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Short communication

Assessing citrus (lemon) based intercropping in the irrigated areas of northern plains of Haryana

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ABSTRACT

On-farm experiment was conducted in the village Badarpursaid of Faridabad district in Haryana to assess the various intercrop combination in the lemon orchard during 2011 to 2014. The lemon variety Baramasi (*Citrus limon*) was planted in the area of 2,000 sq. m. in the year 2011. During *rabi* 2011 to *rabi* 2013-14, different crops like winter vegetables (cabbage and cauliflower), summer crops as muskmelon and fodder maize and *kharif* crops of maize (cob and fodder) and fodder sorghum were grown as intercrop in the orchard. The comparison was made in terms of net return from the system, crop productivity index and land equivalent ratio. Results showed that the best intercropping system was lemon + fodder maize – muskmelon - cauliflower. There was enhancement in land utilization, cropping intensity and farmers' income.

Key words: Intercropping system, lemon orchard, land use system, on-farm experiment.

Intercropping may be an alternate practice for surmounting low productivity in case of low input-low output and small-scale farming systems. Highly-efficient use of land and related profitability are important not only in the development of intercropping systems *per se*, but also in other applications, which have tremendous potential independent of profitability. However, as the level of productivity increases due to technological improvements, it has become imperative to ascertain whether intercropping as compared to sole cropping shall remain the most profitable, productive and resource efficient cropping system. It could be hypothesized that inter-crops may outperform sole crops because of improved resource capture and resource use efficiency. Experience of intercropping autumn sugarcane with winter vegetables showed enhanced efficacy of herbicide for weed control (Kaur *et al*., 3). With particular reference of the developed agriculture, Williams and Gordon (7) reported that the success of many intercropping systems in North America is attributable to the generation of a short term return from an agricultural crop during the early, unprofitable years of a longer term crop that is fruit, nuts or wood. Srivastava *et al*. (5) concluded that pooled data analysis for intercropped versus monocropped citrus orchards showed superiority of mono-cultured (68.5 kg/tree) over intercropped (51.4 kg/tree) orchards. But, intercrop specific analysis revealed that citrus orchards with legumes as intercrop (soybean and chickpea), produced significantly higher fruit yield (72.2 kg/ tree) compared to orchards without intercrops (68.5 kg tree^{1}). These legume-based intercropped orchards maintained much higher levels of leaf nutrients than the orchards without intercrops. In an intercropping experiment (Swain, 6) to assess the effect of various intercrops on the performance of mango in the rainfed uplands of Odisha, it was found that the mango + guava + cowpea intercropping system exhibited better performance in terms of plant height, girth, canopy area, fruit weight and fruit yield of mango closely followed by mango + guava + french bean system. Highest LER was obtained with mango + guava + cowpea intercropping system. Kabura *et al*. (2) compared various pepper-onion intercrop spacing and sole plantings in Nigeria. The sole plantings generally out-yielded the intercrops, but some combinations gave overall LER values greater than 1.0. Recommended spacing for intercrops varied depending on the primary crop in the system. This paper examines the on-farm performance assessment of various intercropping systems of vegetables, fruit and fodder in the newly established lemon orchard. The specific objective of the trial was to assess the best fit intercropping system in the lemon orchard and also to see the relative productivity and profitability of the system under various crop combinations.

The experiment was conducted in the village Badarpur Said under Faridabad district of Haryana under the 'Model Village Project' being implemented in this village since October 2010 by ICAR-IARI, New Delhi. For integrated development of agri-horti system in the village in integrated crop management mode, a lemon orchard was established in the area of 2,000 sq. m. in the year 2011. The lemon variety Baramasi (*Citrus limon*) procured from Punjab Agricultural University, Ludhiana was planted in the orchard as per the scientific practices recommended for this variety. In the first

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year, in summer 2012, muskmelon and fodder maize were intercropped in the orchard. Similarly, in *kharif* 2012, maize cob and sorghum fodder and *rabi* 2012-13 - cauliflower and cabbage were intercropped. The same crop combinations were also assessed in three cropping seasons during 2013-14. The performance of various intercrops was assessed on the parameters of yield (q/ha), cost (Rs./ha), return (Rs./ha), profitability (B:C ratio) and green fodder availability. As two different crops were assessed in three seasons, it was attempted to find out that which crop in each season was the best fit as intercrop with lemon orchard in the given agro-eco system. This was ascertained by computing the Crop Productivity Index (CPI) (Birthal *et al*., 1). Similarly, as the muskmelon is major profitable enterprise among all vegetables and fruits, the Muskmelon Equivalent Yield (MEY) was also computed (Kisku *et al*., 4; Birthal *et al*., 1) to compare the relative status of other crops like cabbage, cauliflower, sorghum fodder, fodder maize and maize (cob). Land Equivalent Ratio (LER) was worked out to ascertain the relative economic efficiency of both the cropping sequences experimented in lemon-based cropping systems.

