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PRODUCTIVITY AND ECONOMICS OF LEGUME AND NON LEGUME INTERCROPS IN APPLE ORCHARD

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ABSTRACT

A field experiment was conducted at Central Institute of Temperate Horticulture during 2009 - 2013 to find out suitable apple based intercrops for high income and sustainability. Eleven need based intercrops comprising of spices and condiments, vegetables, legumes, forage and oil seed crops were evaluated including the control. Apple fruit yield linearly increased in each year irrespective of treatments. Highest average apple fruit yield (10.08 t ha^{-1}) was recorded with apple + red clover intercropping system. Apple + fenugreek system, recorded highest apple equivalent yield (18.96 t ha^{-1}) closely followed by apple + peas intercrops. Maximum total (Rs.565534 ha^{1}) and net returns (`. 559530 ha$^{1}$) were obtained with apple + fenugreek inter crops followed by apple + garlic (`.5, 54000 and 4,05000 `/ha. Apple + fenugreek recorded highest benefit: cost ratio (5.30) followed by apple + swisschard (3.81). Inter crop apple + lentil recorded highest soil nitrogen gain (9.8 kg ha^{-1}) followed by apple + fenugreek (9.7 kgha^{-1}). Intercrop apple +fenugreek also recorded highest available potassium in soil. On the basis of emanated results, apple+ fenugreek was best intercrop for obtaining high income, synergy and sustainability followed by apple + lentil and apple + peas.

Key Words: Intercrops, apple equivalent yield, economics, soil fertility

INTRODUCTION

Apple is one of the important temperate fruits of world and has high priority in the list of growers and consumer's due to higher yield, better taste and nutritive values. It accounts 50 % of total area and 70 % total production of temperate fruits in India (Chadha, 2001). Advent of new root stocks and spur type scion varieties, apple production technology is changing day by day. A closer planting density is being used as tool for improving the productivity of apple. Intercropping is common practice in apple orchard to check the weed growth, improve the soil health and augment the additional income *vis a vis* to maximize the beneficial interaction with sole crop by minimizing the crop competition (Singh, 1999). The successful crop mixture exploits variation between component crops by extending the sharing of resources over time and space (Lithourgidis, *et al*, 2011). It also lowers the needs of external inputs and improves the stability and diversity (Chandra, *et al*, 2013) if ecological niches are kept in the mind while selecting the inter crops. Ecological niche crops do not compete with each other for basic inputs like light, nutrients and water (Rasoul *et al*, 2013). Though intercropping is an old practice in valley, farmers used to grow mustard, oats, rice and some vegetables like kale and cabbage without keeping in view the ecological niche and synergetic interaction benefits of intercrops as well as maximum benefit cost ratios. Success of intercropping system depends mainly on selection of suitable crops and agronomic modification for efficient resources uses. Therefore, an experiment was conducted to find out the most productive and remunerative apple based inter cropping system under Kashmir ecological conditions involving legumes, spices, vegetable forage and oil crops.

MATERIALS AND METHODS

Field experiment was conducted at Experimental Farm of Central Institute of Temperate Horticulture Rangreth Srinagar (Jammu and Kashmir). Geographic position of the experimental site lies between latitude of 34^0 05 N and longitude of $74^0$50 E at an altitude of 1640 m above the sea level. The average maximum (19.63 ^{0}C) and minimum (6.52 ^{0}C) temperature, amount of rainfall (160.72 mm) and relative humidity (58.35 %), evaporation (2.45 mm) were recorded during the cropping season. The experiment was conducted for four consecutive years i.e. 2009 and 2013 on six year old apple orchard of variety Oregon Spur variety grafted on seedling root stock planted at 4 x 4 m inter and intra row spacing. The soil of experimental field was sandy loam slight acidic in nature (6.9 pH) with 0.15 dSm^{-1} EC, 4.5 g kg^{-1}organic carbon, 420 kgha^{-1} available nitrogen and 398 kg ha^{-1} available K. Ten need based intercrops comprising spices, vegetables, legumes, forage and oil crops were included in programme. The experiment comprised of eleven treatments *viz*, T_1: apple + fenugreek; T_2: apple + onion; T_3: apple

