Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(3): 2901-2907
Received: 21-03-2018
Accepted: 25-04-2018

Conjoint effect of Vermicompost and nitrogen on inceptisols of western Uttar Pradesh

Amit Kumar, BP Dhyani, Vipin Kumar, Ashish Rai, Satendra Kumar, NS Rana and KS Nehra

Amit Kumar
Department of Soil Science, Navjeevan Kisan Degree College, Mawana, Meerut, Uttar Pradesh, India

BP Dhyani
Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh-India

Vipin Kumar
Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Ashish Rai
Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Satendra Kumar
Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

NS Rana
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

KS Nehra
Department of Soil Science, Kisan P.G. College Simbhaoli, Hapur, Uttar Pradesh-India

Correspondence
Vipin Kumar
Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Abstract
Vermicompost and nitrogen scheduling on periodic nutrients availability in soil at different growth stages of rice crop were studied with rice (PB-1) and wheat (PBW 502) with two field experiments conducted during 2011-12 and 2012-13 in the Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. Analysis of soil for different physicochemical properties of soil at different growth stages of rice was done. Availability of soil N increased due to addition of vermicompost and more availability was found with delayed application of vermicompost. Phosphorous and potassium were higher in those treatments where vermicompost was applied with 75% N and 100 % PK. Slightly lower soil pH was found with the application of 100% NPK. At all the stages maximum electrical conductivity was found in T_1 where no fertilizer was applied. At flowering highest organic carbon percent in soil was found in case of T_9 while at harvest in T_{10} during both the years. With exception of T_1 rest of the treatments were found statistically at par in respect of available soil Mn during both the years. The application effect of vermicompost on the availability of soil copper was not found at any stage. Availability of zinc at harvest did not varied significantly due to timing of vermicompost. At harvesting Fe varied from 10.75 to 13.13 and 10.27 to 12.27 mg kg^{-1} during 2011 and 2012 respectively.

Keywords: vermicompost, nitrogen, rice, nutrient availability

Introduction
Increased production of rice and wheat helped in self-sufficiency in food grain production. Unsystematic use of inorganic fertilizers and plant protection chemicals for maximizing crop yield has resulted in the deterioration of the physical, chemical and biological properties of rice–wheat growing soils. Growth rate of rice and wheat yields are either stagnant or have declined. Therefore despite the early benefits, Instead of a positive increase in production and productivity, it has become apparent that there are many negative impacts from the green revolution such as reduced natural fertility of soil, salinization of the agricultural soils, decline in soil organic matter content, and poor soil physical condition particularly in rice-wheat system. Deficiency of secondary and micro plant nutrients is mainly attributed to almost neglect of organic manures by farmers after chemical fertilizer became available in the market. In rice-wheat areas of north-west India, deficiency of Zn, Cu, and Mn have been found to the extent of 52-75%, 8.32%, 2.4%, and 1-8% respectively (Yadav *et. al.,* 1998) [36]. Use of both organic and inorganic to increase crop production is called integrated nutrient management. INM system refers to a balanced use of chemical fertilizer in combination with organic sources. These organic sources may be organic manures, green manure, rural wastes, crop residues, bio-fertilizers and vermicompost.

Vermicompost is a natural organic product which is eco-friendly; it does not leave any adverse effects either in the soil or in the environment. Much interest in vermicomposting has been noticed due to the fact that earthworms play an important role in soil improvement, organic matter decomposition and enhancing plant growth (Gupta and Bhagat, 2004) [8]. Certain metabolites produced by earthworms may also be responsible to stimulate the plant growth. Vermicompost also helps in preventing plant diseases (Surekha and Rao, 2000) [31]. The mucus associated with the cast being hygroscopic absorbs water and improve water holding capacity. A positive effect of vermicompost application on yield attributes and yield of various crops have been reported by Vasanthi and Swamy (2000) [34]; Ranwa and Singh (1999) [25]; Das *et al.* (2002) [5] and Singh *et al.* (2005) [28]. Organic sources are applied in soil well before sowing or as basal so that it may stabilize its C: N ratio to an ideal value. A very few work had been documented on the scheduling of organic sources for a particular crop sequence. Vermicompost having an ideal C:N ratio can be tested for its scheduling in rice-wheat sequence. In the present study an attempt was made to study the effect of timing of vermicompost application in integrated mode on soil properties at different growth stages of rice.

