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Effect of integrated nutrient management in potato on growth, productivity, economics, nutrient uptake and soil fertility of wet season rice in potato-sesame- rice system

A.Das and A.K. Barik*

Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan-731236, West Bengal, India

ABSTRACT

An experiment was conducted in farmers' field during wet seasons of 2003 and 2004 to study the effect of nutrient management in potato through vermicompost and urea each with sole and in different proportions on growth, productivity, nutrient uptake, economics and soil fertility of succeeding wet season rice in potato-sesame- rice cropping system. Integrated use of plant nutrients in potato through vermicompost and urea had significant influence on growth, productivity, nutrient uptake, economics and soil nutrient reserve after rice as evidenced from pooled data. Supplementation of 40-60 % recommended dose (RD) of nitrogen from vermicompost and rest from chemical fertilizers in potato exhibited the highest growth, yield attributes and yield, net return, return per rupee investment and nutrient uptake in rice. These treatments also left higher residual available nitrogen, phosphorus and potassium after rice harvest. Use of 100 % RD of N entirely from chemical fertilizers or farmers' practice in potato had lesser residual effect on succeeding wet season rice compared with integrated use of organic (vermicompost) and chemical sources.

Key words: Integrated nutrient management, potato, vermicompost, wet season rice, growth, productivity, nutrient uptake, net return, soil fertility

During the green revolution, the strategy of intensive external input oriented agriculture has depleted soil fertility considerably in all the major agricultural production systems. This has led to a stagnation of food grain production in recent years inspite of consistent increment in fertilizer use (Abrol *et al.*, 2000). This stagnation in agricultural productivity is often attributed to degradation of soil due to various biotic and abiotic stresses inflicted on soil (Wang *et al.*, 2003). Integration of organic inputs with mineral sources of nutrients is giving impetus in sustaining soil health and maintaining there by the productivity levels of agricultural soils. Vermicompost is rapidly emerging as an important source of organic input produced from various organic wastes with the help of some specific groups of earthworms which may be used for such integrated plant nutrient supply system. In the present study, therefore, an effort was made to evaluate the long term effect of vermicompost, a component of integrated plant nutrition system, applied to potato on wet season rice in potato-sesame-rice cropping system.

MATERIALS AND METHODS

An experiment in farmers' field was conducted for two consecutive years during wet season of 2003 and 2004 in red and lateritic soil of West Bengal. The experimental field was situated at $23^0 39^/$ N latitude and $87^0 42^/$ E longitude with an average altitude of 58.9 m above the mean sea level. The soil of the experimental field was sandy loam (ultisol) in texture having pH-5.49 with 0.29% organic carbon, 105.23 kg ha^{-1} of available nitrogen, 25.82 kg ha^{-1} of available phosphorus and 61.63 kg ha^{-1} of available potassium, respectively. The layout of potato experiment during winter (*rabi)* season and sesame experiment during summer season was kept undisturbed for conducting rice experiment during wet season. The potato experiment, comprising of eight treatments [viz. T_1,control (without manure and fertilizers); T_2,100% RD of N (200 kg ha^{-1}) from chemical fertilizers(urea); T_3, Farmers' practice i.e. 5 tonnes FYM ha^{-1} with 150–100–100 of N- P_2O_5- K_2O in kg ha^{-1} from chemical fertilizers; T_4,100% RD of N

(200 kg ha^{-1}) from VC ; $T_{5,}$ 80% RD of N from VC and 20% RD of N from urea ;$T_{6,}$ 60% RD of N from vermicompost and 40% RD of N from chemical fertilizer; $T_{7,}$ 40% RD of N from VC and 60% RD of N from urea and $T_{8,}$ 20% RD of N from VC and 80% RD of N from urea], was laid out in randomized block design with three replications. After application of vermicompost, additional requirement of P_2O_5 and K_2O were met through mineral fertilizers in the form of single super phosphate and muriate of potash, respectively. For cultivation of potato, recommended fertilizer dose was 200-125-125. Vermicompost contained 1.6 % N, 1.0 % P_2O_5 and 1.0 % K_2O and the FYM contained 0.5- 0.2- 0.5 of N- P_2O_5 and K_2O, respectively. Sesame was cultivated without any fertilizer after potato to evaluate the residual fertility of treatments applied in potato. Twenty five day-old seedlings of rice (var. MTU-7029) was transplanted on August 1 and 3 during 2003 and 2004, respectively, with a spacing of 20 cm x 15 cm having three seedlings per hill. In rice, a recommended dose of 60-30-30 of N-P_2O_5-K_2O was applied uniformly in each plot from urea, SSP and MOP, respectively. One third quantity of nitrogen and full quantity of phosphorus and potassium were applied as basal on the day of transplanting. Rest two third of nitrogen was top dressed in two equal splits; one at active tillering stage and the other at panicle primordial initiation stage. Rice was harvested on November 20 and 23 of 2003 and 2004, respectively. Input and output prices of commodities prevailed during each year of experimentation were taken for calculation of economics.

