Indian Journal of Agronomy **53**(3): 205–209 (September 2008)

Integrated nutrient management in potato (*Solanum tuberosum*)–jute (*Corchorus olitorius*) sequence

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Received: October 2007

ABSTRACT

A field experiment was conducted during winter season of 1999-2000 and rainy season of 2002 at Mohanpur, West Bengal to evaluate the performance of potato (*Solanum tuberosum* L.)ñjute (*Corchorus olitorius* L.) sequence as influenced by two complex fertilizers, viz. NPK (10:26:26) and NPK (15:15:15) in conjunction with 25% N as farmyard manure. Integrated use of complex fertilizers either NPK (10:26:26) or NPK (15:15:15) along with FYM (7.8 t/ha), recorded higher yield in comparison with the application of straight fertilizers + FYM (7.8 t/ha) in potato. A conjunctive use of NPK (10:26:26) and FYM in potato followed by an application of 40 kg N + 8.8 kg P + 16.6 kg K/ha or only 40 kg N/ha in jute recorded the maximum yield of tuber (23.77 t/ha) and jute fibre (4.18 t/ha). Integrated use of NPK (10:26:26) and FYM in potato with a fertilizer dose of 150 kg N + 44 kg P + 83 kg K/ha had total uptake of N (160.2 kg/ha), P (30.8 kg/ha) and K (190.9 kg/ha) by the system (potato and jute crops) per annum. After completion of three cropping sequences, it also improved the total N (10.2%), available P (6.3%) and available K (3.9%) status over the initial soil status. Integrated nutrient management with NPK (10:26:26) + FYM in potato followed by application of 40 kg N + 8.8 kg P + 16.6 kg K/ha in jute earned maximum net returns (Rs 48,580/ha) and returns per Re invested (Rs 2.21).

Key words : Economics, Integrated nutrient management, Nutrient uptake, Potato-jute sequence

Potato–jute is an important cropping system in West Bengal, occupying 3 lakh ha. The climate and soil of West Bengal is very much suitable for potato cultivation. Integrated use of organic and inorganic fertilizers often leaves substantial residual effect on the succeeding crops in multiple cropping, particularly in potato-based cropping systems, resulting in efficient crop production (Chettri *et al.*, 2004). Potato requires a high fertilizer dose, and major parts of phosphatic and potassic fertilizers are not utilized by the first-season crop. For a better fertilizer economy in potato-based cropping system, jute seems to be a good succeeding crop after potato under West Bengal condition. High basal dose of straight nitrogenous fertilizers like urea has some deleterious effect on emergence of potato (Sahota and Sharma, 1985). For this, complex fertilizers can very well be applied to potato for better nitrogen economy in potato-jute sequence. Combination of organic and inorganic fertilizer may further improve the productivity of the system. Not much work has been done on the use of complex fertilizers *vis-a-vis* straight fertilizers in the system. The present investigation was carried out to evaluate the performance of potato-jute sequence as influenced by different nutrient-management practices.

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MATERIALS AND METHODS

A field experiment was conducted for 3 consecutive years from winter (*rabi*) season of 1999-2000 to rainy (*kharif*) season of 2002 at the Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur (22°56′ N 88°32′ E and 9.75 m above mean sea-level). The soil was sandy clay-loam with pH 6.8, organic C 0.554%, total N 0.059%, available P 21.8 kg/ha and available K 170.2 kg/ha. The experiment was commenced from the winter season of 1999-2000 and continued for 6 consecutive seasons on the same field without disturbing the lay-out. Initially the experiment was laid out in randomized block design with three replications having seven manurial treatments, viz. control, NPK (10:26:26), NPK (10:26:26) + FYM, NPK (15:15:15), NPK (15:15:15) + FYM, urea + single superphosphate + muriate of potash, and urea + single superphosphate + muriate of potash + FYM applied in potato. Potato crop was fertilized with 150 kg N + 44 kg P + 83 kg K/ha in all the treatments except in the control. The treatments in which 25% N was

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applied through FYM, the quantity of P and K added through it was also taken into account for calculation of inorganic fertilizers. The N, P, K and moisture content of FYM used were 0.48, 0.12, 0.38 and 32% during the first year; 0.52, 0.11, 0.42 and 30% during the second year; and 0.50, 0.11, 0.43 and 30% during the third year of experiment. After harvest of first-season potato crop, all the plots were sub divided into two equal halves. Two fertilizer doses, viz. 40 kg N + 8.8 kg P + 16.6 kg K/ha and only 40 kg N/ha, were randomly allotted to the subsequent jute crop in the subplots of a split plot design. The data of first-season potato were analysed in randomized block design and data of all the other crops in the sequence were analysed as per the split-plot design, considering allocation of manurial treatments to potato in main plot and fertilizer doses to jute in sub-plot. Each sub-plot was of 5 × 3 m size.