Materials and Methods

Two field experiments were conducted during 2011-12 and 2012-13. The study area was CRC of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) which is located at latitude of 29^0 40′ north and longitude of 77^0 42′ east and at an altitude of 237 meter above mean sea level has semi-arid to sub-tropical climate. The experimental soil was sandy loam in texture having, low organic carbon, available nitrogen and medium in phosphorus and potassium. To study the effect of vermicompost scheduling on plant nutrient content and uptake at different growth stages of rice crop consisting ten treatments including; T_1-Control (without NPK) in rice, T_2-100% RDF to rice, T_3-75% N,100% P and K+Vermicompost @ 2 ton ha^{-1} as basal to rice, T_4-75% N,100% P and K +Vermicompost @ 2 ton ha^{-1} at tillering stage to rice, T_5-75% N, 100% P and K + Vermicompost @ 2 ton ha^{-1} at panicle initiation, T_6-75% N, 100% P and K + Vermicompost @ 2 ton ha^{-1} at flowering stage to rice, T_7-50% N, 100% P and K + Vermicompost @ 4 ton ha^{-1} as basal to rice, T_8-50% N, 100% P and K + Vermicompost @ 4 ton ha^{-1} at tillering stage to rice, T_9-50% N, 100% P and K + Vermicompost @ 4 ton ha^{-1} at panicle initiation to rice and T_{10}-50% N,100% P and K + Vermicompost @ 4 ton ha^{-1} at flowering stage to rice. Recommended dose of fertilizers (NPK) for rice crop was 120, 60 and 60 kg ha^{-1}, respectively. The pH was determined in (1:2) soil water suspension (Jackson, 1973) [11], The soluble salts in soils were measured with a conductivity meter, the electrical conductivity was expressed as deci-Siemens per meter (dSm^{-1}), organic carbon was estimated by modified Walkley and Black (1934) [35] method as described by Jackson (1967) [10], available nitrogen was determined by alkaline permanganate method (Subbiah and Asija, 1956) [30], determination of available phosphorus was done by Olsen's method (Olsen *et al*, 1954) [20], available potassium was determined by using neutral ammonium acetate as an extractant (Hanway and Heidal, 1952) [9], available zinc, iron, manganese and copper in soil were extracted by DTPA extractant (Lindsay and Norvell, 1978) [18]. The raw data collected for all parameters at different crop stages during the course of investigation was compiled and subjected to statistical analysis using the analysis of variance technique (Gomez and Gomez, 1984) [7]. The critical difference (at 5 % level of probability) was computed for comparing treatment mean.

Results

Available Nitrogen ($kgha^{-1}$) in soil at different growth stages

At maximum tillering stage available soil N (kg ha^{-1}) varied from 204.03 to 241.53 and 216.94 to 256.97 during 2011 and 2012, respectively (Table 1). With exception of T_3 and T_7 rest of the treatments were found significantly inferior to T_2 in respect of available soil N during both the years. Basal application of vermicompost over 75% N, 100% PK and 50% N, 100% PK resulted in significantly higher available soil N than the other respective treatments of these nutrient levels. Soil available N at panicle initiation stage declined from the value recorded at maximum tillering under different treatments. Available N in soil at this stage varied from 196.07 to 249.73 and 208.98 to 257.78 (kg ha^{-1}) during 2011 and 2012 respectively. The maximum available soil N 249.7 and 257.7 kg ha^{-1} in T_4 were statistically at par with T_3 and found significantly higher than the remaining treatments in both the years. The available N in soil at flowering stage varied from 186.30 to 240.37 and 199.21 to 247.07 (kg ha^{-1}) during 2011 & 2012 respectively. Available soil N in T_2 was found significantly lower than the T_3, T_4 during 2012 but such effect was not noticed during 2011 where T_2 was at par to T_3. Impact of vermicompost inclusion over 75%N, 100%PK and 50% N, 100% PK was also noticed at this stage by recording higher N availability. At harvesting Maximum available soil N 238.3 and 245.8 kg ha^{-1} statistically at par to $T_9$and significantly higher than the remaining treatments was found in T_{10} during 2011 & 2012. Availability of soil N increased due to addition of vermicompost and more availability was found with delayed application of vermicompost.

Available phosphorus (kg ha^{-1}) in soil at different growth stages

P in soil varied from 15.84 to 21.65 and 12.68 to 24.84 kg ha^{-1}at maximum tillering available during 2011 and 2012 respectively (Table 2). Maximum available P in soil during both the years statistically at par to T_3 and significantly higher than the remaining treatments was found in T_2. The effect of basal application of vermicompost with 50% N, 100% PK was non-significant. Availability of phosphorus in control plot was statistically at par to most of the treatments of 50% during 2011 but it was significantly lower than all the treatments during 2012. At panicle initiation stage available soil P declined from the available P recorded at maximum tillering stage in all the treatments and ranged from 15.17 to 19.45 and 11.76 to 22.89 kg ha^{-1} during 2011 and 2012 respectively. The available P in soil at flowering stage further decreased in all the treatments and varied from 14.01 to 17.78 and 11.31 to 14.64 kg ha^{-1} during 2011 and 2012, respectively. At harvest P in soil varied from 13.18 to 17.77 and 11.25 to 13.64 kg ha^{-1} during 2011 and 2012 respectively. Maximum available P in soil during 2011, statistically similar to T_3, T_4, T_5, and T_7 significantly higher than the rest of the treatments was found in T_{10}.

Available Potassium (kg ha^{-1}) in soil at different growth stages

At maximum tillering stage available K in soil varied from 220.17 to 260.40 and 200.34 to 267.66 $kgha^{-1}$ during 2011 and 2012 respectively (Table 3). Although the basal application of vermicompost did not resulted any significant effect but the value was comparatively higher than the other treatments where vermicompost was not applied. At panicle initiation stage available soil K declined from the maximum tillering in all the treatments and ranged from 210.03 to 263.42 and 190.05 to 250.61 kg ha^{-1} during 2011 and 2012 respectively. Available K in soil was significantly higher in the treatment receiving vermicompost application at maximum tillering than as basal with 75% N, 100% PK and 50% N, 100% PK during both the years. The available K in soil at flowering stage further decreased in all the treatments and varied from 208.88 to 254.31 and 176.58 to 265.50 kg ha^{-1} during 2011 and 2012, respectively. Available soil potassium in the treatments receiving vermicompost application at panicle initiation stage over 75% N, 100% PK was significantly higher than the treatments of respective nutrient level during both the years. At harvest available potassium in soil varied from 204.37 to 246.51 and 170.49 to 253.46 kg ha^{-1} during 2011 and 2012 respectively.

