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Performance of legume–sorghum (*Sorghum bicolor*) cropping sequence in Vertisols

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ABSTRACT

A field experiment with legume–sorghum [*Sorghum bicolor* (L.) Moench] cropping sequence was conducted on medium deep black soil during 1990–91, 1991–92 and 1993–94 at Solapur, to study its performance. The grain yield of sorghum was increased by 42 and 105% when preceded by (fodder) cowpea [*Vigna unquiculata* (L.) Walp.] compared with blackgram (*Phaseolus mungo* L.) and soybean [*Glycine max* (L.) Merr.] respectively. Similar trend was noticed in stover yield. Application of 25 kg N/ha to sorghum increased the grain (42%) and stover yields (40%) over the control. Higher sustainable-yield index (0.55) and sustainable-value index (0.46) were obtained from (fodder) cowpea–sorghum sequence. The next best sequence was found blackgram–sorghum, with sustainable-value index of 0.44. The available N content of soil increased and also maintained in the (fodder) cowpea–sorghum sequence.

The role of legumes in fixing atmospheric nitrogen and its availability to succeeding crops has been well- documented, particularly for the dryland crops (Venkateswarlu and Das, 1986). In Vertisols, near Hyderabad, legume cowpea helped to build up higher available N for the succeeding sorghum [*Sorghum bicolor* (L.) Moench.] crop (Das and Rao, 1986). The crop sequence of blackgram (*Phaseolus mungo* L.)–winter sorghum (fodder) or cowpea–winter sorghum is beneficial under dryland agriculture on medium deep soils (Patil *et al.*, 1982; AICRPDA, 1989). However, the work on fertilizer requirement of second crop in a sequence cropping under dryland agriculture in Vertisols is lacking. Therefore present investigation was planned to ascertain the possibility of economizing the nitrogenous fertilizers through legume–sorghum sequence cropping.

MATERIALS AND METHODS

A field trial was conducted on medium deep black soils (Ustrochrept) during 1990–91, 1991–92 and 1993–94 at Dry Farming Research Station, Solapur. The soil was low in nitrogen (0.42% organic carbon), medium in P (7.54 kg/ha) and rich in K (574.9 kg/ha). Seven main treatments consisted of 3 legumes, viz. 'T 9' blackgram 'MACS 57' soybean, 'EC 4216' fodder cowpea with and without fertilizer and rainy-season (*kharif*) fallow. The subplot treatments were, viz. 0 kg N and 25 kg N/ha to winter 'M 35-1' sorghum. Rainy-season pulses, viz. blackgram and cowpea (fodder), were fertilized with 12.5 kg N/ha and 25 kg P_2O_5/ha, whereas soybean with 20 kg N/ha and 40 kg P_2O_5/ha. The experiment was laid out in split-plot design with 4 replications. The net plot size was 6.0 m x 3.6 m. Rainfall received during the crop-growth period of fodder cowpea, blackgram and soybean was 337.6, 373.8 and 377.3 mm in 1990–91; 447.1, 473.1 and 779.1 mm in 1991–92; and 296.9, 390.5 and 393.7 mm respectively in 1993–94. The winter sorghum was grown on residueal soil moisture under dryland conditions. After sowing of winter sorghum, rainfall received was 108 and 12 mm in 1990-91 and 1991–92 respectively. It was 233.8, 173.4 and 165.6 mm for winter sorghum in 1993–94 when sown after (fodder) cowpea, blackgram and soybean respectively. Sustainable yield index (SYI) was calculated by the following formula suggested by Singh *et al.* (1990).

Monetary values of the economic produce were used instead of yield values for calculating sustainable value index.

RESULTS AND DISCUSSION

The average grain yield from blackgram and soybean was 12.28 and 13.00 q/ha respectively. The average green-fodder yield obtained from cowpea was 151.56 q/ha.

