128.54	151.08	193.10	172.09	524.40	578.80	551.60	1823.297	1957.397	1890.347
T_6	28.87	30.04	29.46	130.80	137.45	134.13	163.74	204.80	184.27	528.20	585.57	556.88	1939.667	2127	2033.333
T_7	37.78	39.07	38.42	136.33	143.70	140.02	173.67	206.10	189.88	580.30	624.50	602.40	2121.097	2361.997	2241.547
T_8	21.55	22.57	22.06	90.11	91.59	90.85	128.44	155.80	142.12	303.83	328.90	316.37	1109.197	1205.397	1157.297
T_9	22.57	23.61	23.09	89.36	96.35	92.86	132.83	135.17	134.00	320.53	361.20	340.87	1389.997	1528.097	1459.047
T_{10}	23.54	24.60	24.07	93.56	100.23	96.90	134.92	163.20	149.06	331.70	382.30	357.00	1402.697	1648.997	1525.847
T_{11}	25.19	26.00	25.60	100.57	107.23	103.90	144.13	184.80	164.47	372.80	426.00	399.40	1426.797	1670.063	1548.43
T_{12}	25.51	26.62	26.06	104.61	112.08	108.34	145.05	187.50	166.28	385.30	429.40	407.35	1445.997	1687.93	1566.963
T_{13}	25.88	26.98	26.43	101.52	108.10	104.81	144.64	189.10	166.87	402.10	421.87	411.98	1457.397	1650.997	1554.197
T_{14}	18.94	19.93	19.44	85.56	87.86	86.71	125.58	138.00	131.79	268.30	300.89	284.60	992.3333	1023.647	1007.99
SEm.(±)	2.3351	3.3087	0.07	5.95	6.02	0.90	7.13	7.19	6.65	13.64	18.53	7.27	63.0397	87.418	39.53
CD (0.05)	6.788	6.801	0.20	17.49	17.49	2.76	20.72	20.89	20.32	39.65	45.15	22.06	183.25	254.11	120.785
CV (%)	16.096	15.461	0.36	10	9.54	1.2	8.68	7.21	5.97	6.15	6.34	2.52	7.536	9.32	3.639

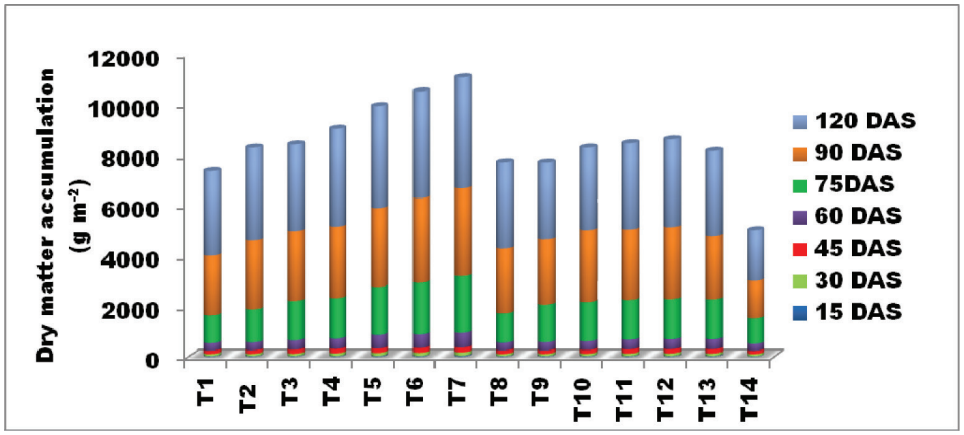

Figure 2. Effect of rockphosphate enriched vermicompost on dry matter accumulation (g m^{-2}) at different developmental stages of ground.

