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Effect of inter-cropping on plant and soil of Mosambi sweet orange orchard under rainfed conditions

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ABSTRACT

An inter-cropping trial was conducted on 3-year-old Mosambi sweet orange orchard planted at 5 m × 5 m spacing and growing under rainfed laterite soil to identify the suitable and profitable intercrops. The intercrops grown were cowpea, ridge gourd, groundnut, radish, black gram, okra, amaranthus and cluster bean. The results of three years of investigation indicated that number of fruits was maximum in Mosambi with groundnut followed by okra. Fruit weight was highest with cowpea closely followed by groundnut and black gram. Fruit quality and N, P and K values in leaves of Mosambi did not significantly differ among the intercrop treatments. Highest net return was calculated from Mosambi + groundnut combination (Rs. 35,820.0/ha) followed by Mosambi + okra (Rs. 22,520.0/ha) and Mosambi + cowpea (Rs. 22,420.0/ha). Highest bio-mass was obtained from cowpea (68 q/ha) followed by groundnut (54 q/ha) and black gram (35 q/ha). Nitrogen concentration in the orchard soil was improved due to growing of leguminous crops while phosphorus and potassium were depleted in all the cases.

Key words: Inter-cropping, Mosambi sweet orange, rainfed, laterite soil, soil fertility.

INTRODUCTION

The Mosambi, a variety of sweet orange (*Citrus sinensis* Osbeck) is most popular in the states of Maharashtra, Rajasthan and West Bengal. It requires sub-tropical dry climate for higher yield and production of good quality fruits. The crop is grown in such agro-climatic situation where annual precipitation is low. The sweet orange plants start bearing 2 to 3 years after planting and reach their maximum capacity within 7-8 years after planting. The sweet orange is planted at a distance of 5 m × 5 m or 6 m × 6 m spacing where there is an ample scope for growing of short duration crops during the initial years. Growing of crops in interspaces of the orchard, called inter-cropping, not only generates an extra income but the practice also helps to check the soil erosion through ground coverage and improves the soil physico-chemical condition. Inter-cropping is one of the techniques of land utilization for optimum production (Bhatnagar *et al*., 2). Selection of suitable intercrops in sweet orange orchard for maximum return as well as to improve the soil fertility status mainly depends on agro-climatic condition of the cultivation area. Limited information is available regarding suitable intercrops and their effect on main crop and orchard soil of sweet orange under rainfed condition as most of the sweet orange orchards in the country are raised under irrigated condition. In laterite soil zone of West Bengal, an area of sweet orange cultivation, where availability of irrigation water during off-season is a serious problem, while sufficient precipitation during rainy season (Middle of June to end of September) creates an ample scope for growing short duration crops for obtaining an extra income. As no work has been carried out in this agro-climatic zone, an investigation was, therefore, made in Mosambi sweet orange orchard to find out the best profitable and suitable intercrops under rainfed condition in laterite soil.

MATERIALS AND METHODS

The investigation was conducted at the Regional Research Station, Jhargram of the Bidhan Chandra Krishi Viswavidyalaya during 2004 to 2006. The inter-cropping trial was made on 3-year-old sweet orange orchard of cv. Mosambi planted at 5 m × 5 m spacing. Life saving basin irrigation was provided during summer months only for first two years after planting and no irrigation from 3rd year. The site is in subtropical climate with less summer rainfall. The sweet orange plants were budded on African rough lemon (*Citrus jambhiri* L.) and were planted in 2001. The soil of the experimental site was laterite having pH 5.0. The inter-crops grown were cowpea (*Vigna sinensis*), ridge gourd (*Luffa acutangula*), groundnut (*Arachis hypogaea*), radish (*Raphanus sativus*), black gram (*Phaseolus mungo*), okra (*Abelmoschus esculentus*), amaranthus (*Amranthus tricolor*) and cluster bean (*Cyamopsis tetragonoloba*). The intercrops were sown one metre away from the trunk leaving an area of 3 sq. m around each tree. The experiment was laid out in a randomized

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block design with four replications and each replication consisted of four sweet orange plants. Yearly fertilizer doses of 10 kg cowdung manure, 300 g N, 100 g P_2O_5 and 200 g K_2O were given per sweet orange plant. The additional amount of 180 g N, 140 g P_2O_5 and 90 g K_2O per plant was applied for the intercrops. The data on the number of fruits per plant were recorded at harvest in all the three years and were statistically analysed. Physico-chemical analysis was done on ten randomly selected mature fruits from each replication. Marketable produce of intercrops and main crop (Mosambi) in terms of per ha and their saleable value were worked out. Bio-mass obtained from the intercrops were weighed and their NPK contents were estimated. NPK content in leaves of Mosambi was also estimated. Fertility status in terms of NPK content of the orchard soil was estimated before and after the experiment.

