

## Production and economics of winter sorghum (*Sorghum bicolor*)–summer vegetables cropping sequences under irrigated conditions of western Maharashtra

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Received : February 2000

### ABSTRACT

A field experiment was conducted during the winter (*rabi*) and summer seasons of 1995–96 to 1997–98 at Rahuri, to study the production potential and economics of (*rabi*) sorghum [*Sorghum bicolor* (L.) Moench]–summer vegetable cropping sequences under irrigated conditions. Sorghum–okra (*Hibiscus esculentus* L.) sequence gave the significantly highest sorghum-grain equivalent yield (260.8 q/ha) and net monetary returns (Rs 110,678/ha) with 95 cm irrigation water during the *rabi* and summer seasons, followed by sorghum–brinjal (*Solanum melongena* L.) (204.59 q/ha and Rs 82,045/ha) with 102 cm irrigation water. Next in order was sorghum–chilli (*Capsicum annuum* L.) and lowest was in sorghum–clusterbean [*Cymopsis tetragonoloba* (L.) Taubert]. The highest consumptive use was recorded in sorghum–okra (125 cm) but maximum water-use efficiency of 174 kg/ha-cm was recorded in sorghum–brinjal. The per day productivity (Rs 440/day/ha) and returns per unit of water used (Rs 1,094/ha-cm) and benefit : cost ratio (5.17) were maximum in sorghum–okra sequence. Optimum level of irrigation (at 80 mm CPE to sorghum and 60 mm CPE to vegetable) recorded the maximum sorghum grain-equivalent yield and net returns than suboptimum (at 125 mm CPE to sorghum and 90 mm CPE to vegetables). The per day productivity was 32 % higher in optimum irrigation than suboptimum irrigation (Rs 262/day/ha).

**Key words** : Sorghum–vegetable crop sequences, Productivity, Irrigation, Economics

Sorghum is the main cereal crop of Maharashtra, occupying 64% areas during the winter (*rabi*) season. After sorghum, there is practice to grow vegetable crops under irrigated conditions during summer.

Maharashtra has vast potential for vegetable production. It is regular source of income at short intervals to the growers and allows better utilization of family labour. Mostly the vegetables like brinjal, okra,

chilli and clusterbean are grown during summer. Surgarcane is the major crop grown in most of the irrigation commands, consuming larger share of available water resource resulting increased groundwater table in several irrigated areas of arid and semi-arid zone inducing salinity hazards. Hence development of alternative cropping sequence having high water-use efficiency is the priority of the day in such areas. Therefore the present field experiment was conducted to evaluate the productivity and economics of winter sorghum–summer vegetables cropping sequence under irrigation conditions.

### MATERIALS AND METHODS

The field experiment was conducted during 1995–96 to 1997–98 at Water Management Project, Rahuri. The experiment was laid out in split-plot design with 3 replications. The treatments comprised 4 crop sequences of winter sorghum, followed by summer vegetables, viz. brinjal, okra, chilli and clusterbean, in main plots and 2 levels of irrigation, viz. optimum (80 mm CPE to sorghum and 60 mm CPE to vegetables) and suboptimum (125 mm CPE to sorghum and 90 mm CPE to vegetables) in subplots. The soil was slightly alkline in nature (pH 8.2), with available N 124.6 kg/ha, available  $P_2O_5$  19.24 kg/ha and available  $K_2O$  648 kg/ha. The soil-moisture content at 1/3 bar and 15 bar was 38.36 and 19.54% respectively. The bulk density was 1.29 g/cm<sup>3</sup>. All crops in cropping sequences were raised with recommended package of practices. The quantity of water to be given was measured with the help of Roplogle flume. The

sorghum crop was harvested for grain purpose and vegetable crops for green vegetables. The production potential in terms of sorghum-equivalent yield and the economics were calculated on the basis of prevailing market rates.