Yield of winter sorghum

Grain yield was significantly increased when preceded by rainy-season pulses during 1990–91, 1991–92 and in pooled mean (Table 1). The sequence of fodder cowpea with recommended dose of fertilizer increased the grain yield of succeeding sorghum over blackgram and soybean fertilized and unfertilized–sorghum sequences. When the data were pooled the fallow–sorghum sequence gave significantly higher grain yield (14.42 q/ha), but it was on par with cowpea fertilized and unfertilized–sorghum sequence. The results are in confirmity with the earlier findings (AICRPDA, 1989). Rainy-season fallow–sorghum sequence increased the grain yield of sorghum by 47 and 105%, whereas the increase in the fodder cowpea–sorghum sequence was 42 and 97% over the blackgram–sorghum and soybean–sorghum sequences respectively. There was more residual available N (162.1 kg/ha) in the soil after harvest of fodder cowpea compared with blackgram (141.3 kg/ha) and soybean (109.2 kg/ha). The more available N in the soil at sowing of sorghum helped in early vigour and good crop stand of the sorghum. The results are in close agreement with those obtained by Das and Rao (1986). The grain yield of sorghum was also significantly increased (42%) when fertilized with 25 kg N/ha over the control in all the years and in pooled mean too.

The stover yield of sorghum was significantly increased in fertilized fodder cowpea–winter sorghum sequence during 1990–91 and in pooled mean over fallow–sorghum sequence and during all the years and in pooled mean over other sequences. The increase was 10, 53 and 139% over fallow, blackgram and soybean– sorghum sequences respectively. Half the recommended dose of nitrogen (25 kg/ha) increased the stover yield of sorghum significantly over the control by 40%.

Sustainable-yield index

The sustainable-yield index was higher (0.57) when sorghum was preceded by cowpea fertilized with recommended dose (Table 2). It was closely followed by cowpea (with no fertilization)–sorghum sequence (0.53), with mean sustainable-yield index of 0.55 from cowpea–sorghum sequence. It was followed by fallow–sorghum sequence (0.47). This indicates that for sustainable production from drylands, the sequence of cowpea–sorghum should be preferred. This is also evident by higher sustainable-value index (0.46) from cowpea–sorghum sequence. The sustainable-value index was

Table 1. Effect of crop sequences and fertilizer levels on yield of winter sorghum

Treatment	Grain yield (q/ha)				Stover yield (q/ha)			
	1990–91	1991–92	1993–94	Pooled mean	1990–91	1991–92	1993–94	Pooled mean
Blackgram–sorghum								
Without fertilizer	9.99	5.18	13.12	9.43	34.72	10.41	30.06	25.06
	(7.73)	(15.01)	(5.82)	(9.52)	(12.77)	(16.96)	(9.55)	(12.89)
With fertilizer	9.34	4.76	16.68	10.24	41.37	17.03	35.67	31.36
	(9.30)	(16.24)	(7.62)	(11.05)	(14.35)	(20.81)	(11.84)	(15.66)
Soybean–sorghum								
Without fertilizer	4.82	3.14	13.44	7.14	19.67	8.10	25.41	17.13
	(11.11)	(10.28)	(14.12)	(11.83)	(17.82)	(27.77)	(31.70)	(25.76)
With fertilizer	4.86	2.87	13.41	7.04	18.51	10.09	26.81	18.49
	(13.55)	(11.55)	(17.48)	(14.19)	(29.25)	(28.93)	(38.40)	(32.19)
Cowpea–sorghum								
Without fertilizer	13.99	11.94	15.28	13.73	49.18	31.06	44.62	41.62
	(-)	(-)	(-)	(-)	(162.22)	(187.45)	(125.00)	(158.22)
With fertilizer	12.45	14.39	15.49	14.20	51.50	37.87	45.30	44.90
	(-)	(-)	(-)	(-)	(193.51)	(99.50)	(140.60)	(144.53)
Fallow–sorghum	10.72	14.12	18.99	14.42	35.59	40.50	41.83	39.30
CD (P = 0.05)	1.68	1.99	NS	1.27	9.07	5.99	8.87	4.35
N (kg/ha)								
0	7.21	7.63	12.07	9.00	26.53	21.20	30.13	25.97
25	11.51	8.47	18.33	12.77	45.05	23.05	41.22	36.45
CD (P = 0.05)	0.68	0.67	1.39	0.53	3.93	1.28	4.78	1.94
Interaction								
CD (P = 0.05)	1.52	NS	NS	1.27	NS	NS	NS	NS