Treatments	At 75DAS			At 90DAS			At 120DAS		
	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled
T_1	1007.63	1185.697	1096.663	1785	2367.647	2076.323	3418.363	3289.363	3353.863
T_2	1297.667	1328.497	1313.082	2052	2714.667	2383.333	3695.663	3689.363	3692.513
T_3	1397.697	1672.197	1534.947	2214	2781.333	2497.667	3001.363	3909.363	3455.363
T_4	1472.297	1687.597	1579.947	2824	2850.68	2837.34	3722.363	4037.363	3879.863
T_5	1823.297	1957.397	1890.347	2842.713	3118.333	2980.523	3786.363	4301.363	4043.863
T_6	1939.667	2127	2033.333	3075.333	3356.78	3216.057	3942.363	4530.963	4236.663
T_7	2121.097	2361.997	2241.547	3316	3488.28	3402.14	4171.363	4634.363	4402.863
T_8	1109.197	1205.397	1157.297	1936.333	2580.913	2258.623	3614.363	3212.363	3413.363
T_9	1389.997	1528.097	1459.047	2202	2602	2402	2822.363	3304.363	3063.363
T_{10}	1402.697	1648.997	1525.847	2272	2868	2570	2943.363	3620.363	3281.863
T_{11}	1426.797	1670.063	1548.43	2292	2805	2548.5	3080.363	3786.363	3433.363
T_{12}	1445.997	1687.93	1566.963	2349	2868	2608.5	3289.363	3712.363	3500.863
T_{13}	1457.397	1650.997	1554.197	2402	2513.333	2457.667	3351.363	3428.363	3389.863
T_{14}	992.3333	1023.647	1007.99	1306	1486	1396	1998.363	2019.363	2008.863
SEm.(±)	63.0397	87.418	39.53	141.03	142.4	117.27	182.9	182.9	184.27
CD (0.05)	1007.63	1185.697	1096.663	1785	2367.647	2076.323	3418.363	3289.363	3353.863
CV (%)	1297.667	1328.497	1313.082	2052	2714.667	2383.333	3695.663	3689.363	3692.513

T_1 (100% phosphorus through SSP)(5.84). Better nutrient availability might have resulted in greater leaf area index. The trend was similar at later stages of observations too. Similar trends were also registered by Ghosh et al.[7], Saha and Hajra[15] Figure 3).

Pooled data (Table 4) and (Figure 4) reveals that 100-pod weight in T_7 (150% phosphorus through rock-phosphate enriched vermicompost grade-I) recorded highest value (93.22 gm) and T_{14} (control) exhibited the lowest value (61.08 gm) among the treatments. In general, irrespective of gradation of vermicompost with the increased in its application increased the 100-pod weight significantly. In general way, the data revealed that, wherever chemical fertiliser was substituted with grade-I, rockphosphate enriched vermicompost, increased the nutrient availability and uptake significantly and ultimately achieved higher value of 100-pod weight. Dayal and Agarwal[4], Babalad[2], Enyi[6], Jaswal and Gupta[9], Rahman and Rahman[10], Ghosh et al.[7], and Tiwari et al.[18] also reported similar result in different crops.

100-kernel weights (Table 4) and (Figure 4) varied significantly with different treatments (Table 4) and (Figure 4) Pooled data revealed that the T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) exhibited the highest value (63.56 gm) of 100-kernel weight, while T_1 (100% phosphorus through SSP) recorded lowest value (53.82 gm) among the fertilized plots. The probable reason was higher available phosphorus and favourable soil condition in T_7. Shanwad[17], Enyi[6], Acuna and Sanchez[1] and Roopadevi et al.[14] also experienced the similar result in different crops.

It was observed (Table 5) and (Figure 5) that T_4 (25% phosphorus through SSP + 75% phosphorus through PC grade II) recorded highest value of haulm yield (3541.1), followed by T_9 (50% phosphorus through SSP + 50% phosphorus through rockphosphate enriched vermicompost grade-II) and T_1 (100% phosphorus through SSP). Moreover, wherever more than 75% phosphorus through rockphosphate enriched vermicompost (grade –I) was applied (i.e. in T_7, T_6 and T_5), also produced quite substantial amount of haulm growth to give the higher economic yield at the end. Ghosh et al.[4] and Raundal et al.[13] also concluded same result with application of P enriched compost in legumes and cereals. T_8 (75% phosphorus through SSP + 25% phosphorus through VC grade-II) recorded lowest value of haulm yield (3159) due to lower vegetative growth. Roopadevi et al.[14] also noticed same result.