RESULTS AND DISCUSSION

It was seen from the data in Table 1 that growth of the Mosambi plants, in respect of height and basal girth were slightly improved due to growing of different crops in the interspace of the plants. Better growth of Mosambi plants was observed where cowpea, groundnut and cluster beans were grown as inter-crops. However, growth parameters were non-significant except plant height and the result was in consonance with the findings of Gonge and Kale (5), who also observed non-significant differences for various growth parameters in Nagpur mandarin due to 16 inter-crop treatments.

Fruit production in Mosambi was found to improve markedly by growing of inter-crops (Table 1). Highest fruit number (51.7) was counted from the plants with groundnut in the interspace followed by okra (35.7) and radish (34.0). Minimum number of fruits (11.7) was counted from the plants where no intercrops was grown. Increase in fruit production due to inter-cropping may be explained from the fact that some intercrops like groundnut, cowpea, black gram and cluster bean have capacity of fixing atmospheric nitrogen that added to the soil and thereby main crop may get additional nitrogen. Sanchez *et al.* (10) also observed beneficial effect of leguminous crops on sweet orange and Singh *et al.* (12) in mandarin orange orchard. The other intercrops like okra, radish, ridge gourd and amaranthus helped the main crop (Mosambi) through indirect way like creating a micro-climate that may have resulted reduction in fruit drop. Besides, floor management for the intercrops like land preparation for sowing, weeding, *etc.* seemed to be beneficial for production of more number of fruits at the initial years of orchard life. The inter-cropping that helped to improve the fruit production of the main crop was also reported by Ghosh *et al.* (4) in sweet orange, Ghosh (3) in guava, and Sarkar *et al.* (11) in mango.

Physico-chemical analysis of Mosambi fruits from intercropped plot (Table 2) revealed that fruit weight was significantly improved due to growing of intercrops and it was measured highest (160 g) in plants with cowpea followed by groundnut (158 g) and black gram (156 g), and they were statistically at par among themselves in fruit weight. Interestingly, all the three intercrops were leguminous group that have capacity to enrich the soil from atmospheric nitrogen. In Mosambi sweet orange, fruit size is considered to be the important consideration for getting premium price, hence, inter-cropping with leguminous crops helped to

Table 1. Effect of inter-cropping on plant growth and fruit yield of Mosambi sweet orange.

Treatment	Plant growth (Percentage of promotion in last 2 years)		No. of fruits/plant				No. of fruits/ha*
	Plant height	Basal girth	1st year	2nd year	3rd year	Average	
Mosambi (Sole)	2.0	0.8	0	15	20	11.7	4680
Mosambi + Cowpea	6.8	4.5	4	56	32	30.7	12280
Mosambi + Ridge gourd	5.0	2.8	2	21	50	24.3	9720
Mosambi + Groundnut	6.0	4.2	7	76	72	51.7	20680
Mosambi + Radish	4.4	1.4	3	75	24	34.0	13600
Mosambi + Black gram	2.8	1.0	4	30	36	23.3	9320
Mosambi + Okra	3.2	1.6	5	57	45	35.7	14280
Mosambi + Amaranthus	3.5	1.4	1	51	24	25.3	10120
Mosambi + Cluster bean	6.7	4.1	1	25	42	22.7	9080
CD at 5%	0.4	NS	NS	7.0	3.2	5.6	-

*Based on 400 plants.

Table 2. Effect of inter-cropping on physico-chemical characteristics of Mosambi fruits (average of 3 years).

Treatment	Fruit weight (g)	TSS (°B)	Acidity (%)	Total sugars (%)	Vitamin C (mg/100 ml juice)
Mosambi (Sole)	130	8.2	0.32	8.0	38.0
Mosambi + Cowpea	160	9.8	0.31	8.8	40.4
Mosambi + Ridge gourd	140	8.4	0.33	8.2	38.6
Mosambi + Groundnut	158	9.6	0.30	8.8	40.0
Mosambi + Radish	135	8.4	0.33	8.0	38.0
Mosambi + Black gram	156	9.4	0.30	8.6	40.2
Mosambi + Okra	140	8.6	0.34	8.2	38.8
Mosambi + Amaranthus	135	8.4	0.34	8.0	38.0
Mosambi + Cluster Bean	150	9.4	0.29	8.6	40.2
CD at 5%	4.0	NS	NS	NS	NS

achieve that goal. Lowest fruit weight (130 g) was measured from the sole plants. Fruit quality of Mosambi was not affected by different crops grown in the interspace (Table 2). Similar observation was also noted by Kanwar *et al.* (8) in citrus and mango, Ghosh (3) in guava, and Bhatnagar (2) in Kinnow.

