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Effect of intercrops on productivity, quality, leaf nutrient status and relative economic yield of apple cv. Red Delicious

Rifat Bhat*, Sharbat Hussain, W.M. Wani, F.A. Banday and M.K. Sharma

*Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar 190 025, Jammu and Kashmir, India. *E-mail: rifat.bhat@rediffmail.com*

Abstract

The present investigations were conducted to assess the effect of intercrops like maize, pea, strawberry, cabbage, red clover, french bean, oats and clean cultivation (control) on productivity, quality, leaf nutrient status and relative economic yield of apple cv. Red Delicious. The results obtained revealed that the intercrops of leguminous nature like (pea, red clover, french bean) resulted in higher productivity, better quality fruits and increased leaf nutrient content in apple as compared to heavy feeder(requiring high level of soil nutrients) crops like maize, oats, strawberry and cabbage. However the apple plants intercropped with control (clean cultivations) performed better than heavy feeder crops. The impact of intercrops on relative economics of apple (system equivalent yield) revealed that the apple plants intercropped with pea gave a net income of Rs 291814.00 per ha with benefit : cost ratio of 1.71 followed by cabbage Rs 224428.00 per ha with the benefit: cost ratio of 1.41 and red clover with a net income of Rs 232395.00 with benefit : cost ratio of Rs 1.40, respectively.

Key words: Intecropping, productivity, quality, leaf nutrient status, apple, relative economics

Introduction

Apple being the predominant temperate fruit of India accounts for about 3 per cent of the total fruit production of the country. Though India stands 8th in apple production in the world, it ranks at 53rd position in terms of productivity. In India, the average productivity of apple is nearly 6.8 t/ha, which is much lower than the average yield of advanced countries *e.g*. Belgium (46.22 t/ha), Denmark (41.87 t/ha) and Netherlands (40.40 t/ha) (Banday *et al*., 2010). Among the temperate fruits in Jammu and Kashmir, apple ranks first covering 66.0 percent area and 87.0 percent production, respectively (Anonymous, 2014-15). Yield of apple has been showing an increase from 4.12 to 10.01 M tonnes per ha (1975-2009). Though it appears to be highest among the apple producing states of the country (Himachal Pradesh 6.0 M tonnes and Uttarakhand 3 M tonnes per ha), yet it is far below the level achieved by advanced apple growing countries. The productivity of apple in the state is 11.70 mt/ha. One of the main reason/causes for this low productivity is less availability of essential nutrients and moisture due to the presence of vulnerable weed both under the canopy of tree as well as in interspaces. Hence, growing of intercrops which are compatible to the main crop, in these interspaces reduces the weed invasion in the early stages of plant growth, increases the yield and produces better quality of the fruits as it reduces the competition for nutrients and moisture between weeds and plants. It contributes to high yield in tropical, subtropical and temperate areas, as it can be environmentally benign by reducing accumulation of nitrate in soil profile (Stuelpnagel, 1993). The fast growing population is another reason for enormous increasing demand for food. So once this system is practised under orchard conditions, it will be the top horticultural option to achieve an upswing growth rate in agriculture on a sustainable basis ensuring food and nutritional security, securing environmental safety, generating employment and alleviating poverty. So this system seems to be the possible solution to meet the continuous increase in demand for food, stability of income and diverse requirements of food, thereby improving the nutrition for small scale farmers with limited resources. Thus, keeping in view the above points the present investigation was undertaken to study the effect of intercrops on productivity, quality, leaf nutrient status and relative economic yield of apple cv Red Delicious at Farm Research Station, Balpora, Shopian, SKUAST-Kashmir during the year 2008.

Materials and methods

The present investigation was carried on nine year old bearing apple plants cv. Red Delicious at Ambri Research Station, SKUAST-K, Pahnoo, Shopian (Jammu and Kashmir) during the years 2008 and 2009. The plants were spaced 6x6 m apart. Intercultural operations were done on the basis of 4 plants per plot with a plot size of 36m^2. There were eight treatments *viz*. maize, pea, strawberry, cabbage, red clover, french bean, oats and clean cultivation (control). The experiment was laid out in the randomized block design with each replicated three times. Maize, cabbage and French bean were sown in kharif (summer) while pea, strawberry, red clover and oats were sown as rabi (winter) crop. All the cultural practices for each intercrop/apple were adapted as per the SKUAST-K package of practices. The experiment was conducted for two consecutive years. Before laying the experimental trial, soil status and growth parameters of apple trees were estimated and the same procedure was followed when apple fruits were harvested. Per cent fruit set was calculated at fruitlet stage by using the formula suggested by Westwood (1993). Floral characters like initial bloom and full bloom were recorded as dates of opening of first flower (10%) and full bloom (80%). The recorded dates were converted into days after reference