The potato cultivar 'Kufri Jyoti' was sown in the third week of November and harvested in the first week of March during all the 3 years of study. Similarly, jute cultivar 'Naveen' was sown in the last week of April and harvested in the first week of September. Spacing in potato was 50 × 20 cm and in jute 20 × 5 cm. Seed rates in potato and jute were 2,500 kg tuber and 5 kg seed/ha, respectively. The N, P and K content of tuber and haulm of potato, stem and leaves of jute were determined by modified Kjeldahl, vanadomolybdate and spectrophotometry methods, respectively. The statistical analysis of data for winter 1999-2000 potato was done adopting randomized block design procedure and for all the subsequent crops by split-plot design. Since the experiment was conducted for three consecutive years on the same field without disturbing the layout, the data were not pooled over the years.

RESULTS AND DISCUSSION

Tuber yield of potato

Tuber yield of potato in the first year was more in the treatments where the potato crop received inorganic fertilizer only in the form of NPK (10:26:26), NPK (15:15:15) or straight fertilizers compared with that of their combined use with FYM (Table 1). The treatments in which 25% N was added through FYM during the first year might have exerted morbid effect on the growth and productivity of potato, probably owing to slower microbial activity for mineralization of FYM in cool winter temperature, which culminated in release of plant nutrients (Das and Banerjee, 1994). But in the second and third years the trend was reversed. The tuber yield was higher in the treatments receiving inorganic fertilizers along with FYM. The respective increment was 6.6, 4.3 and 6.5% during the second year and 8.4, 1.0 and 2.7% during the third year compared with the corresponding treatments in which FYM was not used. It might be due to gradual mineralization of FYM added to the first-year crop in sequence for better nutrient availability in the systems and with its residual effect on the succeeding crops (Chettri *et al.,* 2004). The treatment that received complex fertilizer of NPK (10:26:26) in conjunction with FYM recorded the maximum potato tuber yield in the second (winter 2000-01) and third (winter 2001-02) years, which was significantly higher than in all other treatments.

Application of complete dose of inorganic fertilizer in the succeeding jute crop (40 kg N + 8.8 kg P + 16.6 kg K/ha) had no significant difference in potato-tuber yield compared with the application of only 20 kg N/ha. Of course, there was an increase of 4.9 and 3.1% in tuber yield with the former one during the second and third years, respectively. The interaction effects of manurial treatments applied to potato and fertilizer doses to jute in the sequence on tuber yield were found to be non-significant in the second and third years of experimentation.

Fibre yield of jute

During the first year jute-fibre yield was maximum (4.13 t/ha) in the treatment where the preceding potato crop was manured with NPK (10:26:26) in combination

Table 1. Tuber yield of potato and fibre yield of jute as influenced by integrated nutrient management practices

Manurial treatment to potato	Tuber yield of potato (t/ha)			Fibre yield of jute (t/ha)		
	1999-2000	2000-2001	2001-2002	2000	2001	2002
Control	12.67	9.16	9.78	3.24	3.36	3.37
NPK (10:26:26)	23.10	22.44	23.04	3.88	3.93	3.93
NPK (10:26:26)+ FYM	22.42	23.91	24.97	4.13	4.16	4.24
NPK (15:15:15)	22.60	22.01	23.00	3.59	3.79	3.72
NPK (15:15:15)+ FYM	22.21	22.96	23.13	3.85	3.97	4.06
Urea + SSP + M0P	21.06	19.31	20.78	3.46	3.49	3.68
Urea + SSP + M0P + FYM	20.01	20.57	21.35	3.55	3.75	3.87
SEm±	0.37	0.59	0.67	0.14	0.05	0.04
CD (P=0.05)	1.14	1.82	2.01	0.41	0.15	0.13

SSP=Single superphosphate, MOP=muriate of potash, FYM=farmyard manure

with FYM. It was on a par with that of the treatment receiving combined application of NPK (15:15:15) and FYM. The fibre yield of jute was significantly higher where the preceding potato crop received complex fertilizer NPK (10:26:26) than the treatment receiving NPK through straight fertilizers. In the jute crop of the second and third years, maximum yield of fibre was recorded in the treatment that had a conjunctive use of NPK (10:26:26) and FYM in the preceding potato (Table 1). The integrated use of NPK (10:26:26) and FYM in potato increased in the fibre yield by 6.4, 5.8 and 7.8% compared with its sole use of inorganic form during the first, second and third years, respectively. Jute-fibre yields were higher in all the three years for the treatments in potato receiving integrated use of nutrients in comparison with their sole application in the preceding potato crop. The fibre yield was significantly higher in the former treatments than in the latter in the crops of second and third years. The increase in yield under integrated nutrient management might be due to the gradual mineralilzation of organics, proving that all the essential nutrients from the manure also improved the soil-physical properties (Mondal and Roy, 2001).