The details of cultivation and cost of growing intercrops in Mosambi orchard have been presented in Table 3. It appeared from the data that the highest expenditure (Rs. 12,700/ha) was incurred for groundnut cultivation followed by okra (Rs. 12,500/ha) and cowpea (Rs. 12,000/ha), and lowest in amaranthus (Rs. 7,000/ha), and black gram (Rs. 7,200/ha). Economic analysis of inter-cropping systems has been presented in Table 4. It appeared from the data that highest annual revenue from inter-crop was obtained from cluster bean (Rs. 18,000/ha), closely followed by groundnut (Rs. 17,500/ha) and cowpea (Rs. 16,000/ ha), and lowest from radish (Rs. 9,000/ha). Considering the total cost and monetary return from main and intercrops, it was found that Mosambi with groundnut gave highest net return of Rs. 35,820/ha with an additional income of Rs. 28,800/ha over sole cropping. The next profitable combination was Mosambi with okra, which resulted in net return of Rs. 22,520/ha closely followed by cowpea of Rs. 22,420/ha, which estimated additional income of Rs. 15,500 and Rs. 15,400/ha respectively. It was further revealed that all the intercrops selected for the study were suitable for the Mosambi-sweet orange orchard under rainfed conditions in laterite soil as they gave an additional net return from Rs. 9,160/ha (from ridge gourd) to Rs. 28,800/ha (from groundnut) over the sole plots. Gonge *et al.* (7) reported highest net

Table 3. Cost of cultivation (Rs.) of Inter-cropping in Mosambi sweet orange orchard (average of 3 years).

Treatment (intercrops)	Expenditure (Rs./ha)					
	Spacing of intercrop	Land preparation with power tiller	Cost of mandays for weeding, sowing, manuring, *etc.*	Cost of seeds	Cost of fertilizers	Total expenditure
Mosambi (Sole)	-	-	-	-	-	-
Cowpea	30 × 15 cm	5,000	5,200	900	900	12,000
Ridge gourd	170 × 170 cm	2,000	5,000	1,200	1,000	9,200
Groundnut	30 × 15 cm	5,00	5,500	1,200	1,000	12,700
Radish (as leafy vegetable)	30 × 15 cm	5,000	2,000	950	800	8,750
Black gram	30 × 15 cm	3,000	2,000	1,300	900	7,200
Okra	45 × 30 cm	5,000	5,500	1,000	1,000	12,500
Amaranthus	30 cm (Line to line)	3,000	2,000	1,200	800	7,000
Cluster bean	30 × 15 cm	3,000	5,000	2,500	1,000	11,500

Table 4. Inter-cropping in Mosambi sweet orange orchard - Economic analysis (average of 3 years).

Treatment (Intercrop)	Yield of intercrop (q/ha of orchard area)	Value of intercrop (Rs.)/ha	Number of Mosambi fruits/ha	Value of Mosambi (Rs./ha) @ Rs. 1.50/pc	Total return from Mosambi + intercrop (Rs./ha)	Total expenditure (Rs./ha)	Net return (Rs./ha) (main + intercrop)	Net return over sole orcharding of sweet orange (Rs./ha)
Mosambi (Sole)	-	-	4680	7,020	7,020	-	7,020	-
Mosambi + Cowpea	20.0	16,000	12280	18,420	34,420	12,000	22,420	15,400
Mosambi + Ridge gourd	18.0	10,800	9720	14,580	25,380	9,200	16,180	9,160
Mosambi + Groundnut	7.0	17,500	20680	31,020	48,520	12,700	35,820	28,800
Mosambi + Radish	15.0	9,000	13600	20,400	29,400	8,750	20,650	13,630
Mosambi + Black gram	5.4	10,800	9320	13,980	24,780	7,200	17,580	10,560
Mosambi + Okra	17.0	13,600	14280	21,420	35,020	12,500	22,520	15,500
Mosambi + Amaranthus	17.0	10,800	10120	15,180	25,980	7,000	18,980	11,960
Mosambi + Cluster Bean	30.0	18,000	9080	13,620	31,620	11,500	20,120	13,100

monetary return of Rs. 15,226/ha, while Paslawar *et al.* (9) obtained Rs. 34,301/ha from intercrops in Nagpur Santra during pre-bearing stage.

