Indian Journal of Agronomy **46** (2) : 198–203 (June 2001)

Grain production of wheat (*Triticum aestivum*), and nitrogen and phosphorus balance sheet in soil under sorghum (*Sorghum bicolor*) + cowpea (*Vigna unguiculata*)–wheat crop sequence

ASHOK KUMAR AND J.S. BALYAN

Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012

Received : April 2000

ABSTRACT

A 2-year (1995–96 and 1996–97) field experiment showed that grain and straw yields of wheat (*Triticum aestivum* L. emend. Fiori & Paol.) were maximum when grown after sorghum [*Sorghum bicolor* (L.) Moench] + cowpea [*Vigna unguiculata* (L.) Walp.] (F), followed by cowpea grain (SI) and these were found to be significantly higher than after sole crop of sorghum (F.) Phosphorus applied to previous rainy-season crops up to 30 kg/ha and direct applied N to wheat up to 75 kg/ha helped in increasing the grain and straw yields of wheat in both the years. The nitrogen, phosphorus and organic carbon (%) of soil improved owing to legume introduction in the cropping systems. The net returns and benefit : cost ratio from sorghum + cowpea (F)–wheat sequence were maximum, while sorghum (F)–wheat sequence gave least net returns.

Key words : Sorghum, Cowpea, Straw incorporation, Cropping system

Nutrients requirement of crops is increasing day by day due to intensive cropping and the use of chemical fertilizer is increasing correspondingly without due consideration of organic sources, resulting in lower yield and poor fertility. These fertilizers are very costly and one of the essential aspects of agriculture. Studies have shown that organic source like inclusion of legumes in cropping systems improves nitrogen status of soil and helps increas the yield of base as well as succeeding cereal crops (Balyan, 1990). Therefore the present experiment was conducted to study the economic use of nitrogen through recycling of organic residues in sorghum + cowpea–wheat cropping system.

MATERIALS AND METHODS

A field experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons of 1995–96 and 1996–97 at New Delhi. The treatments consisting of 3

cropping systems, viz. sorghum (F), sorghum + cowpea (F) and cowpea grain (SI), and 3 levels of phosphorus (0, 30 and 60 kg P_2O_5/ha) as main plots replicated thrice in randomized block design during rainy season. In the winter season, the rainy-season plots were divided into 3 subplots and nitrogen levels (0, 75 and 150 kg N/ha) were applied to wheat. The varieties were 'Pusa Chari', 'EC 4216', 'C 152' and 'HD 2285' of fodder sorghum, fodder cowpea, grain cowpea and wheat respectively. Sorghum and cowpea were removed from the field for green fodder 60 days after sowing, while cowpea (grain) was harvested at the maturity and straw was incorporated into the field. The soil was sandy loam in texture with pH 7.8, poor in organic carbon, deficient in N (total N 0.058%) and poor in available P (9.10 kg/ha) and rich in available K (270 kg/ha).

RESULTS AND DISCUSSION

Effect of system

Previous rainy-season crops, i.e. sorghum + cowpea (F) and cowpea grain (SI), being at par augmented the grain and straw yields of succeeding wheat significantly higher than sorghum (F)–wheat crop sequence (Table 1). The increase in wheat yield might be attributed to the effect of legume like cowpea which might have provided an additional N to succeeding wheat through biological N fixation and

Table 1. Grain and straw yields of wheat and length of ear and organic carbon in soil under different treatments

Treatment	Grain yield (q/ha)*	Straw yield (q/ha)*	Length of ear (cm)		Organic carbon (%)	
			1995–96	1996–97	1995–96	1996–97
Cropping system						
Sorghum (F)	35.72	53.38	8.08	7.70	0.38	0.38
Sorghum+cowpea (F)	45.72	62.08	8.41	8.02	0 41	0.43
Cowpea grain (SI)	44.25	59.92	8.66	8.29	0.45	0.46
CD (P=0.05)	2.29	3.45	NS	NS	NS	NS
P_2O_5 (kg/ha)						
0	39.57	54.69	8.25	7.80	0.41	0.42
30	42.55	59.26	8.42	8.09	0.41	0.43
60	43.58	61.37	8.48	8.12	0.42	0.43
CD (P=0.05)	2.29	3.45	NS	NS	NS	NS
N (kg/ha) to wheat						
0	34.94	49.81	8.03	7.64	0.35	0.36
75	44.36	61.95	8.52	8.11	0.44	0.45
150	46.37	64.12	8.60	8.26	0.45	0.47
CD (P=0.05)	2.04	2.92	0.42	0.44	0 03	0.03

*Mean data of 2 years

mineralization of root biomass. The results are similar to those reported by Balyan (1997).

Effect of fertility

Grain and straw yields of wheat being at par due to residual effect of phosphorus at 30 and 60 kg/ha, found significantly superior to the control (Table 1). These findings corroborated the observations of Lal *et al.* (1997).

Higher grain and straw yields of wheat were found with the levels of 150, followed by 75 kg N/ha and these both levels being at par found significantly superior to the control (Table 1). These findings confirm the results of Singh *et al.* (1996).

Length of ear indicated that wheat did not exhibit significant variation due to preceding crops and residual effect of phosphorus in any of the years (Table 1).

Application of N significantly increased length of ear of wheat over no nitrogen level. However, the differences between 75 and 150 kg N/ha were not perceptible (Table 1).

Organic carbon (%)

Neither rainy-season crops nor residual phosphorus influenced the organic carbon (%) in soil after harvesting of wheat experiment (Table 1).

Organic carbon in soil increased significantly with the increase in N up to 75 kg/ha over no nitrogen. However, further increase in N up to 150 kg/ha did not differ markedly over its preceded level (Table 1).

