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Intercropping- An approach to reduce fruit drop and improve fruit quality in guava

Shailesh Kumar Singh[1]*; Madhu Sharma[2]; Pradeep Kumar Singh[3]
[1]Department of Horticulture, Lovely Professional University, Punjab, 144411, India
[2]Department of Vegetable Science, Punjab Agriculture University, Punjab, 141004, India
[3]Department of Vegetable Science, Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, India
***Corresponding author: E-Mail:shailesh.19105@lpu.co.in, Tel: +919855949955**

ABSTRACT

Guava plants responds well to vegetable crops as intercrops and are not adversely affected in respect to yield and fruit quality. Intercropping can not only improve the health of orchard but also generate additional income and employment to the farmers, without any adverse effect on guava production. The suitability of four potential summer vegetable crops viz. arvi (*Colocasia esculenta* var. *antiquerum*), bunda (*Colocasia esculenta* var. *esculenta*), suran (*Amorphophallus companulatus* L.) and turmeric (*Curcuma domestica*), in bearing orchard of guava have been evaluated to determine the effect of intercrops on improvement of guava tree health and hence quality of guava fruits. Intercropping of these vegetable crops in guava had been reported to improve number of fruiting and flowering branches and fruit quality while fruit drop was reported to be improved in both, rainy and winter season guava crops.

KEY WORDS: *Amorphophallus, Colocasia*, Fruit drop, Fruit quality, Guava, Intercropping, Turmeric.

1. INTRODUCTION

Guava (*Psidium guajava* L.), the apple of tropics, is one of the most delicious fruit in India. Bihar and U.P. together has occupied 35% of total area under guava plantation in India. However, the entire guava plantations are very old and have poor productivity. Guava wilt and the poor health of orchards have resulted inferior fruit quality. To ensure proper management of orchard health, an integrated approach for disease management in flood prone areas and salt-affected soils, would be made for better drainage facility, improving the soil fertility status, and microbial activities, balancing the water supply throughout the year by adoption of efficient crop management practices, cropping systems and intercropping of seasonal crops. Among the cropping systems, intercropping has been considered to be more economically feasible crop management practices under perennial trees plantation.

Intercropping means the growing of short terms cash crops in the intervening or inter space available between two rows of main crop till it attains to proper bearing age. This has provided greater opportunity for proper management practices under the guava plantation through intercropping tuber crops. Guava plants have responded well to these intercrops and have not adversely affected in any ways. Intercropping can not only improve the health of orchard but also generate additional income and employment to the farmers, without any adverse effect on guava production (Singh, 2015). Among all intercrops vegetable crops, especially tuber crops, are well suited under old guava plantation due to their shade loving nature. Suran, Turmeric, Arvi and Bunda all can be grown suitably even in the dense shade of old guava orchard but turmeric and suran can perform exceptionally well. Proper exploitation of the genetic potential of an inter crop under shade condition is the underlying concept of an intercropping system (Singh, 2014a). It should be managed in such a way that it does not produce any adverse impact on the fruit plants.

However, no systematic research works have been carried out to work out the impact of intercropping on flowering, fruiting and fruit quality parameters of bearing trees under variable agro-climatic conditions. Keeping in view, the bearing problems in guava growing belts of Uttar Pradesh, the present research paper puts focus on the suitability of four potential summer vegetable crops viz. arvi (*Colocasia esculenta* var. *antiquerum*), bunda (*Colocasia esculenta* var. *esculenta*), suran (*Amorphophallus companulatus* L.) and turmeric (*Curcuma domestica*), in bearing orchard of guava to evaluate the effect of intercrops on improvement of guava tree health and hence quality of guava fruits.

2. MATERIALS AND METHODS

The experiment was carried out at Main Experiment Station, Department of Horticulture, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.). Four summer vegetable crops were grown in 18 years old bearing orchard of guava (cv. L-49) planted at spacing of 6m x 6m. The soil was silt clay loam with 7.98 pH. The area receives an average monthly rainfall of 52mm and with hot and humid climate. Planting of intercrops was done at the distance of 1 m from the guava tree. Before intercropping the vegetable crops, the guava trees were lightly pruned for better framework and to reduce over crowded branches. The experimental plots were prepared well up to fine texture of soil and then FYM were applied and mixed with soil. Nutrients and water were applied for each crop separately as per the schedule.