Available Iron (mg kg^{-1}) in soil at different growth stages

At maximum tillering stage DTPA extractable iron varied from 11.28 to 12.73 and 10.98 to 12.07 mg kg^{-1} during 2011 and 2012 respectively (Table 4). Maximum available iron in soil statistically similar to T_3 and significantly higher than the rest of the treatments was found in T_7. Availability of soil iron at panicle initiation stage varied from 11.19 to 13.75 and 10.68 to 12.94 mg kg^{-1} during 2011 and 2012, respectively. Maximum available soil Fe statistically at par to T_8 and significantly higher than the remaining treatments during both the years was found in T_4. Application 75% N, 100% PK along with 75% N, 100% PK at maximum tillering resulted in significantly higher available soil Fe than the treatments where along with 75% N, 100% PK vermicompost was applied at the time of transplanting but such effect was not noticed with 50% N, 100% PK. The available soil iron at flowering stage varied from 10.96 to 13.93 and 10.48 to 13.81 mg kg^{-1} during 2011 and 2012 respectively. The maximum available soil iron statistically at par to T_5 and significantly higher than the remaining treatments during both the years was found in T_7. Delayed application of vermicompost along with 75% N, 100% PK and 50% N, 100% PK resulted in significantly higher availability of iron than the earlier applications. At harvesting Fe varied from 10.75 to 13.13 and 10.27 to 12.27 mg kg^{-1} during 2011 and 2012 respectively.

Available Zinc (mg kg^{-1}) in soil at different growth stages

At maximum tillering stage available zinc differ from 0.37 to 0.56 and 0.29 to 0.56 mg kg^{-1} during 2011 and 2012, respectively (Table 5). Slightly higher available zinc was found with the application of vermicompost. At panicle initiation available Zn varied from 0.33 to 0.59 and 0.30 to 0.57 mg kg^{-1} during 2011 and 2012, respectively. The Zn at flowering stage varied from 0.26 to 0.54 and 0.24 to 0.55 mg kg^{-1} during 2011 and 2012 respectively. At this stage the availability of zinc in T_2 was slightly lower than the other treatments where fertilizers were applied and in some instances it was significantly lower. At harvest stage availability of zinc varied from 0.22 to 0.53 and 0.20 to 0.53 mg kg^{-1} during 2011 and 2012 respectively. At this stage it was also noticed that the availability of zinc was comparatively higher due to application of vermicompost at various stages. Availability of zinc at harvest did not varied significantly due to timing of vermicompost application although marginally higher values were recorded with delayed application.

Available copper (mg kg^{-1}) in soil at different growth stages

At maximum tillering stage Cu in soil varied from 1.94 to 2.70 and 1.93 to 2.66 mg kg^{-1} 2011 and 2012 respectively (Table 6). Similarly at panicle initiation stage available copper in soil differ from 1.93 to 2.64 and 1.92 to 2.65 mg kg^{-1} during 2011 and 2012 respectively. The available copper in soil was found 1.93 to 2.58 and 1.92 to 2.59 mg kg^{-1} under different treatments at flowering stage during 2011 and 2012 respectively. After the harvest of rice crop the availability of copper was found to range between 1.89 t0 2.55 mg kg^{-1} during 2011 and 1.88 to 2.56 mg kg^{-1} during 2012. With exception of T_1 (Control) the availability of copper in soil did not differ significantly at various growth stages due to application of different treatments during both the years. The application effect of vermicompost on the availability of soil copper was not found at any stage.

Available Manganese content (mg kg^{-1}) in soil at different growth stages

At maximum tillering stage available soil Mn differ from 6.35 to 7.43 and 6.34 to 7.44 mg kg^{-1} during 2011 and 2012 respectively (Table 7). With exception of T_1 (control) rest of the treatments were found statistically at par in respect of available soil Mn during both the years.

Organic carbon (%) in soil at different growth stages

The highest organic carbon percent 0.474 and 0.477 during 2011 and 2012, respectively, was recorded in T_7 where basal application of 4 tons of vermicompost was made with 50 % N, 100% PK (Table 8). The lowest organic carbon 0.402 and 0.394 percent during 2011and 2012, respectively was found in control plot (T_1). At Panicle initiation stage the organic carbon (percent) varied from 0.397 to 0.473 and 0.391 to 0.479 during 2011 and 2012, respectively. The highest organic carbon percent 0.473 and 0.479 percent during 2011 and 2012, respectively, was recorded in T_8 where application of 4 tons of vermicompost was made at maximum tillering stage. The lowest organic carbon 0.397 and 0.391 percent during 2011and 2012, respectively was found in control plot (T_1). Organic carbon (percent) varied from 0.393 to 0.472 and 0.386 to 0.474 during 2011 and 2012, respectively at flowering and 0.388 to 0.470 and 0.382 to 0.472 at harvest. At flowering highest organic carbon percent in soil was found in case of T_9 while at harvest in T_{10} during both the years.

