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Stability and economics of crop sequences under assured water supply

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ABSTRACT

An experiment was conducted during 1981–1986 to study the stability and economics of the multiple-crop sequences under assured water supply. The sequences included cereals, pulses, oilseed and forage crops. Sorghum [*Sorghum bicolor* (L.) Moench]–wheat (*Triticum aestivum* L. emend. Fiori & Paol.)–groundnut (*Arachis hypogaea* L.) was the most stable sequence, giving the maximum net returns. Inclusion of summer groundnut in the sequence increased the net returns. Short-duration pulses and ratooning of sorghum were highly unstable over period of time. Sorghum–gram (*Cicer arietinum* L.)–pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] (for fodder) was also productive and stable crop sequences. Judged from calories productivity sorghum–gram–pearlmillet (fodder) was the best sequence. Based on the protein productivity cowpea (fodder)–sorghum–groundnut was found to be the best sequence.

With ever-increasing demand for food due to population pressure and practically no scope for expansion of area under cultivation, the food production has to be stepped up through increased cropping intensity. Thus, vertical development is the only alternative. Oilseed and pulses are receiving more attention owing to higher prices. Inclusion of these crops in the sequences changes the economics of the sequence cropping (Tomar and Tiwari, 1990; Gupta and Rai, 1990). Inclusion of vegetables is always profitable (Yadav, 1988) and inclusion of forages in sequences for mixed-farming situation is need of the day. In drought-prone area of Maharashtra white revolution has taken place and green fodder for sustaining the same, particularly during the summer months, has necessitated to include fodder crops as the component of multiple-crop sequences. Looking to these needs crop sequences were designed to accommodate fodder crops along with grain crops, oilseed and pulse crops.

MATERIALS AND METHODS

To assess the production potential and economic viability of different crop sequences, an integrated production trial was conducted at Rahuri as a long-term experiment. The experiment was laid out in randomized block design with 4 replications on medium black soil (60–90 cm depth), having pH 8.25, organic carbon 0.53%, available nitrogen 157.46 kg/ha, available P 15.75 kg/ha and available K 408.25 kg/ha. The total annual rainfall during the period was 405.7–536.8 mm compared with expected normal rainfall 523.72 mm. The sequences were selected to include cereals, pulses, fod-

der and oilseed which would fulfil the need of grain and fodder. The recommended fertilizer doses, seed rates and other management practices were adopted for the different crops. The data generated during 1981–86 cycle were taken into consideration for analysis. The data for 1986–86 were not included in study due to unusually delayed sowing of the rainy-season crops because of failure of irrigation system. The yield, gross returns, net returns and coefficient of variation/ha from different crops in various sequences were estimated on the basis of prevailing market rates during the respective years, averaged over 4 years.

Eight crop sequences involved 8 different crops grown for grain or fodder purpose. For comparing productivity of these sequences on uniform basis, sorghum equivalence was worked out on the basis of 4 years. Their absolute yields were also obtained to get an idea of the production potential.

RESULTS AND DISCUSSION

Production potential of sequence

Sorghum [*Sorghum bicolor* (L.) Moench.]–wheat (*Triticum aestivum* L. emend. Fiori & Paol.)–groundnut (*Arachis hypogaea* L.) sequence showed the maximum potential with 151.04 tonnes/ha as sorghum equivalence in 332 days (Table 1). It showed 45.49 kg grain/day productivity. The next best sequence was maize–groundnut. Both these sequences had high-yielding crops like sorghum, maize (*Zea mays* L.) and wheat. Groundnut (rainy season)–wheat–maize for fodder had the lowest productivity. Amongst fodder sequences, sorghum–gram–pearlmillet (fodder) [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz]

Table 1. Season-wise productivity from different cropping sequences (based on average of 4 years)

