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Energetics and economics of cropping sequences and nitrogen levels

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ABSTRACT

A field experiment was conducted at Ranchi during 1993–95, to evaluate the yield, energetics and economics of 5 cropping sequences, viz. soybean [*Glycine, max* (L.) Merr.] – wheat (*Triticum aestivum* L. emend. Fiori & Paol.), cowpea [*Vigna unguiculata* (L.) Walp]– wheat, blackgram (*Phaseolus mungo* L.)–wheat, stylo (*Stylosanthes hamata* L.)–wheat and rice (*Oryza sativa* L.)–wheat. The succeeding wheat in all the sequences was raised at 5 levels of N (0, 25, 50, 75 and 100 kg N/ha). Wheat as a succeeding crop to blackgram gave the maximum yield. Stylo–wheat sequence as a whole proved more profitable, as it gave more net income and net benefit to each rupee of investment, and soybean–wheat sequence provided the maximum protein. Nitrogen 75 kg/ha was found as good as 100 kg N/ha for grain and protein yields in wheat, when grown after legume. The stylo–wheat sequence recorded the maximum output of energy for both economical and biological yields. This sequence was also found more efficient in energy utilization and productivity. Application of 75 kg N/ha to succeeding wheat was more efficient in energy utilization and productivity as compared to lower as well as higher levels of N.

Key words : Energetics, Cropping sequence, Economics, Legumes, Wheat

The maximum biomass production as a source of energy is the only way out to cater to the needs of demographic compulsions in the coming century. Since land is the limited enterprise, judicious cropping to enhance the production of biomass per unit time and space in terms of energy is the need of the hour. The sustainability of a crop-production system, is not merely adjudged by only its biomass yield. The said system must be economically and energetically viable. Therefore, an inclusion of nitrogen fixer (legume) in a sequential cropping system needs to be quantitatively evaluated for its biological potential to produce food, forage

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and fuel. Energy input : output relationship together with economics of 5 cropping sequences consisting of 3 grain legumes, 1 pasture legume, and cereal (rice) followed by wheat was conducted under variable levels of nitrogen.

MATERIALS AND METHODS

The experiment was conducted during 1993–95 at Ranchi, Bihar. Five rainy-season (*kharif*) crops, 'Brag' soybean, 'Gomati' cowpea, 'T 9' blackgram, 'Verano' stylo and 'Browngora' rice, were kept in main plots under recommended level of nutrients and cultural practices. Each plot was further splitted into 5 subplots to put nitrogen levels (0, 25, 50, 75 and 100 kg/ha) for sowing of 'UP 262' wheat during the winter (*rabi*) season. Thus, 25 treatments were kept in split-plot design and replicated thrice.

The soil was sandy loam (37.7% sand, 1.1% silt and 11.2% clay). It was low in pH (6.1) and organic carbon (0.42%), having available N, P and K 230, 15.2 and 180 kg/ha respectively. The nutrients for all legumes @ 25.0 N, 26.4 P and 20.0 K kg/ha, whereas for succeeding rice @ 40.0 kg N, 12.0 kg P and 8.8 kg K/ha were applied. In succeeding wheat, 5 N levels as per treatments along with uniform level of P and K @ 22.0 and 32.0 kg/ha were applied to all plots. The rainy-season crops were grown rainfed and 7 irrigations were given to

Table 1. Yield and economics as influenced by sequence and N level (pooled data of 2 years)

Treatment	Rainy-season crop (tonnes/ha)		Winter season (tonnes/ha)		Protein (tonnes/ha)	Economics	
	Green forage	Straw dry forage	Wheat grain	Wheat straw		Net return (Rs/ha)	Net return (Rs/Re)
Crop sequence							
Soybean–wheat	1.44	2.08	2.32	3.24	7.18	5,695	0.48
Cowpea–wheat	0.94	2.35	2.53	3.56	3.36	4,031	0.35
Blackgram–wheat	1.06	3.06	3.13	4.33	4.39	7,301	0.65
Stylo–wheat	16.00	3.19	2.42	3.28	5.19	12,850	1.33
Rice–wheat	1.88	3.23	2.14	2.96	2.61	1,613	0.04
CD (P = 0.05)			0.42	0.36	0.43	1,613	0.04
N (kg/ha)							
0			1.60	2.86	3.78	3,716	0.30
25			2.17	3.07	4.32	5,442	0.48
50			2.59	3.37	4.70	6,768	0.60
75			3.00	3.87	5.18	8,083	0.70
100			3.17	4.19	5.46	8,551	0.73
CD (P = 0.05)			0.25	0.42	0.36	874	0.08