Soil pH at different growth stages

The maximum pH 8.18 and 7.83 during 2011 and 2012, respectively, was recorded in T_1 where no any fertilizer was applied (Table 9). At panicle initiation stage the pH of soil varied from 7.74 to 8.15 and 7.40 to 7.77 during 2011 and 2012, respectively. The maximum soil pH range 8.15 and 7.77 during 2011 and 2012, respectively, was recorded in T_1 where any fertilizer was not applied. Soil pH varied from 7.76 to 8.12 and 7.41 to 7.71 during 2011 and 2012, respectively at flowering and 7.74 to 8.09 and 7.43 to 7.67 at harvest. Maximum soil pH at both the stages was found in T_1during both the years. The soil pH at different growth stages was lower in T_2 during both the years. EC (dSm^{-1}) of soil at different growth stages

At Maximum tillering stage the electrical conductivity of soil varied from 0.17 to 0.25 and 0.17 to 0.28dSm^{-1} during 2011 and 2012, respectively (Table 10). The maximum electrical conductivity range 0.25 and 0.28 dSm^{-1} during 2011 and 2012 was recorded in T_1 where any fertilizer was not applied. Electrical conductivity of soil at panicle initiation varied from 0.18 to 0.27dSm^{-1} and 0.18 to 0.27dSm^{-1} during 2011 and 2012 respectively. The maximum electrical conductivity was recorded in T_1 during both the years. The electrical conductivity of soil varied from 0.17 to 0.24 and 0.18 to 0.26dSm^{-1} during 2011 and 2012, respectively at flowering and 0.17 to 0.26 and 0.17 to 0.25dSm^{-1} at harvest. At all the stages maximum electrical conductivity was found in T_1 where no fertilizer was applied.

Discussion

Addition of optimal amount of nitrogen in T_2 and mineralization of added vermicompost along with 75% N and 100 % PK at different growth stages resulted in significantly higher nitrogen. The result was supported by Vasanthi and Swamy, 2000 [34]. Total and available N content were also reported to increase significantly with the addition of organic matter (Nahar *et al.*, 1995) [19]. Jat and Ahlawat (2006) [12] reported that application of vermicompost markedly increased total soil N and available soil P status after chickpea and maize after each cropping season over no vermicompost. Vanilarasu and Balakrishnamurthy (2014) [33] observed that application of organic manure and amendments increases available nitrogen and soil organic carbon. Optimal level of phosphorus and potassium resulted in comparatively higher P and K availability at maximum tillering stage. Thereafter availability of phosphorous and potassium was higher in those treatments where vermicompost was applied with 75% N and 100 % PK. Water soluble potassium improved in the soil significantly after rice and wheat with incorporation of compost in the soil at two different levels (Sarwar *et al.*, 2008) [26]. Kumar *et al.* (2017) [14, 15] reported that with the 100% NPK application initially nutrients availability was higher and that might have resulted in better growth and there by more dry matter accumulation. Release of phosphorous and potassium from added vermicompost might have enriched the available soil phosphorous and potassium. Bhandari *et al*., 1992[2] also reported that the NPK fertilizer at 100 % level and their combined use with organic N sources also increase the available N and P by 5.21 kg and 0.8-3.8 kg ha^{-1} from their initial value. Vasanthi and Swamy (2000) [34]; Singh *et al*. (2017) [27] also reported that available NPK and micronutrients were higher in the treatment receiving vermicompost. The combined application of organic and inorganic N sustained the productivity. Rai *et.al*., 2011 [24] also reported that he effect of phosphate and sulphur were found effective in increasing the availability of P at higher doses and the amount of P was found greater in the surface soil in comparison to sub-soil. This might be due to low mobility of P to lower depths of soil hence less availability. The available nutrients like N, P and K increased significantly with the application of various organic sources of nutrients in combination with fertilizers over fertilizer alone. The soils showed the increase in available K status, water soluble and fixed K and maximum amount of K released at 84 days of incubation (Kaur and Benipal, 2006) [13]. P and K in soil increased with the addition of vermicompost in soil (Rahman and Nath, 2013) [22].