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+ lentil; T_4 : apple + garlic; T_5 :; apple + coriander; T_6 : apple + peas; T_7 : apple + lucerne; T_8 : apple + red clover ; T_9 : apple + swiss chard ; T_{10} : apple + mustard ; T_{11} : apple (sole). 30% area was left for sole crop and 70% area under inter crops. The experiment was conducted in randomized block design with three replications. The varieties of fenugreek " NRCSS-2", Onion 'Yellow Globe', garlic 'Muktsar Garlic Selection-1', lentil ' Shalimar lentil-1', Coriander ' Shalimar Dhania-1, Pea " PS-1100" Lucerne ' IGFRI-S-244', Red Clover 'Local', Swiss Chard ' CITH-SC-1' were used in the experiment. Fertilizer doses were calculated on the basis of soil test. Application of 140g N, 30g P_2O_5 and 175g K_2O/tree was done in 2009 and 180 N, 40g P_2O_5 and 225 g K_2O_5/tree in 2010 as per age of apple tree. The half dose of N and full dose of P and K was applied in mid of March before 15 days of flower initiation where as ¼ of N was applied at pea size fruiting stage i.e. end of April and remaining ¼ N in month of August. In intercrops N, P and K were applied @ 40, 60, 20 kg ha^{-1} in fenugreek, 150,60,60 kg ha^{-1} in onion, 150,50,50 kg ha^{-1} in garlic, 60,30,30 kg ha^{-1} in coriander, 30,60,60 kg ha^{-1} in lentil, 40,60,50 kg ha^{-1} in peas, and 60,60,60 kg ha^{-1} in lucerne and red clover, 60:40:40 kg ha^{-1} for the mustard. Recommended irrigations were given as per requirement of the crops. Observations on growth and yield parameters of apple and intercrops were recorded. Physico-chemical properties were studied at proper maturity stage of apple. Fruit firmness was measured with digital penitrometre, T S S with hand refractrometer whereas acidity by method described in AOAC (1984). Soil samples were collected before the sowing and after the harvest of the crops, processed and analyzed for physico chemical properties by following the standard procedures described by (Jackson 1973). The economics was calculated on basis of market price of inputs and outputs. The benefit : cost ratio was calculated by dividing net returns with cost of cultivation of individual treatments. Four years data were pooled together and subjected statistical analysis using the computer package MSTATC (Gomez and Gomez 1995).

RESULTS AND DISCUSSION

Yield

Yield of sole crop influenced significantly with different intercropping patterns. The sole crop showed a linear increase in fruit yield during four consecutive years of experiment irrespective of intercrop treatments. Highest mean apple fruit yield was recorded with apple - red clover intercropping system (10.08 t ha^{-1}) with 104.4 % crop index followed by apple + peas (9.91 t ha^{-1})with 103.1 crop index and apple - lucerne (9.71 t ha^{-1})with 101.0 % however lowest fruit yield was recorded with apple + onion (6.22 t ha^{-1}) followed by apple coriander (7.53 t ha^{-1}). Higher yield and crop index of apple with red clover and peas and lucerne inter crops may be due to atmospheric nitrogen fixing capacity of these leguminous crops, which might have added additional nitrogen in soil and leads to complementary and more efficient use of renewal nitrogen sources for sole crop. It may be also due to some growth hormone released by nitrogen fixers during the nodulation in these leguminous crops. Whereas, crop index and yield loss of apple as compare to sole crop in onion and coriander may be due to their higher nutrient requiremen (Badshah *et al*, 2000). These results are in accordance with the findings of Haquae *et al,* (2001) and Singh (2010). The highest mean apple equivalent yield of four years was observed with apple + fenugreek (18.96 t ha^{-1}) followed by apple + garlic (18.80 t ha^{-1}) and apple + swisschard (15.74 t ha^{-1}). This may be due to better yield of these intercrops

Table 1: Yield of apple, intercrops and apple equivalent yield in different intercropping systems

