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Economic Feasibility of Intercropping of Vegetable Crops Under Kinnow Orchard

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Abstract

Intercropping is based on the principle of efficient utilization of both horizontal and vertical spaces available in fruit orchard. Intercropping in fruit orchard has many advantages including the generation of additional income,ensuring food security and preventing soil erosion through orchard floor covers. Mandarins, which have longer gestation period, are well suited for short duration intercrops and keep the orchard economically viable and feasible till the trees came to bearing stage. The Okra-French bean crop rotation has been reported as most economically viable intercropping system in six years old Kinnow orchard with gross income of Rs. 485304\ha andnet return of Rs. 388629\ha followed by Brinjal-Cauliflower crop rotation with gross income of Rs. 441365\ha and net return of Rs. 355190\ha. However, highest benefit: cost ratio was obtained from Brinjal-Cauliflower crop rotation (4.12:1) followed by Okra- French bean crop rotation (4.02:1) among all intercropping systems.Thus, intercropping short durational vegetable crops like Brinjal, Okra, Cauliflower, French beans, Radish and Spinach have been observed to be economical and profitable intercrops under Kinnow plantation.

Keywords: Beneift: Cost Ratio, Crop rotation, Gross Income, Intercropping, Kinnow, Net return.

Introduction

Citrus belongs to family Rutaceae comprising of more than 162 species among which the mandarin (*Citrus reticulata* Blanco.), grapefruit (*C. paradisi*Macf.),pummelo (*C. grandis*Osbeck*)*, sweet orange (*C. sinensis*(L) Osbeck), acid Lime (*C. aurantifolia*Christm) and lemon (*C. limon*(L) Burn F.) etc. are grown throughout the subtropical world at commercial scale (Swingle and Reece, 1967). Kinnow, the first generation hybrid ofKing Mandarin (*C. nobilis*Lour.) x Willow leaf mandarin (*C.*

*deliciosa*Tenura.) was developed by H.B. Frost at California, Regional fruit station, USA (Joshi *et al.,* 1997; Sharma *et al.,* 2007). Kinnow is popular with the growers and consumers in North India because of its superb fruit quality coupled with good tree vigour, higher cropping potential and better performance than other citrus fruits. Delfts- Fritz (1970) observed that the optimum citrus trees growth and production of citrus are influenced by factors such as soil, climate and age of tree, intensity of transpiration, seasons, rootstocks, topographic locations and wind fluctuation. In general, low soil fertility due to low organic matter and water deficits directly reduces tree growth, fruit set and causes heavy June fruit drop and, consequently, decreases the yield and fruit quality.

Agri-horti system is one of the sustainable practice which insures maximum utilization of natural resources to get very high net income per unit area and time. At early stage of orchard establishment farmers can performintercropping of short durational vegetable crops to generate income from such orchards through effective land utilization (Gill and Bisaria, 1995). The synergistically these fruit trees enrich the soil with organic matter to improve physical-chemical properties of soil and thus improves crop performance (Tian *et al.,* 1993; Sanchez *et al.,* 1996). In Agri-horti system, trees and agricultural crops are combined together and they compete with each other for growth sources such as light, water and nutrients. The resource sharing in component crops may result in complementary or competitive effect depending upon nature of species involved in the system. Intercropping is one of the techniques of land utilization for optimum production (Bhattanagar*et al.,* 2007).Further, the organic matters added from intercrops improves soil fertility and make the mandarin basedagri-horti system ecologically sustainable and economically feasible to the farmers (Upadhaya*et al.,* 1994). Considering the significance of intercropping, four summer season and four winter season vegetable crops were evaluated for their performance and economic feasibility as intercrops in Kinnow orchard.

Materials and Methods

The experiment was conducted in 6 years old orchard of Kinnow intercropped with four potential summer vegetable crops viz. Okra (*Abelmoschus esculentus*(L.)Moench.), French bean (*Phaseolus vulgaris* L.), Radish (*Raphanus*

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sativus L.) and Brinjal (*Solanum melongena*L.) followed by four winter vegetable species viz., Cauli flower (*Brassica oleracea* var. *botrytis*), Pea (*Pisum sativum*), Spinach (*Spanica oleracea*) and Radish (*Raphanus sativus* L) in sequence of crop rotation (Table1).