Intercrop management schedule:

Arvi (*Colocasia esculenta* var. *antiquarum*): Arvi cultivar PKS-1 is one of the choicest germplasm of the Faizabad region which was planted on 15th April, 2002 by using cormels with average weight of 25 g each and plant spacing

was kept 60 x 45 cm (Row x Plant). The first weeding and earthing up was done after one month of planting and second, after one month of first weeding. Before planting, the corms and rhizomes were treated with Indofil M-45 (0.3%). First irrigation was given after 20 days of planting and later irrigations were followed at one month intervals.

Bunda (*Colocasia esculenta* var. *esculenta*): NDB-1 is well adopted germplasm of Bunda for prevailing agro-climatic condition of *Purvanchal* region of UP. It was planted on 16th April, 2002 by using of uniform corms size with an average weight of 30 g each. Corms of bunda were planted at spacing of 60 x 45 cm (Row x Plant). The first weeding and earthing up was done after one month of planting and second, after one month of first weeding. Before planting, the corms and rhizomes were treated with Indofil M-45 (0.3%). First irrigation was given after 20 days of planting and later irrigations were followed at one month intervals.

Turmeric (*Curcuma domestica*): Turmeric prefers tropical humid climate and can be grown suitably under shady conditions. Rajendra Sonia is the most familiar, medium duration variety of turmeric in Bihar and UP. For planting diseases free uniform size of rhizomes with an average 25 g weight of each were selected. The rhizomes were stored in shade upto one week before planting. Planting was done on 17th April, 2002 at spacing of 60 cm x 30 cm. Farmyard manure was applied @ 10t/ha in the furrow along with the recommended dose of N:P:K (25:25:35 Kg/ha). The complete doses of FYM, phosphatic and potassic fertilizers along with half of nitrogen was provided at planting while remaining dose of nitrogen was given in two split doses during 2nd and 3rd irrigation. Five irrigations were provided at the interval of one month. The Rhizomes were treated with Indofil M-45 (0.3%) to prevent them from rhizome rot, root rot and leaf blotch.

Elephant Foot Yam (*Amarphohallus companulatus*): The warm humid climate is ideally suited for suran cultivation. It performs well even under shade of fruit trees. N.D.A.-5 is a mid-season variety of *Amorphophallus* which takes about 190-220 days to mature. Healthy and diseases free corms with an average weight of 200 gm were selected for planting under guava orchard while the larger corms were cut vertically in two, three or four pieces of recommended weight (250-300g) (Singh, 2014b). The corms were stored in shade upto 10 days before planting. Planting was done on 12th April, 2002 in the pits of size 45 cm x 45 cm x 45 cm at the spacing of 75 cm x 75 cm. FYM @ 10 t/ha along with N:P:K doses of @ 35:25:35 kg/ha was applied in the pits. The complete doses of FYM, phosphatic and potassic fertilizers along with half of nitrogen was provided at planting while remaining dose of nitrogen was given in two split doses during 2nd and 3rd irrigation. Total four irrigations were applied at the interval of one month. The corms were treated with Indofil M-45 (0.3%) for 20 -30 minutes before planting to protect them from infection by soil borne diseases.

The brief cultural schedules of intercrops in guava orchard adopted during experiment is given in the Table-1.

Observations recorded: The various parameters of growth, flowering, fruiting and quality of fruits were studied and observed at the proper stage of growth and maturity guava fruits.

Growth parameters of guava trees: The height of guava tree was measured at flowering stage and also at harvesting stage of vegetable crops, from the base of stem to tip part of tree with the help of measuring tape. The spread of guava tree was measured in meters, form both direction i.e. East-West and North-South, with the help of measuring tape.

Flowering and fruiting parameters of guava trees: The flowering shoots or branches on each tree were counted and mean value was determined at the initiation of flowers. The average number of flowers appeared per branch were counted on four randomly selected branches from different directions of guava tree. The average number of fruits appeared on each branch were counted on four selected branches at flowering and fruit setting stage.

Physical characters of guava fruits: The average fruit size of randomly selected 5 fruits was measured as length and breadth by using Vernier calipers and expressed in cm. The fruit volume was recorded by water displacement method and expressed in ml. The specific gravity of fruit was determined by using following formula:

Specific gravity (g/ml) = Average fruit weight (g)/Volume of fruit (ml)

Chemical compositions of guava fruits: TSS content of fruits was determined in ^{0}Brix by hand refractometer. The value was recorded at 20^0 and mean value was expressed in per cent TSS of pulp of guava fruits during both the seasons (AOAC, 1990). The acidity content of fruit was estimated by titrating the sample against N/10 NaOH solution in presence of phenolphthalein indicator. The total titratable acidity was expressed as citric acid using the following formula

1 ml N/10 NaOH ≡ 0.0064 gram citric acid

The sugar content of guava fruits was estimated for total sugar, reducing and non-reducing sugars by using method of Fehling solution as advocated by Lane and Eynon (1943) and described by Ranganna (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-indophenole dye and expressed in mg/100g of fruit pulp (AOAC, 2000).