Treatments	Intercrop yield (t ha^{-1})					Apple yield (t ha^{-1})					Crop index (%)	Apple equivalent yield (t ha^{-1})				
	1st Yr.	2nd Yr.	3rd Yr.	4th Yr.	Mean	1st Yr.	2nd Yr.	3rd Yr.	4th Yr.	Mea		1st Yr.	2nd Yr.	3rd Yr.	4th Yr.	Mean
T_1 Apple + Fenugreek	2.80	2.15	2.29	2.35	2.22	6.29	8.09	11.05	12.59	9.50	9.90	16.59	19.01	19.80	20.46	18.96
T_2 Apple + Onion	15.31	17.50	18.31	17.25	17.09	3.65	5.03	7.15	9.07	6.22	6.48	11.32	13.81	12.67	14.85	13.16
T_3 Apple + Lentil	1.67	1.55	1.77	1.95	1.74	8.15	8.53	9.40	9.60	8.92	9.26	10.94	11.12	11.61	14.80	12.12
T_4 Apple + Garlic	5.24	7.04	8.24	6.55	6.77	7.35	9.05	9.29	9.50	8.80	9.13	16.08	19.12	19.59	20.41	18.80
T_5 Apple + Coriander	1.24	1.17	1.25	1.38	1.26	6.81	7.05	7.78	8.56	7.53	7.84	13.01	12.97	10.22	12.23	12.10
T_6 Apple + Peas	6.15	8.56	9.20	7.56	7.87	7.03	8.95	11.61	12.04	9.91	10.31	11.13	14.63	16.21	17.05	14.76
T_7 Apple + Lucerne	23.73	25.00	24.50	24.65	24.47	6.76	8.95	11.55	11.56	9.71	10.10	10.72	13.12	14.61	16.11	13.64
T_8 Apple +Red Clover	23.00	24.50	28.00	23.76	24.82	7.59	9.06	11.14	12.53	10.08	10.45	11.44	13.15	14.64	15.52	13.69
T_9 Apple +Swiss chard	22.83	24.83	25.03	24.56	24.32	5.45	7.88	9.29	10.03	8.16	8.50	13.03	16.18	15.54	18.21	15.74
T_{10} Apple +Mustard	2.05	2.20	2.06	2.27	2.14	5.05	8.53	9.72	9.93	8.31	9.69	6.77	10.37	11.77	12.20	10.28
T_{11} Apple (sole)	2.01	2.50	2.20	2.55	2.32	6.58	9.05	11.27	11.53	9.61	10.00	7.08	9.65	11.77	12.07	10.14
CD (P=0.05)	0.74	0.91	2.11	1.72	-	0.49	0.72	1.11	0.93	-	-	2.16	2.99	1.71	1.98	-

with apple and their lucrative price in the market. These findings get support with findings of with Sarkar *et al,* (2004) in mango and Arya *et al*, (2010), in aonla, ber and bael fruit crops.

Physico-chemical characteristics of fruits

Physico-chemical analysis of apple fruits with combination of different intercrops revealed that fruit weight, diameter and length improved, significantly. Highest fruit weight (191.3 g) was recorded with apple + lentil intercropping system followed by apple + red clover (190.9g), apple + peas (188.4g) and apple + fenugreek (187.3 g) and were statistically at par with each other. Interestingly, all these four intercrops were leguminous that have capacity to enrich the soil by fixing the atmospheric nitrogen, which helps in plant and fruit growth by helping the cell enlargement. Lowest fruit weight was recorded with apple + swisschard (170.8g) followed by apple + mustard (171.5g), which may be due to nutrient exhaustive nature of these crops. However, these treatments recorded better fruit firmness i.e. 59.59 lbs and 40.41 lbs, respectively. This might be due smaller size of fruit with better balance between nitrogen and potassium in these treatments. Similar findings were reported by Ghosh and Pal (2010) in sweet orange and Bhatnagar *et al*, (2007) in Kinnow.

Table 2: Average of physico-chemical characteristics and economics of apple fruits as influenced by different intercropping systems

Treatments	Fruit Weight (g)	Fruit Diameter (mm)	Fruit Length (mm)	Fruit Firmness (lbs.)	Colour (pt.)	TSS (^{0}B)	Acidity (%)	Net Return (Rs ha^{-1})	B:C ratio
Apple +Fenugreek	187.36	72.5	65.4	35.9	75.8	16.0	0.30	459530	5.30
Apple + Onion	171.06	71.1	63.5	36.0	63.7	14.2	0.20	274390	2.27
Apple + Lentil	191.32	76.0	70.0	33.3	72.8	15.0	0.30	265480	2.70
Apple + Garlic	186.49	74.3	60.3	34.4	74.7	16.8	0.30	405000	2.55
Apple + Coriander	184.10	72.5	60.5	33.2	71.9	17.2	0.22	266620	2.76
Apple + Peas	188.39	72.6	60.5	35.1	65.0	14.5	0.20	322915	2.90
Apple + Lucerne	185.01	70.4	65.0	38.4	71.3	15.8	0.22	314700	3.30
Apple+ Red Clover	190.90	76.4	66.4	31.2	80.8	14.9	0.25	315640	3.32
Apple+ Swiss chard	170.81	64.7	63.0	39.5	83.8	14.9	0.20	374230	3.81
Apple +Mustard	171.48	65.0	62.3	40.5	85.0	16.7	0.25	217780	2.40
Apple	174.40	68.2	65.2	37.2	74.5	14.8	0.35	219455	2.77
CD (P= 0.05)	4.96	2.1	2.2	1.4	2.1	NS	NS		