$$\text{Crop Productivity Index (CPI)} = \frac{\text{Av. yield of the crop obtained (y)}}{\text{Yield of the crop with standard package of practices i.e. obtainable yield (Yi)}}$$

$$\text{Muskmelon Equivalent Yield (MEY)} = \frac{\text{Economic yield of the alternate crop} \times \text{unit price of the crop}}{\text{Unit price of muskmelon}}$$

$$\text{Land Equivalent Ratio (LER)} = \sum_{i=1}^{n} \frac{Ycic}{Ycmc}$$

Where, Ycic is the yield of the ith crop as the intercrop
Ycmc is the yield of ith crop as the main crop
n is the total number of crops taken in the sequence

The village Badarpursaid inhabits about 370 households with total land holding of 300 ha. The per capita average land holding in the village is about 1.50 ha. The soil of the village is sandy and sandy loam. In some patches, soils are loam also. The major cropping sequences practiced by the farmers are sorghum-potato-wheat, sorghum-wheat, paddy-wheat, and vegetables-wheat. The cropping intensity of the village is approximately 200 per cent. The village is fully irrigated and mechanized. *Kharif* crops suffer most from weeds and insect pest than *rabi*. The most prioritized issue of the village is to enhance the cropping intensity so that farm level income may be enhanced. Fruit orchard was the new introduction in the village. The details of various intercropping systems experimented in the village during summer, *kharif* and *rabi* season for the years 2012-13 and 2013-14 are given in Table 1.

Muskmelon cv. Pusa Madhuras was planted in between the lemon plants during summer 2012 in half of the area, *i.e.*, 1,000 m^2. In the remaining half, fodder maize was planted. About 50 lemon plants were accommodated in the total area of 2,000 sq.m. The recommended agronomic practices were followed by the farmers as per the experts' advices. Pusa Madhuras started to bear fruits after 35 days of planting. The average numbers of fruits produced per plants were 5-7, which was as per the potential of the variety. Per plant yield obtained was 7-8 kg with average weight of 1.0 kg. Similarly, fodder maize was also become ready for first cut after 40 days of planting. As evident the Table 2, the average yield obtained from these two crops were 16 and 30 t/ha with net return of Rs. 1,42,000/ ha and Rs. 15,500 in 60 and 75 days, respectively. However, the relatively lower return from fodder maize should not be actualized as the produced green fodder was fed into the dairy production system for yielding milk and getting the returns.

Another intercropping system experimented was maize for cob purpose and its stalk as the green fodder to the animal and fodder sorghum during *Kharif* season in half of the area (1,000 m^2) for two consecutive years in the same one year old lemon orchard. The results as indicated in Table 3 showed that about 2.5 tonnes

Table 2. Performance of muskmelon (cv. Pusa Madhuras) and fodder maize as the intercrop in lemon orchard during summer 2012 and 2013.

Parameter	Unit	Value (muskmelon)	Value (fodder maize)
Total yield	t/ha	16	30
Total cost of cultivation	Rs./ha	18000	10,000
Market price	Rs./t	10000	850
Gross return	Rs./ha	1,60,000	25,500
Net return	Rs./ha	1,42,000	15,500
B:C ratio	-	8.88:1	2.55:1

Table 1. Detail of crops intercropped in the lemon (cv. Baramasi) orchard in different seasons.

Year	Summer	*Kharif*	*Rabi*
2012-13	Muskmelon (Pusa Madhuras) + Fodder maize	Maize (cob) + Sorghum (fodder)	Cauliflower + cabbage
2013-14	Muskmelon (Pusa Madhuras) + Fodder maize	Maize (cob) + Sorghum (fodder)	Cauliflower + cabbage

of maize cobs were harvested from 1,000 m^2 of area in 85 days besides the green stalk to the quantity of 1.0 t as the green fodder in the same period. The green cobs were utilized for domestic purpose and remains of the maize plants as the fodder for the animals. The imputed values for both of them were Rs. 50.0 and Rs. 8,000/ ha, respectively. Thus, there was net saving of Rs. 21,000/ha from dual purpose maize. The profitability of this system thus appears to be relatively impressive as indicated by good B:C ratio (2.31:1), the harvested greed cob also ensured household nutrition security.

From the remaining half 1,000 m^2 area, 4.5 tonnes of sorghum green fodder was harvested in the same period. From the results of both the blocks, green fodder of maize stalk could be made available adequately to one milch animal regularly for 25 days, whereas, from the other block of sorghum, the green fodder could be ensured for two milch animals for 45 days. The computed value of harvested fodder was Rs. 37,000/ha and Rs. 25,200/ha, thus, with the expenditure of Rs. 12-16 thousand/ha for dual purpose maize and fodder sorghum, respectively (Table 3). The economics, however, was lesser in favour for sorghum (B:C ratio, 2.10:1).

During winter season, vegetables, namely, cauliflower and cabbage were intercropped in the orchards during *rabi* 2012-13 and 2013-14. Though, both cauliflower and cabbage crop were slightly affected during the the cropping season 2012-13 due to untimely rains and hailstorms, *albeit* yielded remunerative dividends. Therefore, the same crops were repeated during *rabi* 2013-14. Results as indicated in Table 4 show that about 3.2 tonnes of cabbage and 2.5 tonnes of cauliflower were harvested from 1,000 m^2 area by investing Rs. 4,000 and Rs 3,700, respectively. The net profit thus obtained were Rs. 85,000 and Rs. 11,3000/ha, respectively for both the crops in 110 days. The B:C ratio was in favour of cauliflower (4.1:1) as compared to cabbage (3.1:1).