RESULTS AND DISCUSSION

Integrated nutrient management in potato through vermicompost and urea in various proportions as well as sole application of urea or vermicompost had significant influence on growth attributes of wet season rice except plant height and net assimilation rate which were not significant (Table 1). The treatment receiving 60 % RD of N from VC + 40 % RD of N from urea in potato exhibited the highest leaf area index (3.35), dry matter accumulation (942.8 g m^{-2}), and leaf area duration (46.38 days) of rice. This was at par with 40 % RD of N from VC + 60 % RD of N from urea and 80 % RD of N from VC + 20 % RD of N from urea but significantly higher than farmers' practice and 100 % RD of N solely from chemical fertilizers. Das *et al*. (2003) and Satish *et al*. (2003) were also in conformity with these findings. The highest CGR of rice was achieved from the treatment receiving 40 % RD of N

Table 1. Effect of different treatments in potato on growth attributes of rice in potato-sesame-rice system (pooled data of two years)

Treatment	Plant height at harvest (cm)	LAI at 60 DAS	Dry matter accumulation (g m^{-2})	CGR at 30-45 DAT (g m^{-2} day^{-1})	NAR at 30-45 DAT (g m^{-2} day^{-1})	LAD at 45- 60 DAT (days)
T_1- Control	78.6	2.40	652.5	14.22	9.76	33.62
T_2- 100% RD of N from CF	81.7	2.78	851.2	20.16	10.89	40.59
T_3- Farmers' Practice	82.4	2.58	834.2	20.18	11.88	35.87
T_4- 100% RD of N from VC	83.8	2.95	864.4	19.78	10.86	41.34
T_5- 80% RD of N from VC +20% RD of N from CF	85.3	3.10	892.3	21.09	10.89	42.74
T_6- 60% RD of N from VC +40% RD of N from CF	89.2	3.35	942.8	20.90	9.17	46.38
T_7- 40% RD of N from VC +60% RD of N from CF	86.6	3.10	922.3	21.74	10.11	45.83
T_8-20% RD of N from VC +80% RD of N from CF	82.6	2.65	850.7	20.00	11.29	39.10
CD (P=0.05)	NS	0.34	110.29	5.46	NS	5.67

RD, recommended dose; VC, vermicompost; CF, chemical fertilizer; LAI, leaf area index; CGR, crop growth rate; NAR, net assimilation rate; LAD, leaf area duration; NS, not significant; DAT, days after transplanting.

from VC + 60 % RD of N from urea (21.74 g m^{-2} day^{-1}) in potato. This was similar with other treatments even farmers' practice or 100 % RD of N entirely from chemical fertilizers in potato were at par with this treatment.

A significant influence on yield attributes and yield of wet season rice was found with the application of vermicompost and urea in potato either solely or combinedly in various proportions except panicle length and test weight of rice which were non-significant (Table 2). The use of 40 % RD of N from VC + 60 % RD of N from urea in potato produced the highest number of effective tillers m^{-2} (426.3) and filled grains $panicle^{-1}$(118.95) of rice though it was at par with other proportions of vermicompost and urea except 20 % RD of N from VC + 80 % RD of N from urea. This was significantly higher than sole application of RD of N either from chemical sources or from organic sources like vermicompost towards production of effective tillers m^{-2} . The highest grain yield of rice was achieved from the treatment in potato receiving 60 % RD of N from VC + 40 % RD of N from urea though it was at par with other combinations of vermicompost and urea except 20 % RD of N from VC + 80 % RD of N from urea as well as application of plant nutrients solely from chemical fertilizers. Similar findings were also reported by Jayaram *et al.* (1990).

The use of plant nutrients in potato in an integrated way either through vermicompost and urea in various proportions or their sole application had significant effect on production economics of wet season rice grown in potato-sesame-rice sequence (Table 3). Substitution of 40-60 % RD of N through vermicompost and rest from chemical fertilizers in potato showed the highest net return (Rs.11825 ha^{-1}) and return per rupee investment(1.84). This was at par with other combinations of vermicompost and urea as well as with 100 % RD of N from vermicompost but significantly higher than 20 % RD of N from VC + 80 % RD of N from urea and 100 % RD of N entirely from chemical fertilizers.

