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Effect of integrated nutrient management on sequential productivity, economics and nutrient uptake of rice (*Oryza sativa*) - potato (*Solanum tuberosum*) cropping sequence

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ABSTRACT

A field experiment was conducted at Banaras Hindu University, Varanasi, Uttar Pradesh during 2010-12 to evaluate the effect of nine different combinations of integrated plant nutrient supply including 3 different type of composts prepared from carpet waste generated in huge amount from carpet industry, farmyard manure and compared with the recommended dose of NPK (120:60:60 kg/ha) through inorganic fertilizer on productivity, economics, energetic, nutrient uptake and soil health of rice (*Oryza sativa* L.) - potato (*Solanum tuberosum* L.) cropping sequence. Bio-inoculants such as cellulose decomposers (*Trichoderma viride, Pleurotus sajor*), P-solubilizing microbes (*Bacillus polymyxa*) and free living N-fixers (*Azotobacter* spp), essential nutrients, i.e. S and Zn were used as compost culture to hasten the composting process and improve the quality of the composts. The results indicated that net energy return (260 033.2 ₹/ha), rice grain equivalent yield and nutrient uptake was significantly ($P < 0.05$) higher under recommended dose of NPK compared to the rest of the treatments but statistically similar with 75% RN through inorganic fertilizer and 25% N through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + enriched with S and Zn (251 886 ₹/ha). The soil fertility status was found to be significantly improved due to application of various composts compared to sole application of 100% NPK inorganic fertilizer. Thus, substitution of chemical N-fertilizer to the tune of 25% nitrogen through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + Enrichment with S and Zn increased productivity and profitability in rice-potato cropping sequence with better soil health on long term basis.

Key words: Economics, Energetics, INM, Rice, Potato and Nutrient uptake

Rice (*Oryza sativa*), the prince among cereals is the staple food crop for more than 2/3rd of Indian population which accounts for about 52% of the total foodgrain production and 55% of the total cereal production in India. Rice is the second most important cereal crop in world covering 160 mha with annual production of 461 mt of grain with average productivity of 4.09 tonnes/ha. In India, rice is cultivated an area of 44.50 mha (ranks first) producing 102.75 mt (ranks second) only after China with productivity of 2.20 tonnes/ha (Anonymous 2012). Potato is an economical food and it provides a source of low cost energy to the human diet. In India, potato is cultivated in an area of about 1.34 mha with a total production of about 24.7 mt.

Rice-potato is emerging cropping sequence in Uttar Pradesh. However, both being are exhaustive in nature. The unbalanced use of N fertilizers has at times led to environmental confrontations, disturbance in soil nutrient balance and depletion of soil fertility**.** Even the introduction of high yielding varieties and intensive cultivation with excess and imbalanced use of chemical fertilizers and irrigation showed reduction in the soil fertility status and yield by 38 % of rice crop. These causes have led to renewed interest in the use of renewable sources (organic manures/wastes) and prompted the scientists to find out an alternative agricultural system which involves the farming in a way that harmonize rather than conflict with natural processes operating in a natural ecosystem.

Since the organic wastes (Farmyard manure and carpet wastes) are the source of primary, secondary and micronutrients to the plant growth and constant source of energy for heterotrophic microorganisms which help in increasing availability of nutrients, quality and quantity of crop produce, it can be hypothesized that the use of proper combination of these locally available organic wastes which are narrow in C:N ratio and safe to apply for agricultural purposes, is as critical as that for integrated use. As no single source is capable of supplying the required amount of plant nutrients, integrated use of all sources of plant nutrients is a must to supply balanced nutrition to the crops (Dash *et al*. 2010).

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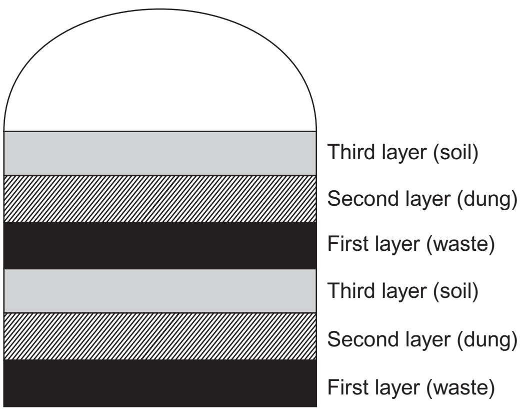
Keeping these facts in consideration, the present investigation entitled, effect of integrated nutrient management on sequential productivity, economics and nutrient uptake of rice – potato cropping sequence was carried out.