The highest (86.43%) shelling out turn (%) (Table 4) (Figure 4) was found in T_7 (150% phosphorus through

Table 3. Effect of rockphosphate enriched vermicompost on LAI at different developmental stages of Groundnut

Treatments	At 30 DAS			At 45 DAS			At 60 DAS			At 75DAS			At 90DAS			At 105DAS		
	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled
T_1	2.11	2.12	2.12	2.88	3.20	3.04	4.35	4.51	4.43	5.82	5.85	5.84	5.48	5.19	5.34	4.15	4.22	4.19
T_2	2.22	2.48	2.35	3.07	3.26	3.16	4.51	4.82	4.67	5.98	6.46	6.22	5.46	6.11	5.79	4.33	4.42	4.38
T_3	2.30	2.46	2.38	3.03	3.45	3.24	4.62	5.03	4.82	6.16	6.71	6.43	5.95	5.97	5.96	4.48	4.56	4.52
T_4	2.38	2.51	2.45	3.16	3.48	3.32	4.67	5.1 5	4.91	6.26	6.88	6.57	6.10	6.21	6.16	4.55	4.81	4.68
T_5	2.35	2.56	2.46	3.28	3.45	3.37	4.82	5.23	5.03	6.47	6.83	6.65	6.21	6.21	6.21	4.61	4.76	4.69
T_6	2.41	2.55	2.48	3.35	3.53	3.44	4.87	5.27	5.07	6.53	7.13	6.83	6.42	6.31	6.36	4.75	4.87	4.81
T_7	2.44	2.61	2.52	3.41	3.57	3.49	5.03	5.41	5.22	6.77	7.26	7.02	6.50	6.41	6.46	4.78	4.95	4.87
T_8	2.14	2.45	2.29	3.00	3.28	3.14	4.40	4.80	4.60	5.82	6.35	6.09	5.54	5.96	5.75	4.32	4.31	4.32
T_9	2.21	2.45	2.33	3.07	3.37	3.22	4.52	4.88	4.70	6.02	6.53	6.28	5.91	5.98	5.95	4.41	4.48	4.45
T_{10}	2.24	2.48	2.36	3.02	3.42	3.22	4.53	5.02	4.77	6.13	6.66	6.39	5.94	5.96	5.95	4.44	4.53	4.49
T_{11}	2.32	2.48	2.40	3.12	3.44	3.28	4.62	5.12	4.87	6.16	6.77	6.46	6.02	6.02	6.02	4.56	4.61	4.59
T_{12}	2.35	2.51	2.43	3.13	3.45	3.29	4.61	5.14	4.87	6.16	6.87	6.52	6.02	6.02	6.02	4.62	4.63	4.63
T_{13}	2.35	2.53	2.44	3.20	3.44	3.32	4.69	5.12	4.91	6.21	6.88	6.55	6.00	6.24	6.12	4.54	4.78	4.66
T_{14}	1.75	1.83	1.79	2.58	2.66	2.62	3.74	3.82	3.78	4.92	5.03	4.97	4.59	4.63	4.61	4.09	4.02	4.05
SEm.(±)	2.26	0.18	0.04	0.17	0.17	0.05	0.19	0.18	0.06	0.24	0.25	0.10	0.23	0.23	0.12	0.12	0.12	0.05
CD (0.05)	0.40	0.52	0.12	0.48	0.50	0.15	0.54	0.53	0.19	0.70	0.71	0.30	0.66	0.67	0.35	0.34	0.35	0.14
CV (%)	10.7	12.87	2.31	9.33	8.84	2.11	7.02	6.43	1.87	6.85	6.46	2.19	6.67	6.67	2.76	4.58	4.52	1.41