date which was selected arbitrarily as March 1st. Fruit yield was estimated by taking weight of all the fruits harvested from the tree under each treatment and expressed as kg/tree. Fruit maturity was worked out from the date of full bloom to the date when the fruit was actually harvested. Fruit length and fruit diameter was measured with the help of Vernier Calliper. Fruit weight was determined by individually weighing the fruits obtained from each experimental plant and average weights recorded. Fruit volume was determined by displacement method. Individual fruits were scored for the colour of the skin using 1-5 scale suggested by Webster and Goldwin (1981). Leaf total nitrogen was determined by Micro-Kjeldhal method (A.O.A.C., 1980), total phosphorus by Vanado-molybedate-phosphoric yellow colour method (Jackson, 1967) and total potassium by neutral normal ammonium acetate method using flame photometer (Merwin and Peech, 1950). Ca^{2+} and Mg^{2+} ions in leaf were determined using Atomic Absorption Spectrophotometer method and were expressed as per cent on dry weight basis. The nutrients estimated were expressed as per cent on dry weight basis. The economics of apple was worked out by determining the impact of intercrops raised on the relative economics of apple as "system equivalent yield". The data was subjected to statistical analysis in S-plus software.

Results and discussion

The data presented in Table 1 revealed that average time of attaining initial bloom, full bloom, per cent fruit set and fruit maturity was earlier in apple trees intercropped with pea followed by red clover and french bean, than heavy feeder crops (requiring high level of nutrients) like maize, oats, strawberry and cabbage when the number of days for these stages was counted from 1st March. However, more number of days were taken to first flower by the apple trees intercropped with control (clean cultivation) and heavy feeder crops *viz.* maize, oats, strawberry and cabbage. This may be possibly due to the fact that apple trees intercropped with leguminous crops (pea, red clover and french bean) had more vigour due to the availability of moisture and nutrients which resulted in greater length of shoots, bears more flowers and more fruits. These intercrops not only adds nitrogen but also makes phosphorus and potassium available to the plants which helps in greater accumulation of carbohydrates so inducing earlier bloom, while heavy feeder crops like maize and oats extract huge amount of moisture and nutrients from the soil thereby not only decrease the availability of nutrients to plants but also increase the duration for both intial bloom, full bloom and fruit maturity. These results are in congruence with Kanwar (2000) and Dris *et al.* (2001).

The data presented in Table 2 revealed that average fruit yield was higher in apple trees intercropped with pea followed by red clover and french bean. However, lowest yield of apple was recorded with maize. Higher yield in apple trees intercropped with pea, red clover and French bean might be due to high fruitset and fruit retention and also legumes increase the absorptive capacity of water and nutrients in upper fertile layer of soils thereby reducing evaporation. They also slightly maintain higher temperature which could essentially help in uptake of nutrients resulting in higher yield. These results are in agreement with Baxter (1970).

Fruits harvested from apple trees intercropped with legumes recorded maximum fruit length, fruit diameter, fruit weight and fruit volume (Table 2,3). However, control (clean cultivation) showed greater fruit length, fruit diameter, fruit weight and fruit volume as compared to heavy feeder crops like strawberry, cabbage, oats and maize. This may be due to the reason that heavy feeder crops (maize and oats) compete strongly for moisture and nutrients with the apple trees as they transpire more water (moisture), resulting in poor quality fruits while N fixation by legumes results in higher availability of nutrients and moisture as they increase water holding capacity of soil which might have helped to increase uptake of nutrients (P, K and Ca) and thus increased dry matter accumulation. These results are in congruence with Yankovoi (1983). Higher intensity of red colour was observed in apple trees intercropped with red clover followed by french bean, pea, control (clean cultivation), strawberry, cabbage, oats and maize. The lowest red colour intensity in apple fruits was observed when intercropped with maize. This may be possibly due to the higher availability of potassium which is

Table 1. Effect of intercrops on initial and full bloom, per cent fruit set and fruit maturity of apple cv. Red Delicious

