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Productivity, profitability and apparent nutrient balance under different crop sequence in mid hill condition*

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Long conventional cropping system of rice (*Oryza sativa* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) is being followed in the most part of the eastern Himalayan region since more than 3 decades (Bera *et al*. 2005). The productivity of rice–wheat system has shown trend consistently declining in most of area and as such the income from this system is hardly sufficient for its continuance on sustainable basis. The present experiment was carried out to evaluate economically viable, feasible, crop sequences and their relative nutrient balance in the soil under mid hill situation of eastern Himalaya.

The field study was conducted during 2007–09 and at Regional Research Station (Hill Zone), Kalimpong (20° 31′ and 27° 31′ North latitude and between 87° 59′ and 88° 53′ East longitude) under the aegis of Uttar Banga Krishi Viswavidyalaya at about 1 250 m above mean sea levels. The soil was sandy loam in texture, high in organic carbon (0.91%), available N (206 kg/ha), P_2O_5 (22.6 kg/ha) and K_2O (229.7 kg/ha) content with *p*H 5.3. The rainfall distribution was very erratic and total rainfall received during 2007–08 and 2008–09 (July–September) was 1 431 and 1 508 mm, respectively. Treatment comprised 11 cropping sequences system (Table 1) with following variety, viz 'Munal' rice (*Oryza sativa* L.), 'RCM 1-3' maize (*Zea mays* L.), 'PBW 343' wheat (*Triticum aestivum* L. emend. Fiori & Paol.), 'PK 472' soybean (*Glycin max* (L). Merr.), 'B 9' mustard (*Brassica juncea* (L.) Czern & Coss), 'Sarda' blackgram (*Phaseolus mungo* L.), 'Kufri jyoti' potato (*Solanum tuberosum* L.), local variety of dollay (chilly) (*Capsicum frutescens* L.), 'Bhainsey' ginger (*Zingiber officinale* L.), 'White short' cauliflower (*Brassica oleracea* L.) and 'Rare ball' cabbage (*Brassica oleracea capitata* L.). Crop included in different sequences were raised with recommended agronomic practices. The treatments were tested in randomized block design with 3 replication. For comparison

Table 1 Nutrient removal and balance sheet of nutrient in different cropping system (pooled analysis of 2007–08 and 2008–09).

Cropping sequence	Total nutrient applied (kg/ha)			Total nutrient removed (kg/ha)			Nutrient balance in soil (kg/ha)		
	N	P	K	N	P	K	N	P	K
Rice–wheat	440	86.0	166.3	378.7	50.3	415.3	+ 61.3	+ 35.6	– 249.3
Soybean–wheat	320	103.2	132.8	479.0	119.9	428.5	– 159.0	– 16.7	– 295.7
Blackgram–wheat	300	108.9	199.2	331.3	43.6	399.8	+ 31.3	+ 65.2	– 200.6
Maize –wheat	520	104.2	197.2	440.4	81.7	462.8	+ 79.6	+ 22.4	–265.6
Maize–cabbage	680	137.6	265.6	696.6	125.5	662.8	– 16.6	+ 12.0	– 397.0
Rice–cauliflower	500	120.4	99.6	462.7	100.4	452.1	+ 37.3	+ 20.0	– 352.5
Ginger–wheat	480	107.2	232.4	388.3	65.9	444.2	+ 91.7	+ 41.2	– 211.8
Dollay (local chilly)–wheat	440	106.2	199.2	511.3	87.4	526.1	– 71.3	+ 18.7	– 326.0
Rice–potato	600	163.4	315.4	511.6	85.0	693.0	+ 88.4	+ 78.3	– 377.6
Maize–mustard	480	94.6	182.6	352.6	82.9	332.7	+127.4	+ 11.6	– 150.1
Rice–mustard	400	77.4	149.4	299.5	41.4	294.4	+ 100.5	+ 35.9	– 145.0
SEm ±				18.6	4.3	19.6			
CD (*P*=0.05)				52.9	12.6	80.9			