It was observed from the data in Table 5 that intercrops itself resulted in good amount of bio-mass which may be helpful for improvement of physico-chemical properties of the orchard soil if we incorporate them. Highest amount of bio-mass was weighed from cowpea (68 q/ha) followed by groundnut (54 q/ha). No bio-mass was obtained from radish and amaranthus as their whole crops were harvested as leafy vegetables. It was observed (Table 5) that bio-mass of the intercrops contained good amount of N, P and K and higher nitrogen was estimated from the bio-mass of leguminous crops (3.35 to 3.46%) although the differences were non-significant. The N, P and K content in leaves of Mosambi was also higher with intercrops of leguminous group and lower in case of non-legume crops, and the differences was statistically non-significant and similar non-significant result of nitrogen content in leaves of mango due to intercrops was also noted by Sarkar *et al.* (11).

In addition to extra income, another objective of inter-cropping is either to improve the fertility status or to exert least harmful effect on soil and plant (main crop). From the data in Table 6, it is clear that there was continuous depletion of nutrients from the soil due to growing of intercrops and it was somehow correlated with the quantity of bio-mass production by the intercrops itself as in case of groundnut. However, growing of cowpea, black gram and cluster bean resulted in improvement of nitrogen status of the soil. Begum *et al.* (1) also reported that organic carbon and available nitrogen content in soil of acid lime orchard was more under leguminous intercrops than the non-leguminous. In the present investigation, the bio-mass available from the intercrops were not incorporated into the respective plots. Therefore, it is assumed, if the bio-mass of the intercrop is incorporated after the harvest of crop, may help to improve the physico-chemical status of the soil. It was further noted that phosphorus and potassium content in the soil were decreased in all the plots which might have been due to more utilization by the intercrops and similar result was also noted by Gonge and Kale (6) in Nagpur mandarin orchard with different intercrops.

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Table 5. Bio-mass available from different intercrops, NPK content in bio-mass and leaves of Mosambi sweet orange (average of 3 years).

Treatment (Intercrop)	Bio-mass (fresh weight) available froms intercrop/ha (q)	NPK content in bio-mass on dry weight basis			NPK content in leaves of Mosambi on dry weight basis		
		N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
Mosambi (Sole)	0.0	-	-	-	2.20	0.13	1.15
Mosambi + Cowpea	68.0	3.40	0.14	1.00	2.72	0.17	1.84
Mosambi + Ridge gourd	15.0	3.10	0.22	1.15	2.10	0.12	1.22
Mosambi + Groundnut	54.0	3.40	0.12	1.20	2.50	0.16	1.60
Mosambi + Radish	0.0	-	-	-	2.00	0.10	1.02
Mosambi + Black gram	35.0	3.35	0.20	1.10	2.68	0.17	1.64
Mosambi + Okra	20.0	3.12	0.20	1.25	2.18	0.12	1.24
Mosambi + Amaranthus	0.0	-	-	-	2.00	0.10	1.00
Mosambi + Cluster bean	45.0	3.45	0.10	1.25	2.62	0.17	1.78

Table 6. Effect of inter-cropping on fertility status of the soil in Mosambi sweet orange orchard.

Treatment (Intercrop)	Before experiment (kg/ha)			3 years after experimentation (kg/ha)			Addition (+) or depletion (-) of nutrients in the soil due to inter-cropping (kg/ha)		
	N	P	K	N	P	K	N	P	K
Mosambi (Sole)	158.0	60.5	166.0	156.0	60.0	165.3	2.0 (-)	0.5 (-)	1.3 (-)
Mosambi + Cowpea	170.7	95.5	201.1	172.0	94.0	201.1	1.3 (+)	1.5 (-)	0.0
Mosambi + Ridge gourd	150.3	80.3	162.3	149.7	80.0	160.8	0.6 (-)	0.3 (-)	1.5 (-)
Mosambi + Groundnut	143.9	60.1	162.3	140.1	60.0	160.2	3.8 (-)	0.1 (-)	2.1 (-)
Mosambi + Radish	136.1	55.2	152.6	134.2	53.2	151.1	1.9 (-)	2.0 (-)	1.5 (-)
Mosambi + Black gram	167.9	95.1	194.0	169.0	95.0	192.3	1.1 (+)	0.1 (-)	1.7 (-)
Mosambi + Okra	152.0	60.8	172.3	151.2	58.1	170.2	1.2 (-)	2.7 (-)	2.1 (-)
Mosambi + Amaranthus	145.0	58.0	152.0	143.0	56.0	151.4	2.0 (-)	2.0 (-)	0.6 (-)
Mosambi + Cluster bean	175.3	82.9	182.2	176.1	82.5	181.5	0.8 (+)	0.4 (-)	0.7 (-)

*Bio-mass of the intercrops was not incorporated into the respective plot after harvest.

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