Figures in parentheses indicate the yield of rainy-season crop

Table 2. Sustainable-yield index of winter sorghum and sustainable-value index of cropping sequence and fertilizer levels

Cropping sequence	Sustainable-yield index			Sustainable-value index		
	0	25	Mean	0	25	Mean
Blackgram–sorghum						
Without fertilizer	0.22	0.31	0.26	0.35	0.49	0.42
With fertilizer	0.17	0.24	0.20	0.42	0.49	0.46
Soybean–sorghum						
Without fertilizer	0.08	0.06	0.07	0.26	0.29	0.27
With fertilizer	0.06	0.14	0.10	0.29	0.33	0.31
Cowpea (fodder)–sorghum						
Without fertilizer	0.48	0.58	0.53	0.42	0.48	0.45
With fertilizer	0.46	0.69	0.57	0.46	0.48	0.47
Fallow–sorghum	0.34	0.61	0.47	0.17	0.28	0.23
Mean	0.26	0.37	0.32	0.34	0.41	0.37

also higher in fertilized blackgram – sorghum sequence (0.42) and blackgram with fertilized sorghum sequence (0.46) compared to fallow–sorghum sequence (0.23). It indicates that for higher returns and to impart sustainability in drylands, double cropping of blackgram–sorghum can be considered than fallow–sorghum sequence in addition to cowpea–sorghum sequence. The results confirm those obtained by Patil *et al.* (1982). As expected application of 25 kg N/ha to sorghum showed the higher sustainable yield index (0.37) and sustainable-value index (0.41) over the control.

Residual fertility of soil

The residual fertility of soil for nitrogen at the fourth year of experiment on legume–sorghum sequence indicated that the available N content of soil at sowing of sorghum was more after blackgram and cowpea either with or without fertilizer application compared with its initial value (Table 3). Available N content of soil after cowpea was higher (159.8 and 164.4 kg/ha) amongst the legumes grown and also compared with fallow treatment. Das and Rao (1986) also reported higher build up of available N after cowpea. Fodder cowpea built up more soil-available N than grain cowpea. The available soil-N was low (107.9 and 110.5 kg/ha after soybean without and with fertilizer application respectively), which may be due to more removal of N by soybean crop.

After 3 cycles of the sequences, the available N status of the soil in the cowpea–sorghum sequence after harvest of sorghum at 0 kg and 25 kg N/ha level was maintained with slight increased level (3–6 kg/ha) compared with initial value of soil-available N (124 kg/ha). Thus post-harvest status of available N at the end of fourth year was found better under the cowpea (fodder)– sorghum sequence compared with other sequences.

Table 3. Available nitrogen status of soil as influenced by legume–sorghum sequence at the fourth year of experimentation

Treatment	N uptake* (kg/ha)	Available N** (kg/ha)	N uptake by sorghum (kg/ha)		Available N at harvest of sorghum (kg/ha)	
			0 kg N	25 kg N	0 kg N	25 kg N
Blackgram–sorghum						
Without fertilizer	26.34	139.8	26.57	40.18	112.2	116.8
With fertilizer	30.50	142.8	40.49	48.99	118.3	119.9
Soybean–sorghum						
Without fertilizer	74.40	107.9	25.59	41.10	119.9	124.5
With fertilizer	92.60	110.5	31.62	45.29	118.3	122.9
Cowpea (fodder)–sorghum						
Without fertilizer	57.80	159.8	33.97	57.53	127.6	129.1
With fertilizer	57.85	164.4	40.91	53.81	129.1	130.7
Fallow–sorghum		150.5	39.68	62.35	110.6	115.2

Initial available N was 124.03 kg/ha
*Rainy-season crops; **at sowing of sorghum

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