The treatments, applied in potato, significantly influenced the plant nutrient (NPK) uptake of wet season rice (Table 3). Application of 60 % RD of N from VC + 40 % RD of N from urea in potato exhibited the highest uptake of nitrogen (90.18 kg ha^{-1}), phosphorus (42.25 kg ha^{-1}) and potassium (108.80 kg ha^{-1}) in rice. This was at par with other treatments having vermicompost and urea in different proportions but significantly higher than 20 % RD of N from VC + 80 % RD of N from urea as well as use of 100 % RD of N solely from chemical fertilizers.

After two years of potato-sesame-rice cropping, integrated nutrient management in potato through vermicompost and urea as well as their sole application showed significant effect on residual

Table 2. Effect of different treatments in potato on yield attributes, yield and harvest index of rice in potato-sesame-rice system (pooled data of two years)

Treatment	Number of effective tillers m^{-2}	Panicle length (cm)	Number of filled grains $panicle^{-1}$	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1- Control	292.0	21.6	96.18	21.5	3.02	5.37
T_2- 100% RD of N from CF	354.6	21.8	110.90	21.4	3.93	6.59
T_3- Farmers' Practice	338.3	21.6	107.00	21.6	3.91	6.37
T_4- 100% RD of N from VC	376.6	22.1	114.45	22.1	4.64	7.01
T_5- 80% RD of N from VC +20% RD of N from CF	403.8	22.1	112.80	22.1	4.60	7.07
T_6- 60% RD of N from VC +40% RD of N from CF	411.4	21.8	116.83	21.5	4.98	6.96
T_7- 40% RD of N from VC +60% RD of N from CF	426.3	21.5	118.95	21.5	4.94	7.00
T_8-20% RD of N from VC +80% RD of N from CF	361.4	21.8	109.40	21.8	4.20	6.58
CD (P=0.05)	37.5	NS	9.15	NS	0.54	1.02

Table 3. Effect of different treatments in potato on economics, nutrient uptake and soil fertility after rice in potato-sesame-rice system (pooled data of two years)

Treatment	Economics		Nutrient uptake (kg ha^{-1})			Soil fertility after rice harvest		
	Net return (Rs. ha^{-1})	Return $rupee^{-1}$ investment	Nitrogen	Phosphorus	Potassium	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
T_1- Control	2744	1.17	52.35	28.07	95.53	38.06	21.25	34.76
T_2- 100% RD of N from CF	6934	1.54	70.11	33.27	99.28	94.17	32.13	120.17
T_3- Farmers' Practice	6547	1.47	68.83	31.96	99.30	89.52	32.92	83.91
T_4- 100% RD of N from VC	9876	1.75	78.04	39.18	103.56	119.56	33.94	119.00
T_5- 80% RD of N from VC +20% RD of N from CF	11763	1.74	85.63	41.73	104.49	122.44	33.92	118.38
T_6- 60% RD of N from VC +40% RD of N from CF	11825	1.82	90.18	42.25	108.80	124.56	35.82	123.97
T_7- 40% RD of N from VC +60% RD of N from CF	11203	1.84	87.68	41.85	107.64	126.84	37.66	127.11
T_8-20% RD of N from VC +80% RD of N from CF	8239	1.59	73.86	35.95	104.07	121.62	39.59	124.81
CD(P=0.05)	3072	0.23	9.95	4.63	6.24	17.21	5.16	20.38
Initial value	-	-	-	-	-	105.23	25.82	61.63

Note: selling price of rice, Rs. 430 per quintal and of straw, Rs. 70 per quintal

available nutrients in soil after harvest of wet season rice (Table 3). Application of vermicompost and urea in various proportions as well as sole application of vermicompost in potato improved the residual soil available nitrogen, phosphorus and potassium over their initial status except control. This improvement could be attributed to slower release of plant nutrients from vermicompost during the entire crop growing season due to its more humified nature as reported by Chettri *et al*. (2004). When compared with integrated supply of organic and chemical sources, residual available nitrogen and phosphorus status significantly declined in the treatment receiving 100 % RD of N entirely from chemical fertilizers and in farmers' practice where available nitrogen reserve was rather lower than initial status of nitrogen. In farmers' nutrient management practice, residual potassium status declined from initial level when compared either with integrated use of plant nutrients through vermicompost and urea or their sole application.

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