Soil N net balance

The difference in total soil N after harvesting of wheat crop and initial soil N status (982, 990) provided the mean N balance in cowpea grain (SI) (90.5 kg/ha) plots, followed by sorghum + cowpea (F) (72.5 kg/ha). Sorghum (F) resulted in negative soil N balance, being 41 kg/ha (Table 2).

Both the higher levels of P_2O_5 (30 and 60 kg/ha) left the mean soil N balance over the seasons to the tune of 40 and 68.5 kg/ha respectively. While the lower quantity of total N was left in the soil of control plot (Table 2).

There was net gain in mean soil N, i.e. 61.00 and 72.50 kg/ha, after wheat harvesting at 75 and 150 kg N/ha respectively. Wheat without N left the soil below the initial soil N status. The loss in soil total N recorded 11.00 kg/ha over 2 seasons (Table 2).

Soil-available P net balance

The mean soil-available P balance over the seasons was highest in cowpea grain (SI) plots, followed by sorghum + cowpea (F). However, sorghum (F) plots recorded minimum soil P balance (Table 3).

Both the highest levels of 30 and 60 kg P_2O_5/ha recorded the mean P balance of 1.73 and 2.04 kg/ha, respectively, in both the years. While the lowest amount of soil P was observed under the control plots (Table 3).

There was a gain of mean soil-available P, 2.40 and 2.68 kg/ha at the levels of 75 and 150 kg N/ha, after harvesting of wheat in both the years respectively. However, lowest amount of soil-available P (0.13 kg/ha) was recorded in the control plots.

Table 2. Balance sheet of total N (kg/ha) in soil as influenced by different treatment

Treatment	At initial stage		After rainy-season crops		After winter crops		Changes in soil N status		N removal by rainy-season and winter crops		Soil N net balance (kg/ha)		
	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	Mean
Cropping system													
Sorghum (F)	982	990	918.08	934.54	932.60	958.00	–64	–56	131.75	128.28	–50	–32	–41.0
Sorghum + cowpea (F)	982	990	1,024.53	1,073.08	1,050.20	1,067.00	42	83	148.86	144 36	68	77	72.5
Cowpea grain (SI)	982	990	1,040.29	1,082 00	1,059.30	1,084.00	58	92	139.20	132.66	87	94	90.5
CD (P=0.05)			71.29	73.88	NS	54.44							
P_2O_5 (kg/ha)													
0	982	990	977.20	1.014.51	987.70	1.012.50	–5	24	130.12	124.74	6	22	14.0
30	982	990	995.32	1,020.60	1.013.30	1,039.00	13	30	155.25	149.40	31	49	40.0
60	982	990	1,010.35	1,045.29	1,051.10	1,058.60	28	55	163.55	158.53	69	68	68.5
CD (P=0.05)			NS	NS	NS	NS							
N (kg/ha) to wheat													
0	982	990			980.00	969.80			82.89	76.42	–2	–20	–11.0
75	982	990			1.031.40	1,064.70			114.81	106.25	48	74	61.0
150	982	990			1,041.70	1,075.51			122.25	111.73	60	85	72.5
CD (P=0.05)					43.47	47.50							

Table 3. Balance sheet of available P (kg/ha) in soil as influenced by different treatments

Treatment	At initial stage		After rainy-season crops		After winter crops		Changes in soil P status		P removal by rainy-season and *winter* crops		Soil P net balance (kg/ha)		
	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	Mean
Cropping system													
Sorghum (F)	9.35	9.14	11.95	12.17	9.90	9.47	2.60	3.03	33.54	30.25	0.55	0.33	0.44
Sorghum+cowpea (F)	9.35	9.14	12.98	13.05	10.81	10 48	3.63	3.91	32.94	31.02	1.46	1.34	1.40
Cowpea grain (SI)	9.35	9.14	13.29	13.75	11.83	12.35	3.94	4.61	25.72	23.77	2.48	3.21	2.84
CD (P=0.05)			1.05	1.16	0.63	0.68							
P_2O_5 (kg/ha)													
0	9.35	9.14	10.71	10 78	10.92	10.48	1.36	1.64	25.31	23.37	1.57	1.34	1.45
30	9.35	9.14	13.50	13.89	11.20	10.75	4.15	4.75	32.13	29.39	1.85	1.61	1.73
60	9.35	9.14	14.01	14.30	11.52	11.05	4.66	5.16	35.04	32.75	2.17	1.91	2.04
CD (P = 0.05)			1.05	1.16	NS	NS							
N (kg/ha) to wheat													
0	9.35	9.14			9.57	9.19			11.11	10.10	0.22	0.05	0.13
75	9.35	9.14			11.90	11.39			14.12	12.80	2.55	2.25	2.40
150	9.35	9.14			12.16	11.70			14.86	13.52	2.81	2.56	2.68
CD (P=0.05)					0.53	0.61							

Table 4. Economics (Rs/ha) of various crop sequences

Sequences	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	Benefit : cost ratio
Sorghum (F)–wheat	31,455	14,853	16,602	1.11
Sorghum + cowpea (F)–wheat	39,966	15,011	24,954	1.66
Cowpea grain (SI)–wheat	33,684	14,399	19,285	1.33

Economics

The maximum net returns obtained in sorghum + cowpea (F)–wheat, followed by cowpea grain (SI)–wheat sequence. Sorghum (F)–wheat sequence gave least net returns (Table 4). This was due to lowest yield of wheat after sorghum during both the seasons and higher cost of production. Sinsinwar (1994) obtained similar results.

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