MATERIALS AND METHODS

A field experiment was carried out for 2 years during 2010-11 and 2011-12 in rice-potato cropping sequence at the Agricultural Research Farm, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (latitude 25^0 18' N, longitude 83^0 30' E and an altitude 125.93 meters), Uttar Pradesh. The initial soil is of sandy clay loam (sand 44.73%, silt 30.17% and clay 25.10%) in texture with pH (7.41), EC (0.34 dS/m), organic carbon (0.48 %), available N (190.50 kg/ha), phosphorus (19.85 kg/ha), potassium 213.44 kg/ha and sulphur (18.93 kg/ha). The climate is sub-tropical and the mean annual rainfall of the area is 1113 mm of which 84% occurs within the monsoon period (June – September). Rice humidity ranges from 80-92%. The experiment with nine treatments consisting of combination of chemical fertilizers and organic sources of nutrients in rice and potato namely, T_1 :100 % recommended dose of nitrogen through chemical fertilizers (RDN), T_2 : 75 % RDN + 25 % N through farmyard manure, T_3 : 50 % RDN + 50 % N through farmyard manure, T_4 : 75 % RDN + 25 % N through carpet waste + cow dung slurry + *Pleurotus sajor*, T_5 : 50 % RDN + 50 % N through carpet waste + cow dung slurry + *Pleurotus sajor*, T_6 : 75 % RDN + 25 % N through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma*, T_7 : 50 % RDN + 50 % N through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma*, T_8 : 75 % RDN + 25 % N through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + enriched with S and Zn and T_9 : 50 % RDN + 50 % N through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + enriched with S and Zn were tested in randomized block design replicated thrice, keeping the lay-out undisturbed throughout the field experimentation.

The enriched composts were prepared as per standard procedure. Microbial inoculant consisted of a combination of microbes, i.e. Phosphate solubilizing bacteria (*Bacillus polymyxa,*), cellulolytic fungus (*Trichoderma viride, Pleurotus sajor*) and free living N-fixer (*Azotobacter chroococcum*). Cellulolytic fungal cultures of *Trichoderma viride* was inoculated @ 300 g/tonne and *Bacillus polymyxa* @ 500 g/tonne of raw material. Carrier based inoculants of *Azotobacter* was applied to raise their number to 100×10^6/ 100 kg of organic material. The cellulolytic fungi were inoculated at the start of composting whereas the nitrogen fixers and phosphate solubulizers were given after 28-30 days of initial composting to protect the microbes from direct exposure to excess heat generated from the materials. For improving the micronutrient content of compost, external spraying of salt solution was of gypsum @ 12 kg/tonne and zinc sulphate @ 200 g/tonne of compost was done at the final turning stage of composting mass.



Recommended dose of N, P and K were 120, 60 and 60 kg/ha, were applied through urea, di-ammonium phosphate and muriate of potash, respectively. Half of N and full dose of P and K were applied as basal before sowing in all the treatments. Remaining half dose of nitrogen was top dressed in two equal splits, i.e. at active tillering and panicle initiation stage of rice crop in two equal doses. In case of potato, the entire dose of P_2O_5 and K_2O along with two third of the nitrogen was applied as basal. The rest nitrogen was given at the time of earthing. The fertilizers were applied by band placement 5 cm away and 5 cm deep from the tubers. Different organic manures like farmyard manure and carpet waste were also applied as basal before sowing in respective treatments. Irrigation was applied on the basis of critical physiological stages of crops. HUR-105 rice and Kufri Badsah potato were sown in the experiment. Plot size was 7 m × 4 m. No insecticides were used in this experiment. The crop management practices were practiced as per standard recommendation.

Soil samples were collected from effective root zone depth (0-30 cm) at the end of two years experimental cycle from each plot air-dried and sieved (2 mm mesh) and stored in polythene bags for analysis. Available nitrogen, phosphorus, potassium, sulphur and zinc content in soil were determined by alkaline potassium permagnate method (Subbiah and Asija 1956), sodium bicarbonate method (Olsen *et al.* 1954), flame Photometer method (Jackson 1973), Zn, Cu and Mn were measured by using the extraction with DTPA solution (Lindsay and Norvell 1978) and available S was determined by turbidimetric method (Chesnin and Yien 1950), respectively.