Available micronutrients in T_2 were lower and in some cases significantly lower than the treatments consisting application of vermicompost. Effect of organic matter addition to improve the availability of micronutrients is well documented therefore results is well expected. In T_2 due to vigorous plant growth, much amount of these micronutrients was extracted from soil therefore lower availability is well expected (Ranwa and Singh, 1999) [25]. Slightly increase in the availability of zinc, iron, copper and manganese in soil with the application of organics has been reported by Kumar *et al*., 2012 [16]. DTPA extractable Zn content in Zn treated and Farmyard manure added plots significantly increased as compared to other plots where Zn was not applied (Arbad *et al.*, 2014) [1]. The most significant influence of vermicompost in increasing the solubility and availability of iron in soil is through solubilisation and mass flow in immediate vicinity of plant (Prasad *et al*., 2010) [21]. Organic carbon in soil at different growth stages remained unaffected due to application of different treatments. Kumar *et al.* (2017) [14, 15] reported that with the advancement in crop growth percent organic carbon declined gradually. Conversion of natural ecosystems into agricultural lands for intensive cultivation severely depletes SOC pools (Kumar *et al*. 2013) [17]. Organic carbon percent in soil at different growth stages was comparatively higher with the application of higher level of vermicompost (Bhaskar, 2003; Tolanur and Bahanur, 2003) [3, 32]. Soil pH measured at different growth stages remained unaffected due to application of different treatments. However, slightly lower soil pH was found with the application of 100% NPK and higher in control. This variation may be due to performance of crop growth in these two treatments. Bhat (2013) [4] reported that a significant decrease in soil pH and EC was observed in organic treatments. Application of compost alone and in combination with chemical fertilizer reduced the soil pH; ammonical nitrogen is a preferential source of nitrogen for rice. Singh *et al.*, 2014 [29] found that with the application of N through organic sources, the value of pH decreased significantly. With better plant growth more ammonical -N will be extracted from soil and H^+ ions will be released to soil solution. While in case of control less NH_4^+-N will be available for absorption therefore less H^+ ions will be released. Reduction in soil pH was also observed with the addition of vermicompost which is obvious due to production of various organic acids on the decomposition of vermicompost (Duhan and Singh, 2002; Rai *et. al.*, 2012) [6, 23]. Electrical conductivity of soil at the different growth stages of rice also remains unaffected with the application of different treatments. Comparatively lower electrical conductivity was recorded with reduced amount of NPK while higher in case of T_1.

Table 1: Effect of different treatments on available nitrogen (Kg ha^{-1}) in soil at different growth stages.

Treatments	Max. Tillering		Panicle Initiation		Flowering		At Harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	204.03	216.94	196.07	208.98	186.30	199.21	180.47	193.38
T_2	239.00	249.43	228.10	239.40	219.10	231.53	213.47	225.90
T_3	241.53	256.97	239.90	253.34	225.37	238.68	221.40	236.84
T_4	227.47	235.52	249.73	257.78	230.63	240.81	228.83	236.88
T_5	226.07	232.77	217.80	224.50	240.37	247.07	213.17	226.44
T_6	226.17	233.69	217.30	224.82	208.33	215.85	220.60	232.90
T_7	228.83	241.74	223.83	231.73	209.90	217.80	203.57	211.47
T_8	217.00	230.29	233.47	246.75	216.20	229.49	209.10	222.39
T_9	217.37	230.64	208.57	221.84	230.67	242.94	232.50	239.20
T_{10}	215.07	227.36	209.73	222.69	199.43	210.72	238.26	245.78
SE(m)	3.62	3.62	3.42	3.85	3.43	2.13	2.46	2.30
CD at 5%	10.84	10.84	10.23	11.52	10.28	6.36	7.37	6.89

Table 2: Effect of different treatments on available phosphorus (Kg ha^{-1}) in soil at different growth stages.

Treatments	Max. Tillering		Panicle Initiation		Flowering		Harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	15.84	12.68	15.17	11.76	14.01	11.31	13.18	11.25
T_2	19.75	23.58	17.25	21.87	15.49	11.78	14.56	10.64
T_3	21.65	24.84	19.26	22.64	17.39	14.26	16.53	12.61
T_4	17.13	20.05	19.45	22.89	17.52	14.47	16.66	12.74
T_5	17.15	20.08	16.83	19.14	17.78	14.64	15.67	10.75
T_6	17.07	20.04	16.44	19.88	15.44	11.79	16.64	10.72
T_7	17.76	20.36	16.88	19.21	15.85	11.35	15.88	10.92
T_8	16.69	19.43	16.53	19.95	15.80	11.30	15.41	10.53
T_9	16.68	19.42	16.08	19.12	16.38	12.26	16.58	12.66
T_{10}	16.69	19.43	16.14	19.18	15.17	11.05	17.77	13.64
SE(m)	0.76	1.44	00.85	00.86	0.62	0.89	0.64	0.92
CD at 5%	2.28	4.30	2.55	2.59	1.84	2.67	1.90	N.S.

Table 3: Effect of different treatments on available potassium ($Kgha^{-1}$) in soil at different growth stages.

Treatments	Max. Tillering		Panicle Initiation		Flowering		Harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	220.17	200.34	210.03	190.05	208.88	176.58	204.37	170.49
T_2	260.40	267.66	242.97	239.25	228.37	241.52	225.28	238.46
T_3	246.54	254.75	254.93	245.85	231.36	243.52	233.21	242.37
T_4	243.63	252.84	263.42	250.61	240.39	239.53	236.88	244.73
T_5	242.76	250.97	234.88	242.57	254.31	265.50	240.37	249.24
T_6	241.71	249.92	229.99	240.85	228.37	241.52	246.51	253.46
T_7	244.66	252.82	238.01	245.63	232.02	244.95	226.37	237.67
T_8	235.80	242.07	248.22	233.94	237.42	241.67	230.47	238.17
T_9	233.59	237.80	231.59	231.46	238.74	243.53	231.81	240.85
T_{10}	234.69	239.22	233.03	232.62	223.09	236.84	239.03	247.32
SE(m)	2.30	1.96	1.65	1.41	1.41	1.41	1.44	1.34
CD at 5%	6.88	5.88	4.95	4.22	4.22	4.22	4.32	4.01

Table 4: Effect of different treatments on available iron (Fe) ($mg\ kg^{-1}$) in soil at different growth stages.