### RESULTS AND DISCUSSION

#### *Effect of yield*

The mean grain yield of winter sorghum was ranged from 27.43 to 28.96 q/ha (Table 3). The differences in grain yield due to levels of irrigation was not significant. The differences in mean yield of green vegetables in summer season was found to be significant (Table 2). The mean yield of brinjal was significantly superior to that of other vegetables. The yield of summer vegetables increased significantly with the increase in frequency of irrigation. The optimum irrigation at 60 mm CPE registered significantly higher yield of vegetables than to suboptimum irrigation at 90 mm CPE. Higher fruit yield (60%) of okra was also obtained under 1.0 IW : CPE requiring 5 irrigations than the stressed irrigation level of 0.4 IW : CPE during summer season at Pusa (DWMR, Patna 1999).

The total sorghum grain-equivalent yield was significantly affected by crop sequences during all the 3 years and on pooled basis also (Table 3). The total grain equivalent of sorghum–okra was maximum and was significantly higher than the sorghum–chilli and sorghum–clusterbean and was at par with sorghum–brinjal sequence. Though the good potential yield of brinjal was obtained, lower prices resulted in low economics returns and

**Table 1.** Yield of summer green vegetables in crops sequences (tonnes/ha)

Treatment	1995-96	1996-97	1997-98	Mean
<i>Crop</i>				
Brinjal	33.96	26.73	30.47	30.38
Okra	17.19	16.19	14.01	15.80
Chilli	7.21	14.37	7.73	9.77
Clusterbean	7.12	12.56	12.48	10.72
CD (P = 0.05)	1.78	2.00	2.77	6.48
<i>Irrigation</i>				
Optimum	16.75	19.02	17.52	17.76
Suboptimum	15.98	16.91	14.81	15.90
CD (P = 0.05)	0.41	0.77	0.75	1.46

**Table 2.** Water used by different sorghum-based crop sequences during 1995-96 to 1997-98 (average data of 3 years)

Treatment	Profile depletion (cm)	Effective rainfall (cm)	Irrigation applied (cm)	Total water (cm)	CU (cm)	WUE (kg/ha-cm)	Returns/ volume of water (Rs/ha-cm)
<i>Crop sequence</i>							
Winter sorghum-brinjal	89	28	95	123	117	174	928
Winter sorghum-okra	96	29	102	131	125	208	1,094
Winter sorghum-chilli	107	28	110	138	135	121	656
Winter sorghum-clusterbean	100	31	106	137	131	118	647
<i>Irrigation</i>							
Optimum	108	28	116	144	136	151	815
Suboptimum	87	31	91	122	118	158	836

hence lower sorghum grain equivalent yield than the okra. The lowest sorghum grain-equivalent yield found in sorghum-clusterbean sequence. All the crop sequences recorded significantly higher grain equivalent under optimum level of irrigation than suboptimum irrigation (Table 2). Significantly maximum yield of green chilly recorded in wettest moisture

regime (1.2 IW : CPE) compared to stressed irrigation regime (0.6 IW : CPE) at Kalyani during summer season (DWMR, Patna 1999).

#### **Water requirement**

The maximum consumptive use of water was utilized sorghum-chilli sequence, followed by sorghum-clusterbean, sorghum-

Table 3. Sorghum-grain equivalent (q/ha) as affected by crop sequence and irrigation level

Treatment	1995-96			1996-97			1997-98			Pooled mean		
	Rabi	Summer	Total	Rabi	Summer	Total	Rabi	Summer	Total	Rabi	Summer	Total
<i>Crop sequence</i>												
Sorghum-brinjal	25.92	182.60	208.43	39.61	164.15	203.76	27.48	174.06	201.58	27.43	173.60	204.59
Sorghum-okra	28.39	287.16	315.56	35.50	215.90	251.40	28.91	183.43	215.68	28.96	228.83	260.88
Sorghum-chilli	25.51	108.51	134.03	36.31	191.60	227.91	28.30	103.10	131.39	27.85	134.40	164.44
Sorghum-clusterbean	20.12	91.86	111.99	36.79	143.53	180.32	30.49	142.61	173.18	28.21	126.00	155.14
CD (P = 0.05)	NS	24.74	29.25	NS	15.97	30.06	NS	22.20	24.39	NS	85.20	87.27
<i>Irrigation</i>												
Optimum	25.55	169.98	195.50	36.78	190.95	227.43	29.31	165.70	195.01	29.82	175.44	205.98
Suboptimum	24.42	165.09	189.51	37.33	166.94	204.27	28.28	135.90	165.86	28.94	155.97	186.55
CD (P = 0.05)	NS	NS	NS	NS	6.40	8.79	NS	6.51	6.62	NS	32.24	29.84