Treatments		Initial bloom (days) after reference date			Full bloom (days) after reference date			Per cent fruit set			Fruit maturity (days from full bloom to harvest)		
		2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T_1	Maize	49.88	50.15	49.62	54.70	55.15	54.82	5.33	6.12	5.70	185.33	187.22	186.23
T_2	Pea	43.18	44.44	43.81	48.78	49.44	48.81	11.88	12.91	12.40	178.00	179.50	179.11
T_3	Strawberry	48.99	49.89	49.34	54.83	55.89	55.34	7.34	8.45	7.91	183.57	184.79	182.99
T_4	Cabbage	49.59	50.82	50.10	55.11	56.82	56.10	7.20	8.02	7.80	183.00	184.21	181.92
T_5	Red clover	45.98	44.32	45.13	50.28	51.32	50.80	10.62	11.88	11.31	180.20	182.10	180.08
T_6	French bean	47.78	48.22	48.00	52.78	53.22	53.00	9.55	10.75	10.05	182.40	184.50	183.35
T_7	Oats	49.70	50.10	49.50	54.57	55.10	54.60	5.41	6.61	6.03	185.80	186.07	185.75
T_8	Clean cultivation (control)	48.59	50.66	50.21	53.99	54.66	55.21	8.89	9.70	9.35	184.60	185.57	184.55
	LSD ($P \leq 0.05$)	0.22	0.10	0.14	0.88	0.52	0.32	0.37	0.28	0.22	2.10	2.42	1.10

Table 2. Effect of intercrops on fruit yield, fruit volume and fruit colour of apple cv. Red Delicious

Treatments		Fruit yield (kg/tree)			Fruit volume (cm^3)			Fruit colour (5 pt. scale)		
		2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T_1	Maize	28.67	29.22	28.60	149.97	150.02	149.86	3.09	3.19	3.13
T_2	Pea	35.17	37.51	36.41	163.86	165.56	166.77	3.52	3.60	3.54
T_3	Strawberry	29.57	31.79	30.70	152.72	153.97	152.99	3.37	3.44	3.40
T_4	Cabbage	29.00	30.57	29.62	151.26	152.14	151.00	3.20	3.32	3.25
T_5	Red clover	34.87	35.62	36.33	160.66	162.12	161.24	3.65	3.72	3.68
T_6	French bean	32.57	33.32	34.44	158.22	160.01	159.71	3.58	3.60	3.59
T_7	Oats	28.56	29.00	29.52	150.88	151.58	150.80	3.18	3.20	3.19
T_8	Clean cultivation (control)	30.27	32.02	31.65	155.29	156.52	157.12	3.43	3.53	3.48
	LSD ($P \leq 0.05$)	2.15	2.20	2.07	0.25	0.36	0.20	0.83	0.32	0.13

Table 3. Effect of intercrops on fruit length, fruit diameter and fruit weight of apple cv. Red Delicious

Treatments	Fruit length (mm)			Fruit diameter (mm)			Fruit weight (g)		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T_1 Maize	53.22	54.36	53.33	54.47	55.24	54.87	137.69	138.88	137.96
T_2 Pea	63.17	65.05	64.52	66.52	68.91	67.36	153.66	155.72	154.69
T_3 Strawberry	56.05	57.62	56.54	58.25	59.10	58.44	141.72	142.55	141.99
T_4 Cabbage	55.27	56.70	55.22	57.48	58.72	57.39	140.50	141.43	140.87
T_5 Red clover	61.52	63.65	62.42	63.42	65.71	64.86	148.24	150.29	150.49
T_6 French bean	58.97	60.48	59.01	61.40	63.55	62.77	144.82	146.86	145.29
T_7 Oats	54.52	55.22	54.79	56.36	57.20	58.46	138.66	139.01	138.12
T_8 Clean cultivation (control)	57.55	58.27	57.19	60.85	61.31	60.77	142.12	143.88	142.05
LSD ($P \leq 0.05$)	0.72	0.88	0.34	0.33	0.47	0.21	0.32	0.46	0.20

from the use of legumes particularly red clover as they provide sufficient moisture which enhances its uptake while uptake of potassium by cereal crops like maize and oats is decreased because of compactness of soil and surface sealing. These results are in line with Alston (1980).

The data presented in Table 4 and Table 5 revealed highest leaf N and Mg in apple trees intercropped with pea whereas lowest was recorded with maize. Leaf P, K and Ca was recorded highest in apple trees intercropped with red clover followed by french bean, pea, control (clean cultivation), strawberry, cabbage, oats and maize. This might be due to the fact that leguminous crops like pea have a symbiotic relationship with rhizobium species which is capable of fixing large amount of atmospheric N thus increasing available soil N. These results are in line with Fisenko (1969), while in case of leaf P, K and Ca the reason may be the higher availability of moisture by clovers, as they can go into the deeper layers of soils for extraction of moisture which might have facilitated the uptake of nutrients, as their uptake is correlated with the availability of H_2O. These results are in conformity with Shylla and Chauhan (2004).