Table 1. Vegetable Intercrops grown under Kinnow orchard in summer and winter season

Crop	Variety	Spacing	Sowing time	Crop	Variety	Spacing	Sowing time
Summer Season Vegetable Intercrops				**Winter Season Vegetable Intercrops**			
Okra	Nidhi	60 x 45	1April	Cauliflower	Top-75	50 x45	30October
Brinjal	Krishna	50 x 45	1 April	Field Pea	Punjab-89	50 x 45	30 October
Radish	Advance white (ASR-112)	30 x 10	1 April	Radish	Kashper	30 x 10	30 October
French bean	Contender	45 x 30	1 April	Spinach	Punjab green	NA	30 October

The observations on various parameters of growth and yield of intercrops, yield and quality of Kinnowfruitsand the economic analysis of inercropping system under Kinnow orchard were recorded at the proper stage.

The total number of plants for each intercrop was recorded after complete emergence and again at full maturity to determine survival of intercrops under shade. Survival percentage was determined at plant maturity.The plant height of each vegetable species was measured from base of plant to apical growth of plant at time of harvesting with the help of meter scale was expressed in cm.The plant spread was measured in cm in two directions i.e. East-West and North-South with the help of meter scale and average was taken.The marketable yield of each summer and winter vegetable crop is recorded on the basis of harvested produce per plant (gram) and expressed in kilograms per plot.

The fruit yield of guava tree was estimated on the basis of the total number of fruits per tree and the average fresh weight of fruits harvested during both rainy and winter season guava crop.TSS content of fruits was determined in brix per cent by hand refractometer. The value was recorded at 20^0Brix and mean value was expressed in

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per cent TSS of juice of kinnow fruits. The acidity content of fruit was estimated by titrating the sample against N/10 NaOH solution and phenolphthalein as internal indicator. The total titrable acidity was expressed as citric acid using the following formula: N1 ml N/10 NaOH = 0.0064 gram citric acid (A.O.A.C., 1990).

The sugar content of kinnow fruits were estimated for total sugar, reducing and non-reducing sugars by using method of Fehling solution as advocated by Rngana (1994). The non-reducing sugar was calculated by deducting the quantity of reducing sugar from total invert-sugar and multiplied by the factor 0.95.The ascorbic acid content of fruit was estimated with the help of 3% metaphosphoric acid and 2, 6-dichlorophenol-indophenoldiol dye (A.O.A.C., 2000) and expressed in mg/100g of fruit pulp.The juice from 1 Kg ofKinnow fruit from each treatment and replication was extracted and their average was taken to express in percentage.

The cost of cultivation of each intercropped vegetable crops was calculated separately by adding the value of each inputs, labour charges, irrigation charges and intercultural operations practiced during the crop seasons.The yield of each vegetable produce were converted into gross income based on the prevalent market price of each produce. The net income was calculated for each intercrop by deducting the cost of cultivation from the gross income obtained in each vegetable crop.The benefit: cost ratio of different intercrops was calculated by dividing the total net income by respective cost of cultivation of different intercrops.

The observations recorded on different aspects were statistically analyzed. The analysis of variances, SE and C.D. were computed as per experimental design using the following statistical methods as supported by Cocharan and Cox (1970).

Results and Discussion

Survival and growth of Intercrops: It is evident from the table (Table 2) that in summer season, the plant population of intercrops under Kinnow plantation was recorded to be highest (789.25 per plot)for Radishfollowed by French bean (164.75 per plant). In winter season, the maximum number of plants (1123 per plot) was recorded in Spinach followed byRadish (753 per plant). The plant population of intercrops was reported to be function of plant spacing as confirmed by findings of

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Reddy *et al.,* (2000) and Resende*et al.,* (2001).The maximum survival (91.08%) was recorded in Cauliflower (95.24%) followed by French bean (91.08%) and Radish (87%).Among all intercrops, only Brinjal had low survival rate (68.24%). High degree of survival of the intercrops grown in Kinnow orchard might be associated with their ability to grow well even in shade. The plant height ranged from (14.50 – 105.60 cm) in summer season intercrops and (16.22- 46.90 cm) in winter season intercrops. The variation in plant height of different intercrops might be associated with difference in their growth behavior.These results are in accordance with the findings of Swain (2014) and Hiwale (2015) who reported that intercropping system exhibited better performance which had been reflected in the form of plant height.Similar results were reported by Singh *et al.,* (2014) in aonla and guava based intercropping systems.