okra and lowest in sorghum-brinjal crop sequences (Table 2). The water-use efficiency was maximum in sorghum-okra, followed sorghum-brinjal. The mean consumptive use in optimum irrigation (136 cm) was 15% higher than suboptimum irrigation (118 cm). These results are in conformity with those obtained by Mary and Balakrishnan (1990). The water-use efficiency was 10% more in sub-optimum irrigation compared with optimum irrigation.

### Economics

The gross and net monetary returns influenced significantly by sorghum-based crop sequences (Table 4). The winter sorghum-okra gave significantly higher gross returns and net returns than rest of sequences except, sorghum-brinjal sequence. The sorghum-brinjal sequence proved to be the next best crop sequence, which also recorded higher net returns than sorghum-chilli and sorghum-clusterbean sequences and were at par with sorghum-okra. The lowest net monetary returns were obtained in sorghum-clusterbean crop sequence. The per day productivity based on the gross returns was maximum in sorghum-okra sequence, followed by sorghum-brinjal. The sorghum-okra sequence recorded the maximum returns per unit of water, followed by sorghum-brinjal sequence. The benefit : cost ratio was also highest under sorghum-okra than other sequences. Similar results were reported by Dhankhar and Singh (1993).

The pooled data revealed that the irrigation applied at optimum level recorded significantly higher gross and net returns than suboptimum irrigation. The per day productivity was 32% higher in

**Table 4.** Economics of summer vegetables preceded by winter sorghum (1995-96 to 1997-98)

Treatment	Gross returns (Rs/ha)				Net returns (Rs/ha)				Mean cost of cultivation (Rs/ha)	Benefit : cost ratio	Prod-uctivity (Rs/day/ha)	Returns/ unit volume of water (Rs/ha-cm)
	1995	1996	1997	Mean	1995	1996	1997	Mean				
<i>Crop sequence</i>												
Winter sorghum-brinjal	99,547	112,922	113,471	108,646	74,152	85,283	86,701	82,045	26,601	4.08	323	928
Winter sorghum-Okra	153,603	137,336	120,614	137,184	127,928	110,414	93,692	110,678	26,506	5.17	440	1,094
Winter sorghum-chilli	64,904	124,384	76,732	88,673	42,328	100,231	51,329	64,629	24,044	3.68	219	656
Winter sorghum-clusterbean	53,603	102,731	98,231	84,855	32,432	78,702	74,202	61,778	23,077	3.67	223	647
CD (P = 0.05)	9,371	10,564	12,421	42,353	9,909	11,009	12,421	42,147				
<i>Irrigation</i>												
Optimum	95,481	127,210	110,062	110,917	70,302	101,799	84,026	85,375	24,687	4.49	346	815
Suboptimum	90,348	111,477	94,462	98,762	68,119	85,516	68,936	74,190	24,572	4.01	262	836
CD (P = 0.05)	NS	4,966	3,874	15,099	NS	5,705	3,874	11,059				

optimum irrigation than that in suboptimum irrigation.

The winter sorghum–summer okra was the most remunerative crop sequence in irrigated semi-arid tract of Maharashtra, whereas sorghum–brinjal sequence proved to be the next best crop sequence with optimum irrigations at 80 mm CPE to winter sorghum and 60 mm CPE to summer okra in the crop sequences.

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