In all the years of study there was no significant difference between the application of a complete dose of fertilizers i.e. 40 kg N, + 8.8 kg P +16.6 kg K/ha and only 40 kg N/ha in jute in relation with fibre yield of jute. However, the former treatment increased the fibre yield compared with application of only 40 kg N/ha by 6.7, 3.5 and 4.5% during 2000, 2001 and 2002, respectively. The interaction effects of manurial treatments applied to potato and fertilizer doses to jute in the sequence on jute fibre yield were found to be non-significant in all the years of experimentation.

Nutrient uptake

Total uptake of N by potato-jute sequence was maximum (160.1 kg/ha) with the treatment involving integrated use of NPK (10:26:26) and FYM in potato, which was significantly higher than its sole use and all other treatments (Table 2). But the treatments involving integrated use of NPK (10:26:26) or NPK (15:15:15) and FYM were at par regarding nitrogen uptake. Addition of 25% N from FYM source along with NPK (10:26:26) and NPK (15:15:15) to potato resulted in 2.2 and 13.1% higher uptake of N by the sequence respectively compared with that from NPK fertilizer alone. This might be due to the beneficial effect of added organic matter, which was derived in connection with the physical and chemical properties of soil (Khanda *et al.*, 2005) Potato, endowed with high yield potential, requires very high amount of nitrogen, thereby leading to high nitrogen uptake in the sequence. Integrated use of

Table 2. Uptake of N, P and K by potato-jute sequence as influenced by integrated nutrient-management practices

Treatment	N (kg/ha)						P (kg/ha)						K (kg/ha)					
	1999-2000		2000-2001		2001-2002		1999-2000		2000-2001		2001-2002		1999-2000		2000-2001		2001-2002	
	Potato	Jute	Potato	Jute	Potato	Jute	Potato	Jute	Potato	Jute	Potato	Jute	Potato	Jute	Potato	Jute	Potato	Jute
Manurial treatment to potato																		
Control	34.48	37.57	30.90	35.76	34.10	33.81	4.17	12.40	3.48	11.95	3.41	11.71	39.40	47.14	35.96	43.99	31.05	42.10
NPK (10:26:26)	97.44	60.15	101.45	60.34	100.03	59.18	12.04	17.63	12.11	17.74	12.12	17.72	109.78	77.53	110.65	78.17	101.13	78.05
NPK (10:26:26)+ FYM	85.77	63.01	107.04	63.08	98.76	62.87	10.43	18.45	12.65	18.92	12.81	19.10	96.98	81.65	117.64	83.92	107.65	84.72
NPK (15:15:15)	97.27	57.59	99.66	58.73	102.95	58.57	11.94	16.55	11.89	17.01	11.95	17.05	104.00	72.56	104.50	75.24	93.32	72.15
NPK (15:15:15)+ FYM	85.80	59.08	103.67	61.23	99.37	60.12	10.35	17.06	12.50	18.04	12.76	18.22	91.79	75.05	110.20	79.48	98.21	83.51
Urea + SSP + M0P	85.38	53.27	90.30	49.58	97.74	50.63	10.49	15.15	10.64	14.93	10.72	15.01	88.02	65.62	94.29	66.24	84.10	66.21
Urea + SSP + M0P + FYM	85.92	55.37	92.35	52.36	97.64	52.81	10.25	15.82	11.10	15.94	11.85	16.20	88.02	68.91	94.29	70.83	86.57	69.41
SEm±	1.92	0.82	0.75	0.49	1.07	0.52	0.23	0.41	0.09	0.23	0.18	0.29	2.05	1.44	0.81	0.78	1.27	0.84
CD (P=0.05)	5.92	2.53	2.30	1.51	3.22	1.59	0.71	1.26	0.27	0.72	0.56	0.88	6.30	4.43	2.49	2.42	3.92	2.57
Fertilizer dose to jute																		
40 kg N + 8.8 kg P + 16.6 kg K/ha		56.41		91.89		56.03		89.71		55.13		16.76		10.96		17.03		10.85
40 kg N/ha		53.88		87.07		52.84		86.18		53.12		15.54		10.28		15.69		10.15
SEm±		0.17		0.32		0.37		0.32		0.37		0.08		0.04		0.13		0.04
CD (P=0.05)		NS		0.94		NS		0.93		NS		NS		0.11		NS		0.11