Table2. Growth and yield of intercrops under Kinnow plantation

Intercrops	Plant population per plot	Survival (%)	Plant Height (cm)	Average Spread (cm)	Yield (Kg/plot)
Okra	75.75	82.33	84.42	79.00	92.77
Brinjal	75.75	68.24	105.60	53.90	30.67
Radish	789.25	87.21	14.57	35.47	58.50
French bean	164.75	91.08	57.32	57.52	18.67
Cauliflower	106.75	95.24	41.82	43.85	97.61
Field Pea	94.75	85.36	46.90	34.17	23.67
Radish	753.00	87.00	16.22	35.95	60.05
Spinach	1123.00	NC	35.57	45.45	40.00

The total yield of vegetable crops grown as intercrop under Kinnow orchard indicates that the yield of intercrops ranged from 18.67 kg per plot in French bean to 97.61 kg per plot in Cauliflower. The variation in yield of various intercrops relatively lower under shade of Kinnow trees when compared with the harvestof these produce by farmers under the monoculture system. The present findings are in conformity with the result recorded by Singh *et al.,* (2014) and Singh *et al.,* (2015) under guava + tuber crops and aonla + suranbased intercropping systems, respectively.

Yield of Kinnow fruits: The yield of Kinnowfruits per plant has been presented in Fig. 1 which indicates that the yield of Kinnow varies from 66.85 Kg – 78.62 Kg per

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plant under various intercropping system. The highest yield (78.62 kg) was recorded in T_1 (Kinnow + Brinjal - Cauliflower) followed by 75.6 Kg in T_3 (Kinnow + Radish - Radish),73.37 Kg in T_2 (Kinnow + Okra - French pea) and 71.5 Kg in T_4 (Kinnow+ French Bean - Spinach) whereas, the minimal (66.85 Kg) was recorded in T_5(Kinnowas sole crop).

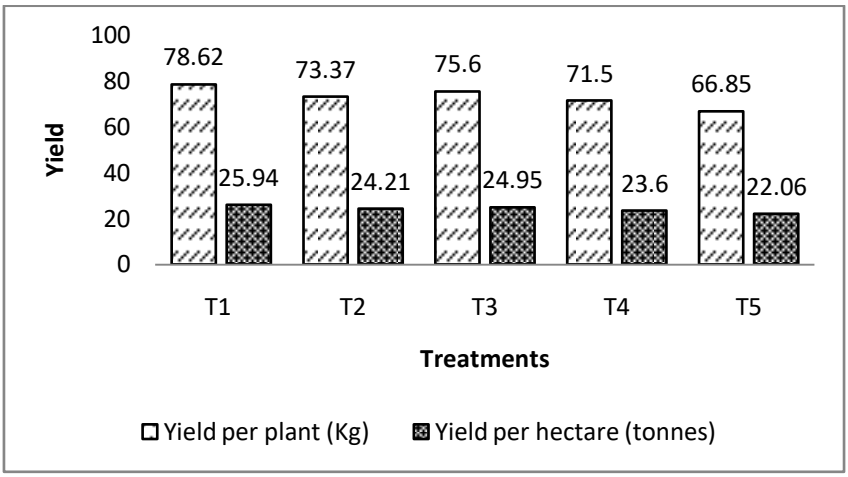

Fig. 1. The yield of Kinnow fruits under different intercropping systems

Similarly, the estimated total yield of Kinnow per hectare has been reported to be maximum (25.94 tonnes/ha) in Brinjal - Cauliflower cropping system followed by Radish- Radish (24.95 tonnes/ha) and Okra - Field pea (23.60 tonnes/ha) intercropping system while it was lowest in Kinnow as sole crop (22.06 tonnes/ha). Thus, the yield of Kinnow fruits has not been reported to get adversely affected by intercropping which might be associated with restricted growth behavior of intercrops grown for short period underneath the tall growing perennial trees of Kinnow. The better nutrient supply and orchard floor management might be responsible factor behind better yield of Kinnow fruits under different intercropping system in comparison to Kinnow a sole crop. This is in conformity with the finding of Tripathi (1976), Shyamal and Verma (1982) under various intercropping system. Similar findings have been reported by Singh *et al.,* (2014) in guava based intercropping system and Singh *et al.,* (2015) in aonla based cropping system.