Soil fertility

Data (Table 3) revealed that there was a gain in available nitrogen with leguminous intercrops. The highest available soil N was recorded in apple + lentil intercrop (429 kgha^{-1}) with gain of 9.80 kg ha^{-1}after four consecutive years intercropping, closely followed by apple + fenugreek (429 kgha^{-1}) with 9.7 kgha^{-1} N gain, apple + lucerne (429 kgha^{-1}) with 9.3 kgha^{-1} N gain, apple + peas (428.0) 8.5 kgha^{-1} N gain, whereas maximum nitrogen loss was observed with apple + mustard intercrop (417kgha^{-1}) with loss of 2.7 kgha^{-1}. Highest available soil K was recorded with apple+fenugreek (403 kgha^{-1}) with gain of 5.4 kgha^{-1}, whereas minimum available potassium was observed with apple + coriander intercropping (385 kgha^{-1}) with loss of 12.4 kgha^{-1} after four years of consecutive cropping. Results are in conformity with findings of Ghosh and Pal (2010), Begum *et al*. (1999), who have also reported improvement of nitrogen status with intercropping of leguminous crops.

Economics

Data (Table 2) revealed that highest cost of cultivation (`.87,500 ha$^{-1}$) incurred for garlic cultivation followed by onion (`. 49,000 ha^{-1}) and

Table 3: Effect of intercropping on fertility status of the soil in apple orchard after 4years

Treatment	pH (1:2)	EC (dSm^{-1})	O. C (g kg^{-1})	Available N (kgha^{-1})	Available K (kg ha^{-1})
T_1 Apple +Fenugreek	6.77	0.15	5.4	429	403
T_2 Apple + Onion	6.90	0.16	5.2	417	396
T_3 Apple + Lentil	6.80	0.13	5.5	429	399
T_4 Apple + Garlic	6.70	0.13	4.6	418	396
T_5 Apple + Coriander	6.75	0.14	4.6	418	385
T_6 Apple + Peas	6.91	0.15	4.9	428	398
T_7 Apple + Lucerne	6.90	0.16	5.1	429	398
T_8 Apple+ Red Clover	6.70	0.14	5.2	426	399
T $_9$ Apple+ Swiss chard	6.90	0.15	5.1	420	396
T_{10} Apple +Mustard	6.90	0.13	4.8	417	394
T_{11} Apple	6.90	0.14	4.9	420	397
Initial soil nutrient status	6.90	0.16	4.6	420	398

peas (Rs. 42,000 ha^{-1}) where as minimum expenditure incurred in mustard (`. 19000 $ha^{-1}$) and red clover (`. 25500 ha^{-1}). The highest expenditure in garlic, onion and peas were due to higher cost of their planting material and more labour involvement in their planting and harvesting. Highest total (`. 6,03,540 /ha) and net (`. 4,98,040/ha) return obtained with apple + fenugreek intercrops followed by apple + garlic i.e `. 5,59050 and `. 4,00550 ha^{-1} total and net return, respectively. Highest benefit cost ratio (5.30) obtained with apple + fenugreek intercrop followed by apple + swisschard (3.81). However, all the intercrops included in programme recorded better B: C ratio than sole crop of apple except apple + mustard intercropping. These findings get support with the findings of Ghosh and Pal (2010) in the sweet orange + cluster bean intercropping and Badshah *et al.* (2000) in legumes and non legumes intercropping in peach. In the present study, results revealed that apple+fenugreek was best intercrop for obtaining high income and sustainability followed by apple + lentil and apple+ peas. The more efficient utilization of growth resources leads to yield advantage and increased stability of fertility as compared to sole cropping. Higher yield, better economic return and improvement of soil fertility the inter crops fenugreek, lentil garlic, peas and red clover may be adopted for growing with apple under medium density orcharding.

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