The treatment wise economics in apple cv. Red Delicious revealed that the trees intercropped with pea gave a net income of Rs.291814.00 per ha with a benefit:cost ratio of Rs 1.71 followed by cabbage (Rs 224428.00 per ha with a benefit: cost ratio of Rs 1.41) and red clover with a net income of Rs 232395.00 with benefit:cost ratio of 1.40 (Table 6). This was mainly due to the seed production of cabbage, additional yield of pea, red clover and French bean and also their better marketing price. These results are in line with Bhuva *et al.* (1988).

From the foregoing discussion, it can be concluded that apple trees intercropped with pea, red clover and french bean resulted in better growth, productivity, quality and leaf nutrient status of apple and proved to be beneficial for sustainable development of orchardists as they have provided more returns. Further clovers should be used as companion crop in orchards as it improves the physical conditions of soils as well as enhances the higher availability of moisture.

Table 4 .Effect of intercrops on leaf N, P, K status of apple cv. Red Delicious

Treatments	Leaf nitrogen (%)			Leaf phosphorus (%)			Leaf potassium (%)		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T_1 Maize	2.00	2.10	2.06	0.152	0.160	0.155	1.66	1.70	1.68
T_2 Pea	2.58	2.68	2.62	0.191	0.195	0.194	1.79	1.82	1.81
T_3 Strawberry	2.37	2.40	2.38	0.161	0.173	0.166	1.75	1.78	1.77
T_4 Cabbage	2.32	2.36	2.34	0.158	0.165	0.162	1.70	1.73	1.72
T_5 Red clover	2.54	2.64	2.58	0.208	0.228	0.219	1.83	1.86	1.85
T_6 French bean	2.48	2.58	2.54	0.185	0.188	0.186	1.80	1.84	1.82
T_7 Oats	2.20	2.22	2.21	0.155	0.154	0.154	1.68	1.71	1.70
T_8 Clean cultivation (control)	2.42	2.45	2.43	0.170	0.177	0.172	1.78	1.81	1.79
LSD ($P \leq 0.05$)	0.03	0.02	0.01	0.02	0.01	0.03	0.01	0.03	0.02

Table 5. Effect of intercrops on Ca and Mg status of apple cv. Red Delicious

Treatments	Leaf calcium (%)			Leaf magnesium (%)		
	2008	2009	Pooled	2008	2009	Pooled
T_1 Maize	1.66	1.68	1.67	0.25	0.27	0.26
T_2 Pea	1.80	1.82	1.81	0.38	0.40	0.39
T_3 Strawberry	1.72	1.74	1.73	0.29	0.31	0.30
T_4 Cabbage	1.70	1.72	1.71	0.28	0.30	0.29
T_5 Red clover	1.92	1.94	1.95	0.35	0.37	0.36
T_6 French bean	1.86	1.88	1.87	0.32	0.34	0.33
T_7 Oats	1.68	1.70	1.69	0.26	0.28	0.27
T_8 Clean cultivation (control)	1.74	1.76	1.77	0.30	0.32	0.31
LSD ($P \leq 0.05$)	0.05	0.04	0.01	0.02	0.05	0.07

Table 6. Effect of intercrops on relative economic yield of apple cv. Red Delicious (system equivalent yield)

Treatment	Pooled apple yield (kg/ha)	Yield of intercrop (q/ha)	Income obtained from intercrops (Rs)	Apple equivalent intercrop yield (kg/ha)	Total system yield (kg/ha)	Total cost of cultivation/ ha	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit cost ratio
T_1 Maize	7436.00	30	24000	600.00	8036.00	140426.00	321440	181014.00	1.28
T_2 Pea	10246.60	21	52500	1312.50	11559.10	170550.00	462364	291814.00	1.71
T_3 Strawberry	7982.00			2200.00	10182.00	197582.00	407280	209698.00	1.06
i)Fruit		12	48000						
ii)Runner		40,000	40000						
T_4 Cabbage	7701.20	1.25	75000	1875.00	9576.20	158620.00	383048	224428.00	1.41
T_5 Red clover	9705.80	100	10000	250.00	9955.80	165837.00	398232	232395.00	1.40
T_6 French bean	8954.40	20	50000	1250.00	10204.40	170550.00	408176	237626.00	1.39
T_7 Oats	7675.20	170	17000	425.00	8100.20	111729.00	324008	182279.00	1.28
T_8 Clean cultivation	7969.00	-	-	-	-	145000.00	339560	194560.00	1.34

*Maintenance cost of established orchard Rs. 5000/Kanal.

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