Treatments	Max. Tillering		Panicle Initiation		Flowering		Harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	11.28	10.99	11.19	10.68	10.96	10.48	10.75	10.27
T_2	11.67	11.29	11.43	11.27	11.39	10.73	10.91	10.75
T_3	12.36	12.07	12.63	11.91	11.85	10.83	11.33	10.31
T_4	11.59	11.16	13.75	12.94	12.59	12.50	11.62	11.03
T_5	11.99	11.31	11.38	11.34	12.32	12.24	11.95	10.86
T_6	11.31	11.29	11.77	11.56	11.65	11.03	12.30	12.22
T_7	12.73	12.07	12.96	12.01	11.64	11.03	11.42	10.97
T_8	11.32	11.43	13.23	12.25	13.21	12.13	11.95	10.87
T_9	11.81	11.11	11.80	11.78	13.93	13.81	11.88	10.76
T_{10}	11.38	11.03	11.35	11.33	12.29	10.99	13.13	12.27
SE(m)	0.20	0.24	0.19	0.28	0.20	0.20	0.21	0.20
CD at 5%	0.60	0.71	0.57	0.82	0.59	0.59	0.63	0.59

Table 5: Effect of different treatments on available zinc (Zn) ($mg\ kg^{-1}$) in soil at different growth stages.

Treatments	Max. Tillering		Panicle Initiation		Flowering		Harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	0.37	0.29	0.33	0.30	0.26	0.24	0.22	0.20
T_2	0.54	0.55	0.47	0.50	0.40	0.41	0.34	0.35
T_3	0.56	0.56	0.53	0.53	0.49	0.50	0.48	0.49
T_4	0.55	0.56	0.58	0.56	0.52	0.54	0.53	0.52
T_5	0.54	0.55	0.56	0.53	0.53	0.55	0.51	0.50
T_6	0.52	0.54	0.52	0.55	0.54	0.53	0.52	0.53
T_7	0.57	0.58	0.53	0.51	0.48	0.49	0.45	0.46
T_8	0.50	0.51	0.59	0.57	0.50	0.47	0.48	0.45
T_9	0.53	0.53	0.54	0.52	0.47	0.46	0.47	0.48
T_{10}	0.51	0.52	0.53	0.54	0.46	0.48	0.46	0.48
SE(m)	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
CD at 5%	0.07	0.09	0.09	0.10	0.10	0.07	0.08	0.08

Table 6: Effect of different treatments on available copper (Cu) ($mg\ kg^{-1}$) in soil at different growth stages.

Treatments	Max. Tillering		Panicle Initiation		Flowering		Harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	1.94	1.93	1.93	1.92	1.93	1.92	1.89	1.88
T_2	2.63	2.64	2.63	2.62	2.56	2.57	2.53	2.54
T_3	2.70	2.66	2.64	2.65	2.58	2.59	2.55	2.56
T_4	2.64	2.64	2.63	2.64	2.57	2.58	2.54	2.55
T_5	2.59	2.59	2.58	2.58	2.52	2.52	2.49	2.49
T_6	2.65	2.60	2.59	2.59	2.53	2.54	2.50	2.51
T_7	2.62	2.62	2.61	2.62	2.55	2.56	2.52	2.53
T_8	2.61	2.62	2.61	2.61	2.55	2.55	2.52	2.52
T_9	2.61	2.62	2.61	2.61	2.54	2.55	2.51	2.52
T_{10}	2.61	2.61	2.60	2.61	2.54	2.55	2.51	2.52
SE(m)	0.07	0.10	0.09	0.12	0.10	0.13	0.11	0.14
CD at 5%	0.21	0.29	0.26	0.35	0.30	N.S.	0.33	N.S.

Table 7: Effect of different treatments on available manganese (Mn) ($mg\ kg^{-1}$) in soil at different growth stages.

Treatments	Max. Tillering		Panicle Initiation		Flowering		Harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	6.35	6.34	6.34	6.33	6.34	6.33	6.30	6.29
T_2	7.43	7.44	7.43	7.43	7.37	7.37	7.34	7.34
T_3	7.43	7.43	7.42	7.43	7.38	7.39	7.35	7.36
T_4	7.42	7.42	7.42	7.42	7.37	7.38	7.36	7.37
T_5	7.41	7.42	7.41	7.42	7.35	7.33	7.31	7.32
T_6	7.41	7.41	7.41	7.41	7.34	7.34	7.35	7.33
T_7	7.39	7.39	7.38	7.38	7.26	7.27	7.25	7.26
T_8	7.38	7.38	7.38	7.38	7.25	7.26	7.24	7.24
T_9	7.37	7.38	7.36	7.37	7.25	7.25	7.23	7.24
T_{10}	7.36	7.37	7.36	7.37	7.24	7.25	7.24	7.24
SE(m)	0.20	0.20	0.66	0.50	1.72	0.68	0.63	0.39
CD at 5%	0.60	0.57	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 8: Effect of different treatments on organic carbon (%) of soil at different growth stages of rice