Sequence	Yield (q/ha)			
	Rainy season	Winter	Summer	Total in sorghum grain equivalence (q/ha)
Maize–wheat–groundnut	43.54 (17.85)	31.55 (13.11)	20.03 (28.97)	145.96 (16.49)
Sorghum–wheat–groundnut	52.91 (14.17)	30.10 (11.62)	17.85 (22.22)	151.04 (10.13)
Greengram–sorghum–groundnut	4.70 (45.23)	42.16 (26.49)	19.00 (24.34)	119.75 (24.75)
Groundnut–wheat–maize (F)	7.16 (29.56)	29.97 (12.03)	478.57 (14.50)	97.76 (11.52)
Sorghum–gram–pearlmillet (F)	58.42 (11.09)	21.55 (20.47)	545.31 (14.50)	131.10 (10.02)
Sorghum–sorghum (R)–groundnut	52.22 (17.72)	17.26 (81.01)	19.53 (25.32)	134.58 (2.34)
Sorghum + pigeonpea–pigeonpea–groundnut	45.69 (12.81)	9.67 (12.07)	18.46 (22.68)	128.33 (11.64)
Cowpea (F)–sorghum–groundnut	290.16 (21.30)	37.87 (27.76)	18.00 (24.16)	118.83 (21.41)

F, Fodder; R, winter season
Figures in parenthesis indicate CV

Table 2. Gross and net returns from different cropping sequences

Sequence	Gross returns (Rs/ha)				Net returns (Rs/ha)			
	Rainy season	Winter	Summer	Total	Rainy	Winter season	Summer	Total
Maize–wheat–groundnut	6,954 (8.52)	7,273 (16.14)	11,747 (19.54)	25,973 (11.92)	3,294 (21.94)	3,931 (35.55)	7,380 (31.51)	14,606 (25.67)
Sorghum–wheat–groundnut	9,646 (16.82)	6,957 (14.21)	10,854 (11.81)	27,458 (10.73)	6,259 (30.06)	3,616 (33.61)	6,489 (19.18)	16,364 (22.82)
Greengram–sorghum–groundnut	2,564 (36.72)	6,795 (28.83)	11,658 (17.52)	21,017 (20.65)	103 (1,156.60)	3,641 (60.80)	7,201 (27.85)	10,944 (44.94)
Groundnut–wheat–maize (F)	3,976 (23.90)	6,909 (12.80)	6,816 (14.53)	17,701 (8.97)	227 (444.54)	3,638 (32.62)	3,331 (32.18)	7,196 (31.72)
Sorghum–gram–pearlmillet (F)	10,411 (14.27)	7,634 (14.41)	5,189 (54.74)	23,234 (14.27)	7,007 (25.12)	5,123 (15.25)	2,202 (134.37)	14,332 (28.60)
Sorghum–sorghum (R)–groundnut	9,298 (21.60)	3,152 (82.61)	11,626 (12.40)	24,076 (23.79)	5,903 (38.60)	1,771 (149.66)	7,169 (23.04)	14,843 (42.49)
Sorghum + pigeonpea–pigeonpea	8,238 (18.35)	3,799 (20.99)	10,927 (16.66)	22,964 (12.38)	4,260 (41.16)	3,080 (26.81)	6,567 (27.20)	13,907 (23.01)
Cowpea (F)–sorghum–groundnut	3,782 (34.46)	6,178 (28.79)	10,850 (12.34)	20,810 (18.08)	1,553 (97.41)	3,040 (67.75)	6,393 (21.77)	10,987 (40.87)

F, Fodder; R, winter season
Figures in parenthesis indicate CV.

was the most promising sequence. Thus, the productivity of the rainy (*kharif*) season has substantial prominance to boost total productivity of sequences. Two cereals in 3 crop sequences were found boosting the productivity. Similar observations were also reported by Yadav (1988).