*Short note

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between crop sequences, the yields of all crop sequences were converted into wheat equivalent on price basis. Productivity values in terms of kg/ha/day was calculated dividing the production of the sequence by total duration of sequence and profitability in terms of Rs/ha/day was obtained by net returns of sequence divided by total duration of sequence (Rautaray 2005). The economics and wheat equivalent yield were computed at prevailing market rates during 2008–09 of different commodities. The market price of rice seed (Rs 10.20/kg), wheat seed (Rs 10.40/kg), soyabean seed (Rs 28/kg), blackgram seed (Rs 45/kg), maize seed (Rs 24/kg), cabbage head (Rs 7/kg), cauliflower head (Rs 10/kg), ginger (Rs 30/kg), dollay chilli (Rs 70/kg), potato tuber (Rs 7.50/kg) Indian mustard seed (Rs 40/kg), rice stover (Rs 260/tonnes), wheat stover (Rs 265/tonnes), soybean stover (Rs 140/tonnes), blackgram stover (Rs 132/tonnes), maize stover (Rs 222/kg), mustard stover (Rs 150/tonnes), cabbage leaf (Rs 2/kg) and cauliflower leaf (Rs 3/kg) were taken for calculating the gross return accured from the system. The crop sequence was evaluated based on a sustainability index (Gupta *et al.* 2006). The N, P and K were applied through urea, single superphosphate and muriate of potash respectively. In case of potato instead of muriate of potash, potassium sulphate was applied. Initial soil status and plant sample under different cropping sequence was collected and analyzed following the standard procedure.

The highest removal of N was recorded in maize–cabbage cropping sequence, and was significantly superior to other cropping sequence (Table 1), followed by rice – potato and dollay (chilly) – wheat sequence. The maximum removal of N may be attributed to greater biomass production of crops under these cropping systems (Sharma and Sharma 2002). The phosphorus and potassium uptake by different cropping system in a year was 41.4–125.5 kg P/ha and 294.4–693.0 kg K/ha, respectively. Amongst all cropping sequence maize–cabbage was found to the most exhaustive cropping system, which resulted in highest P uptake and significantly superior to all the tested sequences. The highest removal of K was recorded in rice–potato sequence which, however, showed statistical parity with maize–cabbage cropping system. Highest K uptake by rice–potato sequence was due to exhaustive nature of potato for K nutrient. Amongst all the tested sequences, least nutrient mining was recorded with rice–mustard rotation, and was statistically at par with blackgram–wheat sequence.

Budgeting of the nutrients added as fertilizer and of those removed by the crops showed maximum deficit of nitrogen in soybean–wheat and was followed by dollay (chilly)–wheat cropping sequence. This deficit was mainly due to lesser quantity of N applied to the legume crops and higher N concentration in the plant as well as higher biomass production (Mukherjee and Moktan 2008). The balance of P was positive in all the cropping system except soybean–wheat sequence. This varied from 11.6 of maize–mustard to 78.3 kg/ha in rice–potato sequence. This shows that the P removed by the crops was less than that applied to them. The maximum deficit of P 8.3 kg/ha/year was observed in soybean–wheat sequence, indicating that the quantity of P applied to crop was less than that removal from the soil. The highest gap between addition and removal was observed in potassium, which resulted in negative K balance in all the cropping systems. The maximum deficit of K was observed under maize–cabbage, followed by rice–potato (Sharma *et al.* 2008). These results indicate an alarming situation for mining

Table 2 Wheat equivalent yield, mean crop yield, economics and other parameter under different cropping system (pooled analysis of 2007–08 and 2008–09)