Kinnow fruit quality: The chemical analysis of Kinnow fruits obtained under different intercropping system have been presented in Table3, which confirms significant effect intercropping system. The highest (11.80ºBrix) TSS was reported in

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T_4 (Kinnow + French bean - Spinach) followed by 11.67º Brix in T_5(Kinnow sole), both of these are significantly better than T_1 (Kinnow + Brinjal - Cauliflower) and T_2 (Kinnow + Okra - French pea).

Table3. Quality of Kinnow fruits under different intercropping system

Treatments	TSS (ºBrix)	Total acidity (%)	Ascorbic acid (mg/100gm)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Juice content (%)
T_1	11.25^{b}	1.04	19.22^{b}	9.70^{c}	4.16^{b}	5.51^{c}	45.83^{ab}
T_2	11.30^{b}	0.977	19.52^{b}	10.03^{b}	4.37^{a}	5.66^{b}	44.40^{b}
T_3	10.67^{c}	1.18	20.57^{a}	10.14^{ab}	4.34^{a}	5.80^{b}	45.07^{b}
T_4	11.80^{a}	0.993	20.30^{a}	10.22^{a}	4.16^{b}	6.07^{a}	46.97^{a}
T_5	11.67^{a}	1.09	18.60^{c}	10.14^{ab}	4.27^{a}	5.90^{ab}	46.45^{a}
Mean	11.34	1.06	19.64	10.05	4.26	5.79	45.75
SMe±	0.54	0.896	0.641	0.121	0.102	0.188	0.727
CD(0.05)	0.358	0.461 (NS)	0.39	0.169	0.156	0.211	1.31
CV	2.05	2.83	1.29	1.09	2.37	2.37	1.86

The maximum acidity (1.18%) was found in T_3 (Kinnow + Radish - Radish) followed by 1.09% in T_5 (Kinnow as sole crop) and 1.03% in T_1 (Kinnow + Brinjal - Cauliflower) whereas the minimum of acidity was recorded in T_2(Kinnow + Okra - Field pea) and T_4 (Kinnow + French bean - Spinach) as0.97% and 0.99%, respectively. The maximum ascorbic acid value (20.57mg/100gm) was reported in T_3 (Kinnow + Radish - Radish) which was at par with 20.30mg/100gm in T_4 (Kinnow + French bean - Spinach),and was significantly better than T_2 (Kinnow + Okra - French bean) and T_1 (Kinnow + Brinjal - Cauliflower) which contain 19.52mg/100gm and 19.22mg/100gm ascorbic acid, respectively. However, lowest ascorbic acid content was found in T_5 (Kinnow sole crop) with 18.6mg per 100gm of fruit juice.

The maximum total sugar (10.22%) was reported in T_4 (Kinnow + French bean - Spinach) which was significantly higher than allother treatments and was followed by 10.14% in T_5 (Kinnow sole) and T_3 (Kinnow + Radish - Radish), respectively. The maximum (4.37%) reducing sugar was found in T_2 (Kinnow + Okra - French bean) which was at par with 4.34% in T_3 (Kinnow + Radish - Radish) and 4.27% in T_5 (Kinnow sole), however maximum (6.06%) non-reducing sugar was found in T_4

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(Kinnow + French bean - Spinach) followed by 5.9% in T_5 (Kinnow sole). The maximum (46.97%) fruit juice percent was reported in T_4 (Kinnow + French bean - Spinach) followed by 46.45% in T_5 (Kinnow sole).

Data pertaining to quality related attributes of Kinnow fruits influenced by intercropping in summer and winter season clearly indicates a significant effect of intercropping on TSS, sugar, acidity, ascorbic acid and juice percent which might be associated with orchard floor management through the practices followed during inter-cropping. Although non-significantly but positive influence of inter cropping tuber crops on guava and aonla has been reported by Singh *et. al.*, (2015) and Singh and Singh (2015), respectively.The content of quality related attributes has been reported relatively lower in some of the inter crops like lower TSS when radish was grown as inter crop; lower acidity when okra, French pea, spinach and French bean were grown as inter-crop; and sugar when Brinjal and cauliflower were taken as intercrop. However, these lowering of quality attributes was not significant in comparison to control. This justify that the quality attributes have not been adversely affected due to growing intercrop in Kinnow which is in confirmitywith Nelliate*et. al.,* (1974) and Kumar *et. al.* (2000) in Papaya based intercropping system.