Plot-wise plant samples collected at the time of harvesting were chopped, dried and ground and digested in conc. H_2SO_4 for determination of N content (kjeldahl's method), tri acid mixture for determination of P (Vanado Molybdo Phosphoric Yellow colour method), K were estimated by flame photometer method (Jackson 1973) and micronutrient (Zn, Cu, Fe and Mn) was determined with the help of atomic absorption spectrophotometer. Microbial population (Bacteria, fungus and Actinomycetes count) were determined using serial dilution technique.

The economics and rice grain equivalent yield were computed at prevailing market price of inputs and outputs. Data on grain/tuber and straw/haulm yields, net return obtained from the cropping sequence during last 2 years were pooled. The various practices involved in crop production and economic yield of component crops in the sequences were converted into equivalent value of chemical energy (MJ/ha). For these conversions, standard values as given by Mittal *et al.* (1985) were used (Table 5). The total energy return of the sequence was obtained by conversion of economic yield of the sequence into energy equivalent whereas, the net energy return was worked out by deducting total input involved in the sequence in energy term from the total energy return.

The data collected on different parameters were subjected to statistical analysis following the procedure described by Cochran and Cox (1992).

RESULTS AND DISCUSSION

Yield

Rice grain yield obtained from compost treatment where 75 % RDN was applied through inorganic fertilizer and 25 % N through Carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + enrichment with S and Zn and treatment where 75 % RDN was applied through inorganic fertilizer and 25 % N through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* were not significantly different from the yield obtained from inorganic fertilizer (Singh and Chandra 2011). The highest grain yield under inorganic sources of nutrient (Dash *et al.* 2010) might be due to immediate release and availability of nutrients compared with organic nutrient sources which have relatively slow nutrient release and may achieve yield stability in the long run (Banik *et al.* 2006 and Bejbaruha *et al.* 2011). Such slow and low N supply via organic compost was compensated when applied along with chemical fertilizers. The beneficial effect of N fixing bacteria, *Azotobacter* to increase the yield is related not only to their N fixing proficiency but also with their ability to produce antibacterial and antifungal compounds, growth regulators and siderophores (Majumdar *et al.* 2007). The enriched compost with S and Zn may influence yield due to their catalytic or stimulatory effects on most of the physiological and metabolic process of plants (Mandal *et al.* 2009).

The maximum tuber yield was obtained under the treatment where 75% RN through inorganic fertilizer + 25 % carpet waste enrichment with bio-fertilizer along with S and Zn which was at par with 100% RN was applied through inorganic fertilizer and 75 % RN through inorganic fertilizer and 25 % N through Carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* but significantly superior to those of other INM treatments in this respect (Table 1). This might be due to greater availability of nutrients in soil, improved physical condition and higher total uptake of nutrients because of better root penetration leading to better absorption of nutrients and moisture which ultimately resulted in higher yields (Meena *et al.* 2010).

Table 1 Effect of integrated nutrient management on production potential of rice-potato sequence (pooled data of 2010-12)

Treatment	Yield(q/ha)	
	Rice	Potato
T_1 (100 % recommended N through chemical fertilizers)	57.21	24.9
T_2 (75 % RN + 25 % N through farm waste compost	51.34	23.9
T_3 (50 % RN + 50 % N through farm waste compost	46.74	22.5
T_4 (75 % RN + 25 % N through C_1**)	52.14	24.1
T_5 (50 % RN + 50 % N through C_1)	48.38	23.0
T_6 (75 % RN + 25 % N through C_2**)	54.47	24.5
T_7 (50 % RN + 50 % N through C_2)	49.29	23.3
T_8 (75 % RN + 25 % N through C_3**)	56.10	25.0
T_9 (50 % RN + 50 % N through C_3	50.36	23.6
SEm±	1.334	0.629
CD (P=0.05)	4.150	0.80

*120 kg N/ha, phosphorous @ 60 kg P2O_5/ha and potassium @ 60 kg K_2O/ha were commonly applied to all the treatments. ** C_1, C_2 and C_3 are the three best sources of compost (N) prepared through organic wastes, i.e. C_1: Carpet waste + cow dung slurry + *Pleurotus sajor*, C_2: Carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma*, C_3: Carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + Enriched with S and Zn.