Treatments	Max. Tillering		Panicle Initiation		Flowering		At harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	0.402	0.394	0.397	0.391	0.393	0.386	0.388	0.382
T_2	0.460	0.465	0.454	0.458	0.449	0.453	0.447	0.448
T_3	0.472	0.476	0.462	0.461	0.464	0.467	0.461	0.463
T_4	0.454	0.458	0.473	0.475	0.468	0.471	0.463	0.466
T_5	0.453	0.456	0.446	0.449	0.469	0.473	0.464	0.465
T_6	0.452	0.455	0.445	0.447	0.446	0.447	0.467	0.468
T_7	0.474	0.477	0.464	0.468	0.461	0.463	0.455	0.457
T_8	0.459	0.463	0.473	0.479	0.461	0.463	0.457	0.454
T_9	0.457	0.460	0.452	0.457	0.472	0.474	0.466	0.458
T_{10}	0.455	0.459	0.450	0.455	0.449	0.454	0.470	0.472
SE(m)	0.038	0.038	0.022	0.028	0.032	0.032	0.038	0.038
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 9: Effect of different treatments on pH of soil at different growth stages of rice 2011-2012.

Treatments	Max. Tillering		Panicle Initiation		Flowering		At harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	8.18	7.83	8.15	7.77	8.12	7.71	8.09	7.67
T_2	7.71	7.48	7.74	7.43	7.76	7.41	7.91	7.59
T_3	7.85	7.59	7.84	7.56	7.87	7.58	7.85	7.57
T_4	7.83	7.57	7.86	7.54	7.88	7.56	7.87	7.58
T_5	7.94	7.55	7.89	7.52	7.85	7.53	7.84	7.55
T_6	7.82	7.67	7.85	7.51	7.86	7.52	7.85	7.53
T_7	7.75	7.49	7.78	7.43	7.80	7.45	7.79	7.46
T_8	7.72	7.46	7.76	7.41	7.78	7.42	7.76	7.44
T_9	7.81	7.45	7.97	7.40	7.95	7.62	7.74	7.43
T_{10}	7.74	7.53	7.77	7.67	7.79	7.44	7.77	7.45
SE(m)	0.11	0.11	0.11	0.11	0.09	0.11	0.08	0.11
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 10: Effect of different treatments on EC (dSm^{-1}) of soil at different growth stages of rice

Treatments	Max. Tillering		Panicle Initiation		Flowering		Harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1	0.25	0.28	0.27	0.27	0.24	0.26	0.26	0.25
T_2	0.23	0.26	0.25	0.25	0.22	0.24	0.24	0.23
T_3	0.22	0.24	0.23	0.22	0.23	0.23	0.25	0.24
T_4	0.21	0.23	0.22	0.21	0.22	0.22	0.23	0.23
T_5	0.20	0.22	0.21	0.23	0.20	0.23	0.22	0.22
T_6	0.19	0.21	0.20	0.22	0.21	0.21	0.19	0.21
T_7	0.17	0.19	0.18	0.20	0.18	0.19	0.17	0.19
T_8	0.18	0.17	0.20	0.18	0.19	0.20	0.18	0.18
T_9	0.19	0.18	0.19	0.20	0.18	0.19	0.17	0.17
T_{10}	0.17	0.18	0.18	0.19	0.17	0.18	0.18	0.19
SE(m)	0.063	0.067	0.062	0.068	0.060	0.056	0.054	0.059
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