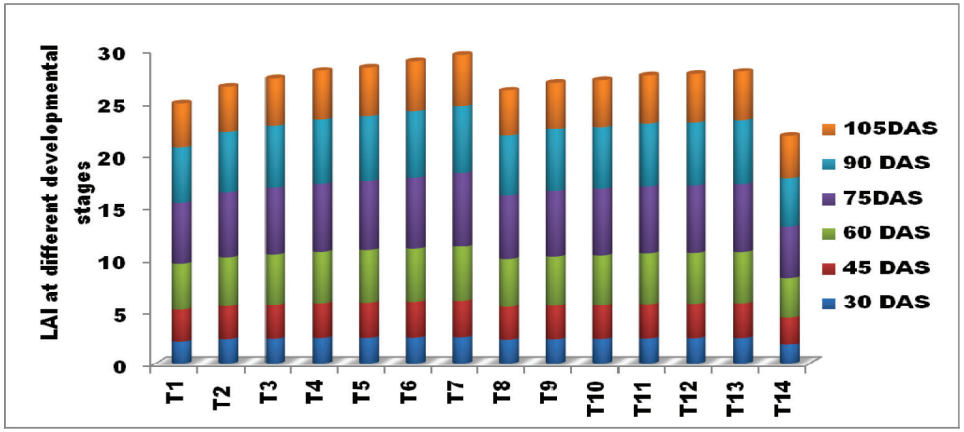

Figure 3. Effect of rockphosphate enriched vermicompost on LAI at different developmental stages of Groundnut.

Table 4. Effect of rockphosphate enriched vermicompost on 100-pod weight (g), 100-kernel weight (g) and shelling outturn % at harvest of groundnut

Treatments	100-kernel weight			100 -pod weight			Shelling out turn %		
	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled
T_1	52.35	55.29	53.82	59.88	65.79	62.84	59.57	56.09	57.84
T_2	42.38	50.50	46.44	70.37	71.44	70.91	57.04	59.18	58.11
T_3	44.78	51.51	48.15	72.67	74.43	73.55	63.32	68.34	65.84
T_4	41.27	50.07	45.67	73.35	79.31	76.34	68.93	76.09	72.51
T_5	41.51	47.58	44.55	78.57	81.61	80.10	69.40	76.32	72.87
T_6	45.67	56.68	51.18	82.44	87.61	85.03	76.84	85.07	80.96
T_7	63.68	63.43	63.56	87.87	98.56	93.22	87.62	85.22	86.43
T_8	45.75	57.79	51.77	59.43	66.63	63.04	54.95	61.22	58.09
T_9	44.78	56.66	50.72	70.72	75.37	73.05	56.98	69.43	63.21
T_{10}	47.60	59.71	53.65	74.51	76.26	75.39	58.47	69.83	64.15
T_{11}	52.86	50.92	51.89	74.30	85.33	79.82	72.06	64.20	68.13
T_{12}	45.26	57.78	51.53	81.40	85.50	83.45	60.75	75.77	68.26
T_{13}	45.32	52.32	48.82	83.26	94.40	88.83	64.40	73.24	68.82
T_{14}	40.18	44.58	42.38	59.81	62.34	61.08	48.73	50.88	49.81
SEm.(±)	0.15	0.13	2.3298	0.17	0.17	1.74	0.24	0.24	3.22
CD (0.05)	0.44	0.38	7.11	0.50	0.50	5.32	0.69	0.71	9.83
CV (%)	0.56	0.42	6.55	0.41	0.37	3.23	0.64	0.60	6.82

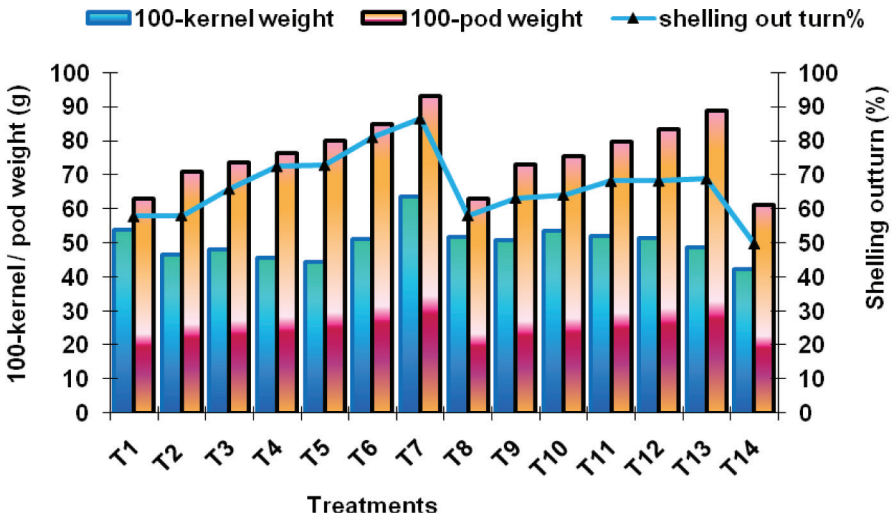

Figure 4. Effect of rockphosphate enriched vermicompost on 100-pod weight (g), 100-kernel weight (g) and shelling out turn % at harvest of groundnut.