Economic analysis and Benefit: cost estimation: The cost of cultivation (Table 4) of different cropping systems were estimated as maximum in T_4 (Kinnow + Freanch bean - Spinach) as Rs. 101725\ha followed by T_2 (Kinnow + Okra - French bean) as Rs.96675\ha, T_3 (Kinnow + Radish - Radish) as Rs. 96400\ha, and T_1 (Kinnow + Brinjal - Cauliflower) as Rs. 86175\ha. The minimum cost of cultivation was estimated in T_5 (Kinnowas Sole crop) which was Rs. 42100\ha. It was observed from the table that the highest gross income was obtained from T_2 (Kinnow + Okra - French bean) as Rs. 485304\ha followed by T_1 (Kinnow + Brinjal - Cauliflower) as Rs. 441365\ha, T_4 (Kinnow + Freanch bean - Spinach) as Rs. 416780\ha and T_3Kinnow + Radish - Radish as Rs. 408701\ha whereas, the minimum gross return was estimated in T_5 (Kinnow as sole crop) which was Rs. 264720\ha.

Table 4: Cost of cultivation and aconomic analysis of different intercropping systems

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Treatments	Input cost for summer and winter season intercrops (Rs.)		Input cost (Rs.) for Kinnow (C)	Total input cost (Rs.) a = A+B+C	Gross income (b)	Net income (c)	B:C Ratio (c/a)
T_1	36500	46875	2800	86175	441365	355190	4.12
T_2	42625	51250	2800	96675	485304	388629	4.02
T_3	46650	46650	2800	96100	408701	312601	3.25
T_4	60225	38700	2800	101725	416780	315055	3.09
T_5	0	0	42100	42100	264720	222620	5.29

The highest net return was obtained from T_2 (Kinnow + Okra - French bean) as Rs. 388629\ha followed by T_1 (Kinnow + Brinjal - Cauliflower) as Rs. 355190\ha, T_4 (Kinnow + French bean - Spinach) as Rs. 315055\ha and T_3 (Kinnow + Radish - Radish) as Rs. 312601\ha whereas the minimum net return was recorded in T_5 (Kinow as sole crop) which was Rs. 222620\ha. It is observed that the highest cost-benefit ratio was obtained from T_5 (Kinnow sole) as 5.29 followed by T_1 (Kinnow + Brinjal - Cauliflower) as 4.12, T_2 (Kinnow + Okra - French pea) as 4.02, T_3 (Kinnow + Radish -Radish) as 3.25 and the minimum (3.10) was reported in T_4 (Kinnow + French bean - Spinach).

The assessment of economic values of different intercropping systems in terms of gross-income, net-income and cost: benefit ratio clearly indicated that the maximum gross income and net income were estimated under various intercropping systems as compared to sole crop of kinnow. The present findings revealed that the growing of intercrops in the kinnow orchard increased the net return per ha due to additional income obtained by intercrops. The present observations are in agreement with the findings of Hugar*et al.* (1991) intercropping of vegetables in guava plantation with high return per hectare. Similarly, the high cost: benefit ratio of these cropping systems may be due to high yield and market price of produced: with low investment involved in their cultivation as confirmed by Kumar *et. al.* (2013) in litchi based intercropping system.

Conclusion

Thus, it is clear from the present results that intercropping of vegetable crops have been found economically superior as compared to sole crops of kinnow. The findings

are in accordance with observation recorded by Bhuwa*et al.* (1988) and Rajput *et al.* (1980). Thus, intercropping of suitable short duration intercrops in Kinnow orchard has been reported to be useful for better orchard managementand is an economical practice to generate additional income to the farmers.Brinjal, Cauliflower, French pea, Radish and Spinach are suitable intercrops which can be grown well under shade of Kinnow trees. Further, intercropping does not have any negative impact on yield and quality of Kinnow fruits.

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