Rice grain equivalent yield

Rice Grain Equivalent Yield was computed based on selling price of the crops. Pooled data showed that different INM treatments differed significantly in respect of rice grain equivalent yield (Table 2). The maximum RGEY was recorded under the treatment where 100% nitrogen applied through chemical fertilizer which was at par with 75% N through inorganic fertilizer + 25 % N through carpet waste enrichment with biofertilizer along with S and Zn and T_6 (75% inorganic fertilizer + 25 % carpet waste enrichment with bio-fertilizer) and these were significantly better than rest of the treatments in respect of RGEY. This was due to higher yield of respective crops in the sequence under inorganic fertilizer treatment (Singh and Chandra 2011). This might be due to immediate release and availability of nutrients when compared with organic nutrients sources which release nutrients instantly resulting higher crop biomass production. On the contrary, organic sources release nutrients slowly for longer period that does not meet the crop demand thus reduces crop bio-mass production. However, combined application of nutrients, 75% RDN through fertilizer and 25% N through carpet waste enriched with bio-fertilizer along with S and Zn produced higher biomass due to synchronized and balanced nutrients supply for a longer period of time due to their capability to supply essential nutrients other than N, P and K (Bejbaruah *et al.* 2011).

Table 2 Effect of integrated nutrient management on RGEY, economics and energetics of rice - potato sequence

Treatment	RGEY (q/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	Energy input (MJ × 10^3/h)	Net energy return (MJ × 10^3/h)
T_1 (100 % recommended N through chemical fertilizers)	264.71	70 910	330 944	260 033	41.25	262.53
T_2 (75 % RN + 25 % N through FYM)	250.09	76 236	312 302	236 066	41.34	249.63
T_3 (50 % RN + 50 % N through FYM)	234.24	81 563	291 640	210 076	41.31	233.19
T_4 (75 % RN + 25 % N through C_1**)	252.97	74 956	315 634	240 678	39.9	254.12
T_5 (50 % RN + 50 % N through C_1)	239.63	79 003	298 962	219 958	38.34	241.65
T_6 (75 % RN + 25 % N through C_2**)	258.22	76 746	322 978	246 232	39.9	258.39
T_7 (50 % RN + 50 % N through C_2)	243.46	82 613	303 298	220 684	38.32	245.94
T_8 (75 % RN + 25 % N through C_3**)	264.43	78 356	330 242	251 886	39.17	265.83
T_9 (50 % RN + 50 % N through C_3)	247.03	85 803	307 936	222 132	36.96	250.96
SEm±	2.64	NA	2 578	4 328.31		
CD (P=0.05)	8.20	NA	7 995	13 850		

*120 kg N/ha, phosphorous @ 60 kg P_2O_5/ha and potassium @ 60 kg K_2O/ha were commonly applied to all the treatments. **C_1, C_2 and C_3 are the three best sources of compost (N) prepared through organic wastes, i.e. C_1: carpet waste + cow dung slurry + *Pleurotus sajor*, C_2: carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma,* C_3: carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + Enriched with S and Zn. Selling price of rice ₹ 12/kg and potato ₹ 10/kg.

Economics

Economic analysis showed that the lowest cost of cultivation (70 910.82 ₹/ha) incurred under treatment where 100% RN through inorganic fertilizer. The highest gross and net returns were obtained from the crop sequence receiving 100% RN through inorganic fertilizer followed 75% RN through inorganic fertilizers and remaining 25% RN through carpet waste enriched with bio-fertilizer along with S and Zn and 75% RN through inorganic fertilizer + 25 % carpet waste enriched with bio-fertilizer compared to the rest of the treatments (Table 2). This is ascribed to higher yield of the crops inorganic nutrient management practices. Whereas, lower yield of crops in organic nutrient management practices except treatments T_6 and T_8 might have resulted in significantly lower gross and net returns.