Statistical analysis: The analysis of data was carried out through CRD (completely randomized design). The testing of significance of difference between the treatment means was done with the help of Critical Difference (CD) at 5% level of significance. The overall significant differences between the treatments were determined by F-test.

Table.1. Brief cultural schedules of selected intercrops in guava orchard.

Vegetable intercrops		Spacing (cm) R x P	Variety/ Germplasm	Planting time
Common name	**Botanical name**			
Arvi	*Colocasia esculenta var. antiquarum*	60 x 45	P.K.S.-1	15.04.02
Bunda	*Colocasia esculenta var. esculenta*	60 x 45	N.D.B.-3	16.04.02
Suran	*Amorphophallus companulatus*	75 x 75	N.D.A.-5	12.04.02
Turmeric	*Curcuma domestica*	60 x 30	Rajendra Soniya	17.04.02

Manure and fertilizers				Weight of planting materials (g)	Seed rate (Kg/ plot)
FYM (t/ha)	**N (Kg/ha)**	**P (Kg/ha)**	**K (Kg/ha)**		
5.00	30	20	30	25	10.8
5.00	30	20	30	30	12.9
10.00	35	25	35	200	41.4
10.00	25	25	35	25	16.2

3. RESULTS AND DISCUSSION

Growth Parameters of guava trees: It is evident from the data shown in Figure-1 that the plant height and spread of guava trees were not significantly affected due to intercropping of seasonal vegetable crops. The average tree height of guava varied from 5.59 m to 5.96 m. However, intercropping of turmeric had shown better response to tree height (5.96 m) followed by arvi (5.89) and suran (5.68 m) as compared to control (5.66 m). Tree spread ranged from 6.97m to 7.45m with an average spread of 7.12m. However, intercropping of turmeric between interspace of guava bearing trees had better response to plant spread (7.45 m) followed by suran (7.17 m); whereas, other treatments were found to be at par as compared to control. It is clear from the results that the growing of seasonal vegetables did not show any adverse effect on growth of guava trees because the vegetable crops grown in guava plantation have their restricted growth behaviour and showed little competition with the root system of guava trees. It has also been supported by other workers (Ghosh and Chand, 1984) that growing of short duration seasonal crops in between perennial trees did not show much effect on plant growth of sole crop. Better growth of guava trees intercropped with tuber crops might be associated with better soil nutrition and moisture status as reported by Singh *et al.* (2016) and better orchard floor management as confirmed by Singh and Sharma (2016).

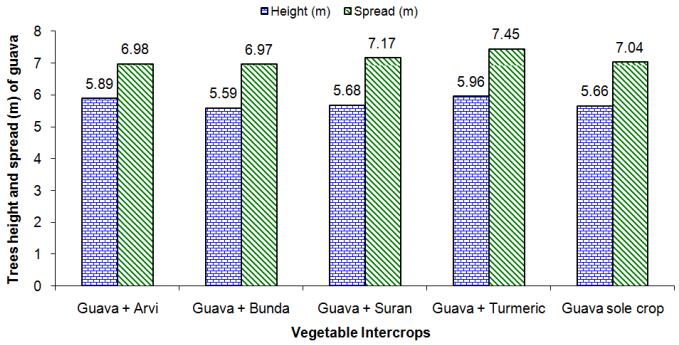

Figure.1. Guava tree height and spread as a function of intercropping tuber crops