As there were six crops experimented in three seasons in two years as intercrops in one-year-old lemon orchard, it was inevitable to find out which crop may be the best fit as intercrop and in which season. For this, both the economic indicators namely net return/ ha, B:C ratio as well as agronomic indicators like crop productivity index and muskmelon equivalent yields were taken into consideration. The results as presented in Table 5 showed that net income was highest muskmelon as the summer crop option followed by cauliflower as the winter crop choice. For rainy season, dual purpose maize emerged as the main option. The table further revealed that the CPI was highest for muskmelon (0.90) followed by cauliflower (0.79). However, in *kharif*, CPI was superior for fodder sorghum albeit the greater return from dual purpose maize made it as the best choice. Another indicator MEY also indicated the decision in favour of cauliflower and dual purpose maize as the best fit for winter and rainy season intercrop option.

In order to arrive at the general conclusions, the obtained results were further analyzed on larger system basis, *i.e.*, cropping system. The economic indicators thus calculated for different intercropping system were obtained and presented in Table 6. It is evident from the table that the trends of all the indicators of system economics followed the same trends as those indicated in above analysis. However,

Table 4. Performance of winter cabbage and cauliflower (2012-13 and 2013-14) as the intercrop in lemon orchard.

Parameter	Unit	Value (cabbage)	Value (cauliflower)
Yield obtained	t/thousand m^2	3.2	2.5
Gross cost of production	Rs/ha	40,000	37,000
Gross return	Rs./ha	1,25,000	1,50.000
Net return	Rs/ha	85,000	1,13,000
B:C ratio	-	3.1 : 1	4.1 : 1

Table 3. Performance of maize (green cob) and sorghum (fodder) as the intercrops in lemon orchard during *kharif* (2012 and 2013).

Parameter	Unit	Value (maize)	Value (sorghum)
Yield obtained			
Green cob	t/thousand m^2	2.5	-
Green fodder/ fodder stalk		1.0	4.5
Gross cost of production	Rs./ha	16,000	12,000
Green fodder availability (obtained from 1,000 m^2 area)	Days	25	45
Gross return	Rs./ha	37,000	25,200
Net return	Rs./ha	21,000	13,200
B:C ratio	-	2.31:1	2.10:1

Table 5. Performance of various crops in different seasons as the intercrop options in actually planted area (1,000 m²).

Season	Crops	Avg. yield (t/thousand m²)	Cost of cultivation (Rs./ thousand m²)	Net income (Rs./ thousand m²)	B:C ratio	CPI	MEY
Summer (2012 to 2013)	Muskmelon	1.60	1,800	1,4200	8.9	0.90	-
	Fodder maize	03.0	1,000	1,550	2.6	0.64	1.72
Kharif (2012 to 2013)	Fodder sorghum	04.5	1,200	1,320	2.1	0.36	1.49
	Maize cob	0.25	1,600	3,700	2.3	0.29	1.80
	(Extra fodder)	01.0					
Rabi (2012-13 to 2013-14)	Cabbage	03.2	4,000	8,500	3.1	0.78	4.17
	Cauliflower	02.5	3,700	11,500	4.1	0.79	4.51

CPI = Crop Productivity index; MEY = Muskmelon equivalent yield

Table 6. Relative performance of various intercrops in lemon orchard.

S. No.	Parameter	Unit	Intercropping combination	
			Lemon + Fodder maize – Muskmelon-Cauliflower	Lemon + Maize (cob) – Fodder sorghum-Cabbage
1.	Gross cost of the system	Rs./ha	68,000	65,000
2.	Gross return of the system	Rs./ha	2,42,500	1,65,200
3.	Net return of the system	Rs./ha	1,74,500	1,00,200
4.	B:C ratio	-	3.56	2.54
5.	Net profit/ day	Rs./day	478.08	274.52
6.	Land Equivalent Ratio (LER)	-	3.00	2.30
7.	System's utilization viability ranking	-	I	II

the magnitude of these indicators for the whole cropping systems was impressive. The intercropping system of lemon + fodder maize-muskmelon-cabbage was found superior in terms of net return/ ha/ year (Rs. 1,74,500) and B:C ratio (3.56:1) as compared to lemon + maize (cob + fodder)-fodder sorghum-cauliflower. The net profit per day and land equivalent ratio (LER) was better in former cropping system (Rs. 478.0 and 3.0) than in later (Rs. 274.5 and 2.3), thus rendering the intercropping system first as the best choice.

The intercropping of perennial lemon with vegetables, fruit and fodder has enhanced the profitability in the irrigated areas. The lemon orchard intercropped with fruit (muskmelon), fodder maize and cauliflower in summer, *kharif* and winter season emerged as the most profitable combination.

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