Energetics

In general, the lowest energy input was recorded under the treatment (Table 2) where 50 % RN was applied through inorganic fertilizer and 50 % N through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + enrichment with S and Zn compared to rest of the treatments. However, net energy return was maximum under the treatment where 75 % RN was applied through inorganic fertilizer and 25 % N through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB +

Table 3 Effect of integrated nutrient management on total nutrient uptake by rice - potato sequence

Treatment	Nitrogen uptake (kg/ha)	Phosphorus uptake (kg/ha)	Potassium uptake (kg/ha)	Sulpher uptake (kg/ha)	Zinc uptake (g/ha)	Iron uptake (g/ha)	Copper uptake (g/ha)	Manganese uptake (g/ha)
T_1 (100 % recommended N through chemical fertilizers)	170.19	62.17	130.82	11.82	589. 92	1227.81	52.83	1448.94
T_2 (75 % RN + 25 % N through FYM)	158.135	56.09	120.53	10.955	499.12	1265.28	44.62	1170.15
T_3 (50 % RN + 50 % N through FYM)	150.32	52.28	112.44	10.335	412.17	995.08	36.11	929.13
T_4 (75 % RN + 25 % N through C_1**)	160.21	57.09	122.43	11.22	525. 38	1072.98	45.11	1227.79
T_5 (50 % RN + 50 % N through C_1)	152.97	53.46	115.27	10.54	468. 26	547.72	39.43	1051.11
T_6 (75 % RN + 25 % N through C_2**)	163.21	58.84	125.32	11.45	557.07	1139.16	49.5	1300.4
T_7 (50 % RN + 50 % N through C_2)	154.53	54.36	116.61	10.75	483.10	1057.22	42.26	1071.29
T_8 (75 % RN + 25 % N through C_3**)	167.475	60.25	128.03	11.74	582.26	1165.32	51.61	1389.35
T_9 (50 % RN + 50 % N through C_3)	157.08	55.27	118.53	10.93	499.61	1111.36	43.95	1144.41
SEm±	2.65	1.17	2.74	0.126	10.80	12.96	0.91	20.47
CD (P=0.05)	8.20	3.62	5.85	0.39	33.50	38.9	2.70	63.50

*120 kg N/ha, phosphorous @ 60 kg P_2O_5/ha and potassium @ 60 kg K_2O/ha were commonly applied to all the treatments. ** C_1, C_2 and C_3 are the three best sources of compost (N) prepared through organic wastes, i.e. C_1: carpet waste + cow dung slurry + *Pleurotus sajor*, C_2: carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma*, C_3: carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + Enriched with S and Zn

Table 4 Effect of integrated nutrient management on bio-chemical properties of soil at the end of the experimental cycle

Treatment	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (kg/ha)	Available Zn (mg/kg)	Bacteria population × 10^5	Actinomycetes population × 10^4	Fungi population × 10^3
T_1 (100 % recommended N through chemical fertilizers)	190.79	22.01	214.62	19.03	0.527	49.14	24.98	25.51
T_2 (75 % RN + 25 % N through FYM)	194.15	22.20	218.13	20.12	0.521	59.16	30.78	27.56
T_3 (50 % RN + 50 % N through FYM)	197.75	22.30	221.43	20.15	0.527	59.98	31.46	29.83
T_4 (75 % RN + 25 % N through C_1**)	195.28	22.75	216.87	20.29	0.529	59.60	31.00	28.07
T_5 (50 % RN + 50 % N through C_1)	198.33	22.60	222.46	20.38	0.531	60.14	31.48	30.18
T_6 (75 % RN + 25 % N through C_2**)	196.11	23.95	215.80	20.54	0.539	59.76	31.18	28.10
T_7 (50 % RN + 50 % N through C_2)	201.92	24.65	223.50	20.80	0.540	63.14	33.76	30.71
T_8 (75 % RN + 25 % N through C_3**)	197.68	24.60	215.79	22.76	0.76	59.85	31.33	28.33
T_9 (50 % RN + 50 % N through C_3)	202.98	25.80	223.91	23.50	0.85	77.88	40.02	35.13
SEm±	2.70	1.18	1.87	0.81	0.097	5.32	2.53	1.60
CD (P=0.05)	8.50	3.7	5.80	2.65	0.30	18.75	8.58	8.5
Initial	190.50	19.85	213.44	18.93	0.52			

*120 kg N/ha, Phosphorous @ 60 kg P_2O_5/ha and Potassium @ 60 kg K_2O/ha were commonly applied to all the treatments. **C_1, C_2 and C_3 are the three best sources of compost (N) prepared through organic wastes, i.e. C_1: carpet waste + cow dung slurry + *Pleurotus sajor*, C_2: carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma,* C_3: carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + Enriched with S and Zn

Trichoderma + enrichment with S and Zn which was comparatively superior to all other INM treatments but closely related with the treatment where 100% RN applied through inorganic fertilizer.