References

1. Arbad BK, Ismail S, Dhawan AS. Influence of long term use of farmyard manure and inorganic Fertilizer on grain yield and nutrient availability in Vertisols under soyabean-safflower sequence cropping. Legume Research. 2014; 37(6):600-606.
2. Bhandari AL, Sood A, Sharma KN, Rana DS. Integrated Nutrient Management in Rice-Wheat System. Journal of the Indian Society of Soil Science. 1992; 40:742-747.
3. Bhaskar J. Effect of integrated use of inorganic fertilizers and FYM or green leaf manure on uptake and nutrient use efficiency of rice-rice system on an Inceptisols. Journal of the Indian Society of Soil Science. 2003; 51(1):47-51.
4. Bhat ZA. Effect of organic and inorganic sources of nutrition on nitrogen and potassium dynamics in soil, (M.Sc. Ag. Thesis), 2013. Retrieved from http://krishikosh.egranth.ac.in/bitstream/1/5810002274/1/Zahoor%20Final%20Thesis%20Cd.pdf
5. Das PK, Jen MK, Sahoo KC. Effect of integrated application of vermicompost and chemical fertilizer on growth and yield of paddy in red soil of South Eastern Ghat Zone of Orissa. Environment and Ecology. 2002; 20(1):13-15.
6. Duhan BS, Singh M. Effect of green manuring and nitrogen on yield of and uptake of Micronutrients by rice. Journal of the Indian Society of Soil Science. 2002; 50:178-180.
7. Gomez AK, Gomez AA. Statistical procedures for Agricultural Research Second Edition. John Wiley and Sons, New York, U.S.A, 1984.
8. Gupta RD, Bhagat KC. Earthworms do miracles in agriculture. Indian Farmers' Digest. 2004; 37(2):41-44.
9. Hanway JJ, Heidel H. Soil analysis methods as used in Iowa State College, Soil Testing Laboratory. Iowa State College Bulletin. 1952; 57:1-131.
10. Jackson ML. Soil chemical analysis prentice hall of India private limited, New Delhi, India, 1967.
11. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India, 1973.
12. Jat RS, Ahlawat IPS. Direct and residual effect of vermicompost, bio-fertilizers and phosphorus on soil nutrient dynamics and reductivity of chickpea-fodder maize sequence. Journal of the Indian Society of Soil Science. 2006; 12(2):41-54.
13. Kaur N, Benipal DS. Effect of crop residue and farmyard manure on K forms on soils of long term fertility experiment, Indian Journal of Crop Science. 2006; 1(1-2):161-164.
14. Kumar A, Dhyani BP, Rai A, Kumar V. Effect of timing of vermicompost application and different level of NPK on growth, yield attributing characters and yield of rice in rice-wheat cropping system. International Journal of Chemical Studies. 2017; 5(5):2034-2038.
15. Kumar A, Dhyani BP, Rai A, Kumar V. Residual Effect of Applied Vermicompost and NPK to Rice on Growth and Yield of Succeeding Wheat and Chemical Properties of Soil. International Journal of Current Microbiology and Applied Sciences. 2017; 6(11):1087-1098.
16. Kumar M, Yaduvanshi NPS, Singh YV. Effect of Integrated Nutrient Management on Rice Yield, Nutrient Uptake and Soil Fertility Status in Reclaimed Sodic Soil. Journal of the Indian Society of Soil Science. 2012; 60(2):132-137.
17. Kumar R, Rawat KS, Singh J, Singh A, Rai A. Soil aggregation dynamics and carbon sequestration. Journal of Applied and Natural Science. 2013; 5(1):250-267.
18. Lindsay WL, Norvell WA. Development of a DTPA test for zinc, iron, manganese and copper. Soil Science Society America Journal. 1978; 42(3):421-428.
19. Nahar K, Haider J, Karim AJMS. Residual effects of organic manure and influence of nitrogen fertilizer on soil properties and performance of wheat. Annals of Bangladesh Agriculture. 1995; 5(2):73-78.
20. Olsen SR, Cole CV, Watanable FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate, Washington, USDA circular. 1954; 939:1-18.
21. Prasad J, Kurmakar S, Kumar R, Mishra B. Influence of integrated nutrient management on yield and soil properties in maize-wheat cropping system in a Alfisol of Jharkhand. Journal of the Indian Society of Soil Science. 2010; 58(2):2000-2004.
22. Rahman B, Nath D. Nutritional status of organically amended soils of subtropical humid climate of Tripura. International Journal of Farm Sciences. 2013; 3(1):51-57.
23. Rai A, Mishra S, Sharma DP. Effect of fly ash and sewage sludge on chemical properties of soil and yield of radish (*Raphanus sativus*). New Agriculturist. 2012; 23(1):49-54.
24. Rai A, Saleem M, Mishra S, Devi M. Phosphate availability in alluvial soil as affected by sulphur application with pea (*Pisum sativum* L.) As a test crop. Bioved. 2011; 22(2):239-241.
25. Ranwa RS, Singh KP. Effect of integrated nutrient management with vermicompost on productivity of wheat. Indian Journal of Agronomy. 1999; 44(3):554-559.
26. Sarwar G, Schmeisky H, Hussain N, Muhammad S, Ibrahim M, Safdar E. Improvement of soil physical and chemical Properties with compost application in Rice-wheat cropping system. Pakistan Journal of Botany. 2008; 40(1):275-282.
27. Singh L, Sharma PK, Kumar V, Rai A. Nutrient content, uptake and quality of pearl millet influenced by phosphorus and zinc fertilization (*Pennisetum galaucum* L.) under rainfed condition. International Journal of Chemical Studies. 2017; 5(6):1290-1294.
28. Singh RK, Athokpam HS, Zaliana C, Singh NG. Integrated management of Azolla, vermicompost and urea on yield of and nutrient uptake by rice and soil fertility. Journal of the Indian Society of Soil Science. 2005; 53(1):107-110.
29. Singh S, Bhat ZA, Rehman HU. Influences of organic and integrated nutrient management on physico-chemical properties of soil under basmati-wheat cropping sequence. The Bioscan. 2014; 9(4):1471-1478.
30. Subbiah B, Asija GL. A rapid procedure for estimation of available nitrogen in soil. Current Science. 1956; 25(8):259-260.
31. Surekha J, Rao PA. Influence of vermicompost and FYM on the pest complex of bhindi. The Andhra Agricultural Journal. 2000; 47:228-231.
32. Tolanur SI, Badanur VP. Changes in organic carbon, available N, P and K under integrated use of organic manure, green manure and fertilizer on sustaining productivity of pearl millet-pigeon pea system and fertility of an Inceptisols. Journal of the Indian Society of Soil Science. 2003; 51:37-41.

33. Vanilarasu K, Balakrishnamurthy G. Influences of organic manures and amendments in soil physiochemical properties and their impact on growth, yield and nutrient uptake of banana. The Bioscan. 2014; 9(2):525-529.
34. Vasanthi D, Swamy K. Efficacy of vermicompost to improve soil fertility and rice yield. Journal of the Indian Society of Soil Science. 2000; 47(2):268-272.
35. Walkley A, Black CA. Estimation of organic carbon by chromic acid and titration method. Soil Science. 1934; 37(1):28-29.
36. Yadav RL, Prashad K, Gangwar KS, Dwivedi BS. Cropping systems and resource-use efficiency. Indian Journal of Agricultural Sciences. 1998; 68(8):548-58.