rockphosphate enriched vermicompost grade-I) and T_1 (100% phosphorus through SSP) showed the lowest value (57.84%) and T_{13} (150% rockphosphate enriched vermicompost grade-II) (68.82%) was in 5th rank. This was due to higher kernel weight and lesser pod weight in T_7 in comparison with other treatments. The general information that surfaced from this data set that rockphosphate enriched vermicompost grade-I treated plots enhanced the nutrient availability and improved the percentage of shelling out turn significantly in comparison with chemical fertiliser treated plots. The treatments under grade-I vermicompost could able to

Table 5. Effect of rockphosphate enriched vermicompost on pod yield, haulm yield and harvest index of groundnut at harvest

Treatments	pod yield (kg ha^{-1})			Haulm yield (kg ha^{-1})			Harvest index (%)		
	2012	2013	pooled	2012	2013	pooled	2012	2013	pooled
T_1	1384.00	1574.00	1479.00	3238.2	3309.1	3273.7	36.6	32.04	34.32
T_2	1620.00	1767.00	1693.50	3231.0	3472.0	3351.5	34.05	33.73	33.89
T_3	1908.00	2157.00	2032.50	3155.3	3419.1	3287.2	40.39	38.69	39.54
T_4	2150.00	2220.00	2185.00	3580.0	3502.2	3541.1	40.51	38.82	39.665
T_5	2154.00	2263.00	2208.50	3228.0	3303.0	3265.5	40.64	40.69	40.665
T_6	2157.00	2300.00	2228.50	3177.1	3348.0	3262.6	42.63	40.75	41.69
T_7	2381.00	2420.00	2400.50	3191.0	3162.0	3176.5	44.82	43.26	44.04
T_8	1511.00	1675.00	1593.00	3175.0	3243.0	3209.0	32.29	33.87	33.08
T_9	1854.00	2077.00	1965.50	3344.1	3635.1	3489.6	36.81	36.37	36.59
T_{10}	1897.00	2107.00	2002.00	3043.0	3529.0	3286.0	36.71	37.39	37.05
T_{11}	2077.00	2174.00	2125.50	3268.1	3264.2	3266.2	41.76	39.99	40.875
T_{12}	2078.00	2190.00	2134.00	3220.2	3373.0	3296.6	39.88	39.38	39.63
T_{13}	2097.67	2210.00	2153.83	3114.4	3289.9	3202.2	40.6	40.2	40.4
T_{14}	1027.70	990.00	1008.85	2225.0	2342.0	2283.5	30.77	30.62	30.695
SEm.(±)	118.69	98.58	167.63	193.4	122.3	73.6	1.846	1.0795	0.7323
CD (0.05)	345.03	286.58	487.28	562.1	355.5	224.9	5.368	3.1381	2.2372
CV (%)	10.95	8.5	9.06	10.6	6.4	3.2	8.348	4.978	2.724

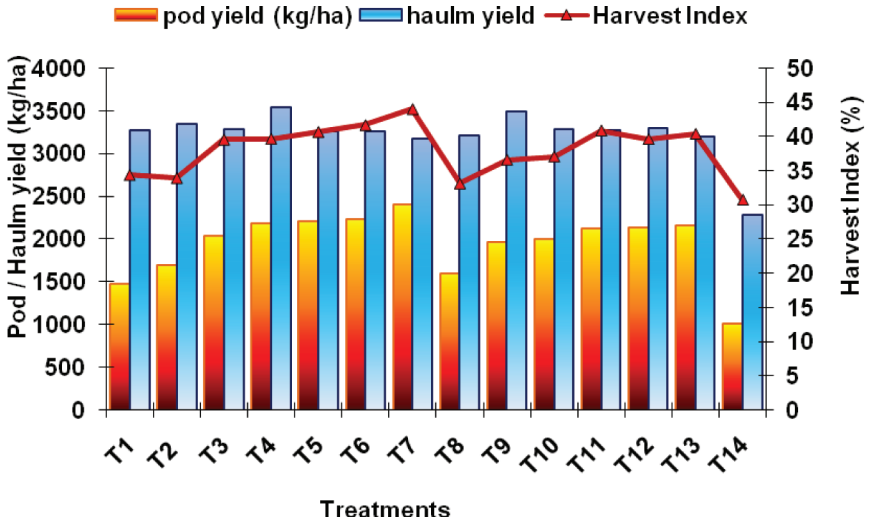

Figure 5. Effect of rockphosphate enriched vermicompost on pod yield, haulm yield and harvest index of groundnut at harvest.

supply all other essential elements apart from P in more balanced way, may be due to the better mineralization of organic matter under comfortable sphere of activity of earthworm.