wheat. Grain and straw yields of grain crops and green and dry herbage yields of forage crops were recorded. The energetics (MJ/ha) of each treatment (sequences × N levels) was calculated on the basis of energy inputs (human labour, bullocks hour, diesel, fertilizers, seeds and pesticides) output (grain, straw and dry herbage yields), and energy productivity (g/MJ/ha) was calculated dividing the mean grain yield of 2 years by corresponding energy input as per Paneshwar and Bhatnagar (1994). The economics were calculated on the basis of prevailing farm rate during the years.

RESULTS AND DISCUSSION

Yield

Wheat grown (Table 1) after blackgram gave significantly the highest grain as well as straw yields among rest of the preceding legumes and rice; however, stylo–wheat sequence was found more remunerative system owing to higher forage biomass production, followed by better price of the same. Introduction of a forage component in a cropping system resulted in higher net profit to per rupee investment (Prasad and Kerketta, 1991). Soybean, being a crop of having more protein, accounted for better contribution to protein harvest due to the fact that soybean–wheat sequence resulted in maximum protein which was followed by stylo–wheat sequence.

Though an increase the N application in increased the wheat yield, application of 75 kg N/ha was found statistically similar to

Table 2. Energy input : output relationship as influenced by sequence and N level (pooled data of 2 years)

Crop	Energy input (MJ/ha/year)	Energy output (MJ/ha/year)		Energy-use efficiency		Energy productivity (g/MJ/ha)
		Economic yield	Biological yield	Economic yield	Biological yield	
Crop sequence						
Soybean–wheat	19,896	5,5223	102,836	2.78	5.16	349.7
Cowpea–wheat	19,087	50,999	103,263	2.67	5.41	365.9
Blackgram–wheat	19,087	61,554	125,156	3.22	6.55	444.3
Stylo–wheat	18,883	91,120	139,346	4.83	7.38	465.5
Rice–wheat	20,705	55,076	98,559	2.66	4.76	322.0
CD (P = 0.05)		4,260	6,562	0.22	0.33	22.5
N (kg/ha)						
0	16,492	49,560	91,533	3.01	5.55	376.3
25	1,007	57,831	102,960	3.22	5.72	382.9
50	19,533	64,010	113,593	3.28	5.82	389.5
75	210,48	70,022	126,911	3.33	6.03	404,9
100	22,577	72,585	134,163	3.21	5.92	398.9
CD (P = 0.05)		2,966	6,039	0.16	0.31	20.6

wheat produced at 100 kg N/ha and the same was true for net benefit : cost ratio and protein yields too. It indicated that saving of 25 kg N/ha in wheat cultivation can be possible, if it is grown as a succeeding crop to legume.

Energetics of cropping sequence

Rice–wheat sequence required higher energy than all the legume–wheat sequences due to higher indirect energy input in terms of rice seed. Singh *et al.* (1997) also reported such a higher energy requirement by cereal–cereal sequence. Energy output in terms of economic and biological yields was recorded significantly higher under stylo–wheat sequence due to higher energy value of forage component. Among the grain legume–wheat sequences, blackgram–wheat sequence accounted for the maximum output of energy. The stylo–wheat sequence was further found more efficient in energy utilization to per unit of energy investment for economic as well as biological yields and the same also accounted for highest energy productivity which was followed by blackgram–wheat sequence.

Energetics of N to succeeding wheat

An increase in level of N increased the energy input. Application of 75 kg N/ha was quite sufficient to produce statistically equal amount of energy to what was recorded in presence of 100 kg N/ha. However, for energy-use efficiency, levels of 25, 50 or 75 kg N/ha were equally good and addition of 100 kg N/ha decreased the energy-use efficiency of wheat compared to that was accounted at 75 N/ha for both economic and biological yields. The energy productivity further revealed the fact that application of N beyond 75 kg N/ha to wheat after legume was not advisable, since it recorded a decreasing trend.

Thus wheat grown after legume with 75 kg N/ha is more productive in terms of wheat and protein yields as well as more remunerative, and the same is also more energetically viable. Among the sequences, stylo–wheat sequence is better than rest of the tested sequences, however, wheat raised after blackgram gave higher wheat yield than when it is grown either after other legumes or rice.

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