Cropping system	Wheat equivalent yield(kg/ha)	Mean crop yield			Cost of cultivation (Rs /ha)	Net returns (Rs /ha)	Benefit: cost ratio	Production	Profitability	Net profit or loss over rice–wheat system (Rs /ha)	Sustainable yield index (%)
		Kharif	*Rabi*	Total				(kg/ha/day)	(Rs /ha/day)		
Rice–wheat	5 135	4 316	3 619	7935	46 320	58 520	2.26	28.75	212.06		35.1
Soybean–wheat	6 012	1 950	3 614	5564	49 640	70 090	2.41	19.18	248.57	11 560	48.9
Blackgram–wheat	6 581	1 313	3 885	5198	50 840	83 510	2.64	18.44	308.15	24 970	64.9
Maize–wheat	6 376	4 102	3 821	7923	47 130	70 180	2.48	28.91	256.13	11 650	49.0
Maize–cabbage	5 858	4 013	64 301	68314	46 910	64 550	2.57	325.30	307.42	6 030	42.2
Rice–cauliflower	4 534	4 509	46 900	51409	44 100	53 530	2.21	239.11	248.99	–4 990	29.0
Ginger–wheat	4 629	2 302	3 419	5721	45 160	53 660	2.18	18.27	171.45	–4 860	29.2
Dollay (local chilly) –wheat	4 341	1 208	3 516	4724	39 940	50 880	2.27	14.99	161.53	–7 640	25.9
Rice–potato	3 779	4 319	42 319	46638	47 190	44 560	1.94	190.35	181.91	–13 960	18.3
Maize–mustard	4 453	3 916	1 094	5010	45 640	51 000	2.11	19.57	199.23	–7 520	26.0
Rice– mustard	5 246	4 617	1 019	1019	45 840	60 710	2.32	20.95	225.72	2 190	37.6
SEm ±	191										
CD (P=0.05)	563										

of nutrients from hill soils, which requires a fresh look to revise them as per needs of the crops in the cropping system. However, this nutrient mining was quite low with blackgram–wheat sequence compared to all other tested system, indicating that this is most suitable under mid hill situation of eastern Himalayan region.

The pooled analysis data indicated that wheat equivalent yield of blackgram–wheat sequence was significantly higher than rest of the rotation except maize–wheat cropping sequence (Table 2). This tested crop sequence resulted in 28.2.% more grain yield over traditional practice of rice–wheat system. Profitability in term of Rs/ha/day was highest with blackgram–wheat, followed by maize–wheat and soybean–wheat, while production in terms of kg/ha/day was the highest in maize–cabbage sequence, followed by rice–cauliflower sequence.

Amongst *kharif* crop rice gave the highest mean grain yield (4 617 kg/ha) in rice–mustard sequence, followed by maize and ginger in maize–wheat and ginger–wheat rotation, respectively. Within *rabi* season grain yield, wheat shared of 3 885 kg/ha under blackgram – wheat sequence, and was followed by mustard crop under rice – mustard rotation (Table 2). However, per unit production of cabbage was highest and was followed by cauliflower and potato. Further study reveled that wheat production was more in blackgram–wheat cropping system compared to other sequence, presumably owing to beneficial effect of legumes on succeeding crop. This corroborates the earlier findings of Rao and Rogers (2006).

Blackgram–wheat crop sequence was found to be highly sustainable, giving 64.9% sustainability yield index, followed by maize–wheat and soybean–wheat sequence (Table 2). Sustainable index of rice–wheat sequence was quite low, this might be due to drop in soil organic matter and imbalance use of fertilizer and no N contribution from the atmosphere N-fixation (Gill 2008).

Economic analysis (Table 2) indicated that blackgram–wheat sequence gave the highest net returns (Rs 83 510/ha), followed by maize–wheat and soybean – wheat rotation. The results also revealed that higher benefit : cost ratio was obtained from blackgram–wheat (2.64) and maize–cabbage (2.57) cropping sequence. This corroborate with the earlier finding of Choudhary *et al*. (2001). However, least ratio was obtained with rice–potato (1.94), followed by maize–mustard (2.11) cropping sequence. Blackgram–wheat, maize–wheat and soybean – wheat sequence gave higher net returns of Rs 24 970, 11 650 and 11 560 thousand/ha, respectively, over traditional rice – wheat rotation which was most dominating sequence in hills.

SUMMARY

The productivity, profitability and sustainable yield index were higher under blackgram – wheat and maize – wheat cropping sequence than the traditional rice –wheat sequence. Further, overall nutrient mining by this system was quite low compared to other sequences which are practised in this region.

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