The phosphorus through rockphosphate enriched vermicompost was applied in higher percentage, the value of harvest index (Table 5) and (Figure 5) improved significantly. T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) registered the highest value of harvest index in both the years (44.82% and 43.26%). The lowest value of harvest index was found in T_2 (75% phosphorus through SSP + 25% phosphorus

through grade I) in both years (33.73% and 33.89%). This was due to lower pod yield and higher biomass yield corresponding to the treatment. Ghosh et al.[7] also concluded similar result in P enriched compost.

Phosphorus use efficiency (Table 6) and (Figure 6) in case of Partial factor of productivity was highest for the treatment T_5 (100% of rockphosphate enriched vermicompost grade-I) (55.21 kg ha^{-1}) followed by T_4 (25% rockphosphate through SSP + 75% phosphorus through phosphocompost grade–I) (54.63 kg ha^{-1}). Lowest Partial factor of productivity was the T_{13} (150% phosphorus through rockphosphate enriched vermicompost grade-I). Agronomic efficiency was higher in T_5 (100% of rockphosphate enriched vermicompost grade-I) (29.99 kg ha^{-1}) followed by T_4 (25% rockphosphate through SSP + 75% phosphorus through phosphocompost grade–I)

Table 6. Effect of rockphosphate enriched vermicompost on Phosphorus use efficiency in ground nut

Treatments	Partial factor of productivity (PFP) (kg/ha)	Agronomic efficiency (AE) (kg/ha)	Apparent recovery (AR) (%)	Physiological use efficiency (PUE) (kg/ha)
T_1	36.98	11.75	47.325	24.84
T_2	42.34	17.12	99.825	17.15
T_3	50.81	25.59	97.575	26.23
T_4	54.63	29.40	141.45	20.79
T_5	55.21	29.99	219.8	13.64
T_6	44.57	24.39	239.42	10.19
T_7	40.01	23.19	306.4667	7.57
T_8	39.83	14.60	104.1	14.03
T_9	49.14	23.92	123.625	19.35
T_{10}	50.05	24.83	179.925	13.80
T_{11}	53.14	27.92	119.725	23.32
T_{12}	42.68	22.50	244.22	9.21
T_{13}	35.90	19.08	207.55	9.19

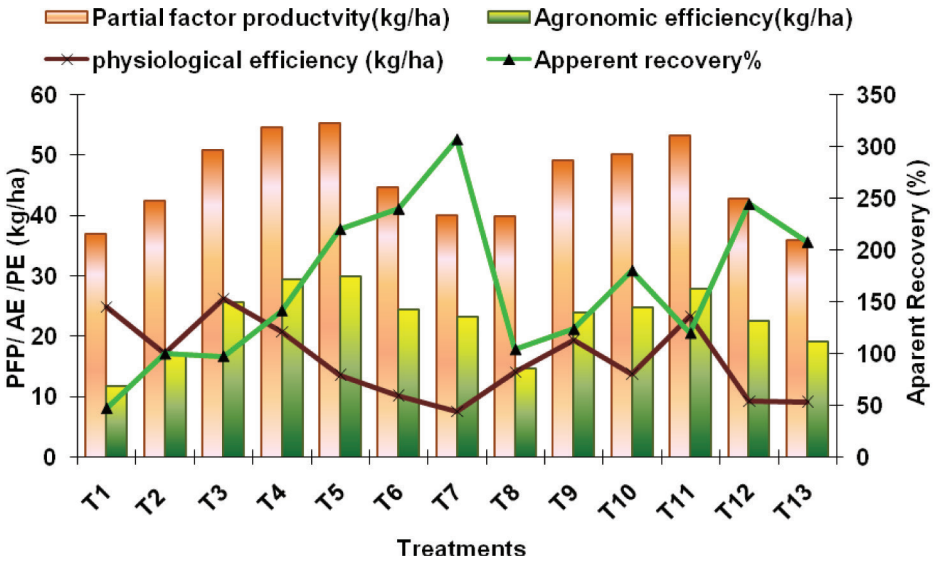

Figure 6. Effect of rockphosphate enriched vermicompost on Phosphorus use efficiency in ground nut.