Treatment	K (kg/ha)					
	1999-2000		2000-2001		2001-2002	
	Potato	Jute	Potato	Jute	Potato	Jute
Manurial treatment to potato						
Control	39.40	47.14	35.96	43.99	31.05	42.10
NPK (10:26:26)	109.78	77.53	110.65	78.17	101.13	78.05
NPK (10:26:26)+ FYM	96.98	81.65	117.64	83.92	107.65	84.72
NPK (15:15:15)	104.00	72.56	104.50	75.24	93.32	72.15
NPK (15:15:15)+ FYM	91.79	75.05	110.20	79.48	98.21	83.51
Urea + SSP + M0P	88.02	65.62	94.29	66.24	84.10	66.21
Urea + SSP + M0P + FYM	88.02	68.91	94.29	70.83	86.57	69.41
SEm±	2.05	1.44	0.81	0.78	1.27	0.84
CD (P=0.05)	6.30	4.43	2.49	2.42	3.92	2.57
Fertilizer dose to jute						
40 kg N + 8.8 kg P + 16.6 kg K/ha		72.62		88.90	74.57	91.02	73.81
40 kg N/ha		66.93		80.34	67.68	82.34	67.32
SEm±		0.29		0.31	0.44	0.42	0.38
CD (P=0.05)		NS		0.91	NS	1.21	NS

FYM and inorganic fertilizers either as complex or straight form recorded significantly higher P uptake in potato-jute sequence compared with the use of inorganic forms only (Table 2). Maximum annual uptake of phosphors was recorded by the integrated use of NPK (10:26:26) and FYM (30.78 kg/ha) which was 3.4% more than in the treatment where only NPK (10:26:26) was applied in potato. Similar trend was noticed in the treatment involving integrated use of FYM with NPK (15:15:15) or straight fertilizers. Integrated use of FYM and straight fertilizer resulted in 5.5% higher uptake of P over its sole use in potato. Integrated use of NPK (10:26:26) and FYM in potato recorded higher K uptake (190.68 kg/ha) in the system (Table 2). This might be due to increased availability and uptake of potassium resulting from added FYM, and perhaps also due to prolific root system developed by the balanced nutrient application, leading to better absorption of water and nutrients. The uptake of K in the system followed the same pattern of yield.

Soil-fertility status and nutrient balance

The soil-nutrient status after completion of three continuous cropping sequences is presented in Table 3. It shows that the total N, available P and available K status of soil after three sequences, i.e. after sixth crop, improved with the integrated use of FYM and complex fertilizers except in the treatments where straight fertilizers were used or no fertilizer was applied. There was a build-up of 10.2% total N, 6.3% available P and 3.9% available K in the soil compared with the initial status with the manurial treatment in which integrated use of FYM and NPK (10:26:26) in potato. There was an appreciable increment in nutrient status of soil, which became possible due to the application of organics as FYM and incorporation of jute leaves in the system. Chettri *et al.* (2004) also observed improvement in soil-fertility status with integrated nutrient management in potato-based cropping sequence under West Bengal condition.

Nutrient balance was higher in the manurial treatments received inorganic fertilizers alone. Maximum (184.1 kg N, 260.4 kg P and - 62.2 kg K/ha) balance of nutrients after the sixth crop was recoded with the treatment in which straight fertilizers were applied to potato crop (Table 3). It might be due to greater production and better utilization of nutrients in the treatments where there was a combined use of FYM and inorganic fertilizers, resulting in low balance. Generally in potato-based crop sequences the K balance became negative, which could be improved with integrated use of FYM and complex fertilizers in long run.