Stability of sequence

Wheat was the most stable crop. It was included in 3 sequences and yielded 30.0–31.5 q/ha grain with CV 11.6–12.1. This showed that for wheat, environment in respect of weather and water supply was the congenial. This may be one of the reasons for cultivation of wheat in spite of lower productivity. Due to availability of high-yielding varieties, practically pest and disease free-environment and relatively less sensitive to sowing period, wheat continues to be favoured a crop. Winter sorghum with more than 4 tonnes/ha grain yield showed CV 26.5. Hence it is difficult to be a choice crop in multiple cropping. This crop is very sensitive to sowing dates and to shootfly when sown early and to cold when sown late. Ratooning rainy-season sorghum as winter crop proved disastrous with not only low yield (17.26 q/ha) but also with very high CV (81.01). This may be one of the reasons why ratoon cropping did not become popular under assured water supply. Amongst the rainy-season crops, sorghum appeared more stable. It was tried in 4 sequences, giving yield 4.5–5.29 tones/ha and CV 12.8–17.7. None of the other rainy-season crops tried were as stable and productive as sorghum. Greengram (*Phaseolus radiatus* L.) in rainy-season was not only poor yielder but highly variable and unstable. The productivity was

Table 3. Grain productivity, net returns, protein and calories per day in different cropping sequences

Sequence	Grain productivity (kg/ha/day)	Protein productivity (kg/ha/day)			Calories* productivity (Kcal/ha/day) $\times 10^5$	Net returns (Rs/ha/day)
		Grain	Fodder/ straw	Total		
Maize–wheat–groundnut	28.65	4.12	7.51	11.63	1.12	43.99
Sorghum–wheat–groundnut	30.38	4.11	8.05	12.16	1.16	49.29
Greengram–sorghum–groundnut	20.26	3.18	16.37	20.05	0.82	33.67
Groundnut–wheat–maize (F)	17.51	2.55	9.62	12.17	0.68	24.99
Jowar–gram–peralmillet (F)	34.77	4.24	13.20	17.44	1.20	43.04
Sorghum–sorghum (R)–groundnut	25.36	3.47	7.60	11.07	0.99	42.29
Sorghum + pigeonpea–pigeonpea–groundnut	21.21	3.33	6.19	9.52	0.34	39.96
Cowpea (F)–sorghum–groundnut	22.08	3.36	30.50	33.36	0.91	34.99

* Based on grain yield only.

found highly fluctuating due to sensitivity to both seeding time and pest and diseases. Groundnut as a rainy-season crop had low production coupled with high CV. However, groundnut as a summer crop was more productive and stable. It was studied in 6 crop sequences and yielded on an average 1.88 tonnes/ha with CV 22–29. This productivity was almost 3 times the productivity of rainy-season. Intercropping sorghum + pigeonpea [*Cajanus cajan* (L.) Millsp.] was not productive and hence may not be suitable under intensive cropping system.

Net returns

The net returns give the extent of advantage by a particular sequence. On the basis of net returns, sorghum–wheat–groundnut sequence was most productive compared with the other sequences (Tables 2, 3). This was followed by sorghum–sorghum (winter season)–groundnut. Since sorghum ratoon required less management, the net returns were higher compared with maize–wheat–groundnut sequence. However, the stability of ratoon was lower. On the basis of net returns, sorghum–gram (*Cicer arietinum* L.)–pearlmillet (fodder) was also highly paying. Thus, short duration, higher money value and less cost of management were desirable traits for getting higher net returns from any sequence. Based on stability, however, sorghum–wheat–groundnut was the most remunerative not only in terms of productivity but also in terms of net returns. Inclusion of groundnut in crop sequences was also found paying by Malvia *et al.* (1986).

Productivity based on calories

Data on this aspect showed that sequences giving higher grain yield showed the maximum calories productivity in the sequence of sorghum–gram–pearlmillet (fodder), followed by maize–wheat–groundnut.

Protein productivity

Protein productivity was worked out on grain and fodder production. Cowpea [*Vigna unguiculata* (L.) Walp.] (fodder)–sorghum–groundnut showed the highest protein productivity (33.86 kg/ha/day). It was followed by greengram–sorghum–groundnut (20.05 kg/ha/day). The lowest protein productivity was noticed in sorghum–pigeonpea–groundnut system.

It was concluded that sorghum–wheat–groundnut and sorghum– gram–pearl millet (fodder) cropping systems were found to be adaptable on large scale under intensive cropping programmes. These 2 cropping systems would take care of farmers interested in grain farming and dairy farming also.

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