(29.40 kg ha^{-1}). However, Apparent recovery, was highest in T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) (306.46%) followed by T_{11} (100% phosphorus through rockphosphate enriched vermicompost grade-II) (244.22%). In the same way maximum value of Physiological use efficiency was noticed under the treatment T_3 (50% rockphosphate through SSP + 50% phosphorus through phosphocompost grade–I) (26.23 kg ha^{-1}) and it was followed by T_4 (25% rockphosphate through SSP+75%phosphorus through phosphocompost grade–I) (20.79 kg ha^{-1}). However, rockphosphate enriched vermicompost treated plots recorded the lower values of Phosphorus use efficiency than the integrated treated plots might be due to corresponding higher values of absorbed phosphorus in applied plots. Thus it was very clear from this (Table 6) that organic sources of P increased the partial factor of productivity and Agronomic efficiency up to either 100% of its use or in integration with chemical. However in 125% and 150% organic treatments the availability of nutrient showed better and proved surplus for the standing crop which showed luxury consumption of nutrient by standing crop through it. Dwivedi[5] got more pronounced effect of P enriched compost on P use efficiency and relative agronomic effectiveness.

4. Conclusion

Pooled analysis of data of two years studies showed that highest pod yield was obtained from T_7, that receiving 150% phosphorus through rockphosphate enriched vermicompost grade-I) whereas, the treatment receiving 100% recommended dose through sole application of chemical fertiliser (T_1) was lowest yield among the fertilized plots. T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) was followed by T_6 (125% phosphorus through rockphosphate enriched vermicompost grade-I) and T_5 (100% phosphorus through rockphosphate enriched vermicompost grade-I) which were at par with each other.

Dry matter accumulation for Treatment T_7 ((150% phosphorus through rockphosphate enriched vermicompost grade-I) recorded higher dry matter accumulation than T_{13} (150% rockphosphate enriched vermicompost grade-II). Treatment T_1 (100% phosphorus through SSP) recorded lowest values almost all sampling.

Increasing trend of LAI values up to 75 DAS and thereafter declined. Both the organic treatment T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) and T_{13} (150% rockphosphate enriched vermicompost grade-II) had higher LAI than sole chemical treatment T_1 (100% phosphorus through SSP).

In general way, the data revealed that, wherever chemical fertiliser was substituted with grade-I, rockphosphate enriched vermicompost, increased the nutrient availability and uptake significantly and ultimately achieved higher value of 100-pod weight.

100-kernel weights varied significantly with different treatments. Treatment T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) exhibited the highest value of 100-kernel weight, while T_1 (100% phosphorus through SSP) recorded the lowest value among the fertilized plots.

Treatment T_4 (25% phosphorus through SSP+75% phosphorus through PC grade II) recorded highest value of haulm yield (3541.1), followed by T_9 (50% phosphorus through SSP + 50% phosphorus through rockphosphate enriched vermicompost grade-II) and T_1 (100% phosphorus through SSP).

Rockphosphate enriched vermicompost grade-I treated plots enhanced the nutrient availability and improved the percentage of shelling out turn significantly in comparison with chemical fertiliser treated plots may be due to the better mineralization of organic matter under comfortable sphere of activity of earthworm.

Higher percentage the value of harvest index observe in T_7 (150% phosphorus through rockphosphate enriched vermicompost grade-I) registered the highest value of harvest index in both the years. The lowest value of harvest index was found in T_2 (75% phosphorus through SSP + 25% phosphorus through grade-I) in both years. This was due to lower pod yield and higher biomass yield corresponding to the treatment.

It was very clear from this result that organic sources of P increased the partial factor of productivity and Agronomic efficiency up to either 100% of its use or in integration with chemical. However in 125% and 150% organic treatments the availability of nutrient showed better and proved surplus for the standing crop which showed luxury consumption of nutrient by standing crop through it.

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