Economics

The economics of integrated nutrient-management

Table 3. Balance sheet of total N, available P and available K in potato-jute sequence as influenced by integrated nutrient-management practices

Treatment	Initial soil status (kg/ha) (a)			Nutrient added through fertilizer and leaf fall (kg/ha) (b)			Uptake by both potato and jute (kg/ha) (c)			Final soil status (kg/ha) (d)			Balance (kg/ha) [(a+b) – (c+d)]		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Control	1,180	21.8	170.2	174.1	34.6	66.6	206.6	47.1	239.6	1,240	21.1	161.1	- 92.4	- 11.8	- 163.9
NPK (10:26:26)	1,180	21.8	170.2	663.5	338.3	407.3	478.5	89.3	555.3	1,280	22.4	171.9	84.7	248.2	- 149.6
NPK (10:26:26)+ FYM	1,180	21.8	170.2	665.3	338.7	410.9	480.5	92.3	572.5	1,300	23.1	176.8	64.7	245.0	- 168.2
NPK (15:15:15)	1,180	21.8	170.2	661.8	338.2	405.2	474.7	86.3	521.7	1,260	22.0	171.9	107.0	251.5	- 118.2
NPK (15:15:15)+ FYM	1,180	21.8	170.2	663.9	338.4	407.2	469.2	88.9	538.2	1,280	22.9	175.0	97.7	248.3	- 135.8
Urea + SSP + M0P	1,180	21.8	170.2	651.0	337.3	396.9	426.9	76.9	464.4	1,220	21.7	164.9	184.1	260.4	- 62.2
Urea + SSP + M0P + FYM	1,180	21.8	170.2	654.0	337.6	399.8	436.4	81.1	478.0	1,240	22.1	169.3	157.6	256.1	- 77.3

Table 4. Economics of potato-jute sequence as influenced by different integrated nutrient management practices (mean data of 3 years)

Treatment	Yield (t/ ha)			Cost of fertilizers and manures (Rs/ha)	Total cost of cultivation (×10³ Rs/ha)	Net returns (×10³ Rs/ha)	Returns per Re invested (Rs)
	Potato tuber	Jute					
		Fibre	Stick				
40 kg N+8.8 kg P+ 16.6 kg K/ha to jute							
Control	10.79	3.36	6.61	909	35.91	17.31	1.48
NPK (10:26:26)	23.02	4.07	9.32	5,039	40.04	44.33	2.11
NPK (10:26:26)+ FYM	24.11	4.38	9.78	5,158	40.16	48.58	2.21
NPK (15:15:15)	22.74	3.77	8.99	6,775	41.78	39.62	1.95
NPK (15:15:15)+ FYM	22.81	4.03	9.35	5,945	40.95	41.92	2.02
Urea, SSP, MOP	20.94	3.59	7.95	4,940	39.94	34.50	1.86
Urea, SSP, MOP + FYM	20.87	3.78	8.36	4,817	39.81	35.02	1.88
40 kg N/ha to jute							
Control	10.28	3.28	6.21	400	35.40	16.56	1.47
NPK (10:26:26)	22.70	3.75	8.48	4,530	39.53	41.73	2.06
NPK (10:26:26)+ FYM	23.42	3.98	9.06	4,649	39.65	42.94	2.08
NPK (15:15:15)	22.33	3.63	8.31	6,266	41.27	36.83	1.89
NPK (15:15:15)+ FYM	22.71	3.89	8.68	5,436	40.44	39.26	1.97
Urea, SSP, MOP	19.83	3.49	7.40	4,431	39.43	32.57	1.83
Urea, SSP, MOP + FYM	20.41	3.67	7.65	4,308	39.31	34.28	1.87

Cost of cultivation excluding the cost of fertilizers and manures in potato-jute sequence – Rs 35,000/ha

practices in potato-jute sequence provides average crop productivity, net return and return per rupee investment (Table 4). The treatment with integrated use of NPK (10:26:26) + FYM in potato followed by 40 kg N + 8.8 kg P + 16.6 kg K/ha in jute produced the maximum net return of Rs 48,580/ha, closely followed by the integrated use of NPK (10:26:26) + FYM in potato followed by only 40 kg N/ha in jute, with Rs 42,937/ha. Returns per Re invested were also maximum with the former treatment (Rs 2.21). The other complex fertilizer NPK (15:15:15), when used in combination with FYM in potato followed by 40 kg N + 8.8 kg P + 16.6 kg K/ha in jute, produced Rs 2.02 return per rupee investment. It was because of higher productivity of crops under combined application of FYM and complex fertilizers and consequently with a higher market price of the produce.

It was concluded that to get maximum productivity (23.77 t/ha of tuber and 4.18 t/ha of jute fibre) and profitability (Rs 48,580/ha) from a potato-jute cropping sequence under West Bengal condition, the crop should be manured with integrated use of NPK (10:26:26) and FYM (7.8 t/ha) to potato, followed by 40 kg N + 8.8 kg P + 16.6 kg K/ha to jute crop. Complex fertilizer either NPK (10:26:26) or NPK (15:15:15) proved superior to straight fertilizers in influencing the productivity and profitability of the crop.

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