Nutrient uptake

Maximum uptake of nutrients (N, P, K, S, Zn, Cu and Mn) by rice – potato cropping sequence were recorded when the crop received 100% RN through inorganic fertilizer (Table 3). It was closely followed by the treatment having application of 75% RN through fertilizer and remaining 25% through carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + enrichment with S and Zn which might be due to higher nutrient concentration along with higher biomass production (Bejbaruah *et al.* 2011). It may be attributed to regulated availability of nutrients in soil and positive interaction effects of organic and inorganic sources of nutrients (Gogoi *et al.* 2010). It may also be due to *Rhizobium* inoculation which not only influenced the N uptake but improved the P and K uptake also, similarly, inoculation of PSB and other bio-fertilizer also increase N and K uptake along with P uptake by solubilization of insoluble organic phosphate, decomposition of phosphate rich organic compound and production of plant growth promoting substances (Tripathi *et al.* 2009).

Soil fertility status

The fertility status of soil after 2 years improved considerably by the integration of NPK, organic manure, *Rhizobium, Azotobacter*, *Trichoderma* and PSB compared to initial value and 100% NPK (Table 4) applied through inorganic fertilizer.

The available N and S content in soil was highest where 50% RN applied through inorganic fertilizer and 50% through enriched carpet waste with S and Zn along with biofertilizer inoculation. This might be due to *Rhizobium* and PSB integrated with NPK, suggesting the fact that PSB has also helped in biological N-fixation by *Rhizobium* by adding the various plant growth-promoting substances (Tripathi *et al.* 2009) in the soil.

Available P content in soil was increased with combined application of inorganic and organic fertilizer which might be due to solubilization of the native P in the soil through release of various organic acids and CO_2 during decomposition, which helps in solubilizing the native soil P (Tripathi *et al.* 2009) as well as reduce the fixation of phosphate by providing protective cover on sesqueoxides and chelating cations (when applied along with inorganic fertilizer) which in turn enhanced the availability of P (Singh *et al.* 2008).

The available K status in the soil increased significantly due to combined application of organic manures, bio-fertilizers and inorganic fertilizer compared to inorganic fertilizer alone (Table 4). This may be due to reduction of K-fixation, solubilization and release of K due to the interaction of organic matter with clay, besides the direct potassium addition to the potassium pool of the soil.

The increase in available zinc in soil with carpet waste or other organic manure with inorganic fertilizer (Table 4) might be due to formation of organic chelates of higher stability which decrease their susceptibility of precipitation (Gogoi *et al.* 2010).

Application of organic manure along with inorganic fertilizer (Table 4) registered significantly higher values of microbial (bacteria, fungi and actinomycetes) count

Table 5 Details of equivalents for direct and indirect source of energy

Particulars	Units	Equivalent energy (MJ/ha)
Human labour		
Adult men	Man-hour	1.96
Women	Woman hour	1.57
Diesel	Litre	56.31
Petrol	Litre	48.23
Electricity	KWh	11.93
Machinery		
Electric motor	Kg	64.80
Farm machinery	Kg	62.70
Chemical fertilizer		
Nitrogen	Kg	60.6
P_2O_5	Kg	11.1
K_2O	Kg	6.7
Farmyard manure	Kg (dry mass)	0.3
Seeds		
Output of crop production sequence and not processed		Same as that of output of crop production sequence
Output of crop production sequence and is processed before using it for seed (potato, groundnut, cotton)		Add 1.5 MJ/kg for potato, to the equivalent energy of the product of crop production sequence
Output		
Main product		
Cereal (Rice)	Kg (dry mass)	14.7 (The main output is grain)
Tuber vegetables		
Medium food value Potato	Kg	3.6
By products		
Straw, stalk	Kg (dry mass)	12.5

compared to the treatment where 100% nitrogen was applied through inorganic fertilizer. This might be due to enhanced organic carbon content of the soil and increased secondary and micronutrient in the soil which helped to increase the microbial population (Singh and Dhar 2011) and compost might have served as ready energy source for the growth and multiplication of microbes.

Thus it may be concluded from the above study that substitution of 25% N in recommended chemical fertilizer dose through organics particularly carpet waste + cow dung slurry + *Pleurotus sajor* + *Azotobacter* + PSB + *Trichoderma* + enriched with S and Zn increased the productivity of rice – potato cropping sequence, improved the nutrient utilization by the crop, reduced the use of chemical fertilizers without any deteriorations on soil health and ecological balance.

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