Flowering and fruiting parameters of guava trees: Data presented in Figure-2 indicates that number of fruiting branches/tree of guava was not significantly affected due to intercropping. The average number of branches per tree varied from 50.27 to 54.71. The average number of flowers per shoot ranged from 14.17 to 17.56 in rainy season, while 5.01 to 7.12 flowers/shoot in winter season guava, which did not show significant differences due to effect of intercropping. However, the highest (17.83) number of flowers per shoot was observed due to intercropping of Bunda followed by Arvi (16.64), in rainy season; whereas, in winter season, it was highest (7.12) in trees intercropped with arvi followed by suran (5.75). It is evident from Figure-3 that average number of fruits per shoot ranged from 10.00 to 12.67 in rainy season crop whereas, 3.97 to 5.33 fruits/shoot in winter season crop. However, the highest (12.67) number of fruits per shoot was observed in sole crop of guava followed by intercropping of bunda (11.93), which did not show significant variations among other intercrops. During the winter season crop, the highest (5.33) number of fruits per shoot was observed with intercropping of arvi followed by sole crop guava (4.85) as compared to other intercrops, which did not exhibited significant differences. Like flowering and fruiting, rainy season guava fruits had shown high degree of fruit drop which ranged from 27.85% in sole crop guava to 33.09% in guava trees intercropped with bunda. Relatively lower fruit drop was reported in winter season guava crops, ranging from 20.76% in guava trees intercropped with turmeric to 27.21% in guava trees intercropped with bunda.

The number of flowers per shoot and percentage of fruit setting were also recorded higher in intercrop trees as compared to sole crop of guava, which clearly indicated that the intercropping of seasonal summer vegetables did not show adverse effects on flowering and fruiting of guava. The present findings that the number of flowers initiated per fruiting branches and per cent fruit setting of rainy season guava was maximum than winter season guava which might be due to more replacement of nutrients from the trees after harvest of high quantity of fruits during rainy season guava. The high level of flowering and fruiting in intercropped guava trees might be associated with balanced nutrient in plant tissues which had ensured batter utilization of photosynthetic materials as confirmed by findings of Singh *et al.* (2016). Maji and Das (2013) had also reported that intercropping improved flowering and fruiting of guava without affecting their own production potential. They have further confirmed that trees intercropped with cabbage, brinjal, elephant foot yam, chillies, turmeric and coriander considerably improved fruiting and significantly reduced fruit drop in guava.

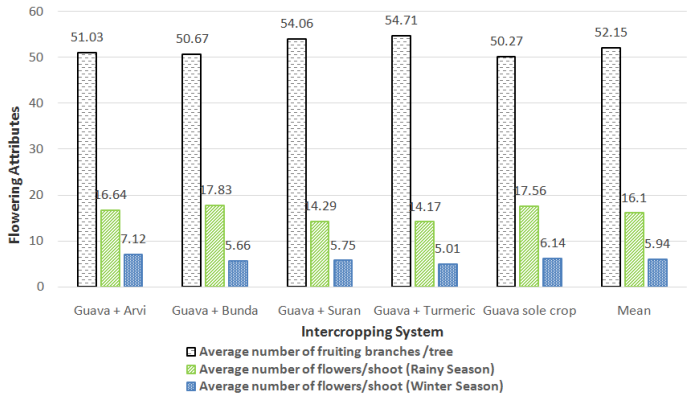

Figure.2. Flowering attributes of guava as function of intercropping tuber crops

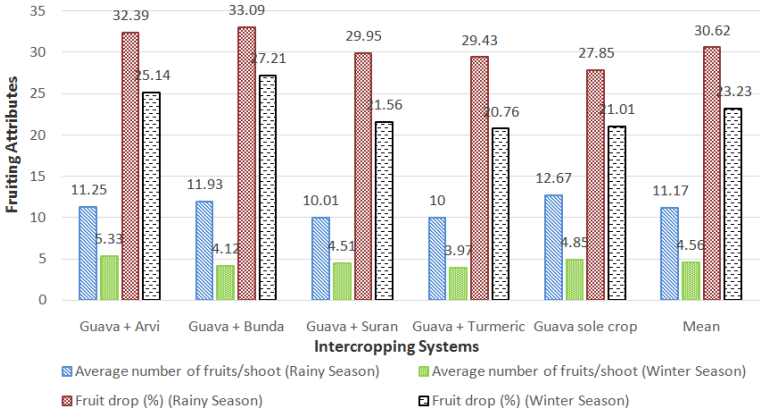

Figure-3: Fruiting attributes of guava as function of intercropping tuber crops

Physical characters of guava fruits: The observations on physical attributes like fruit size, fruit weight and specific gravity has been presented in Table-2. The average length of fruits varied from 5.00 to 5.13 cm and 5.53 to 6.07 cm in rainy and winter season guava fruits, respectively; whereas, diameter of fruits varied from 5.20 to 5.53 cm and 6.04 to 6.12 cm, respectively, which did not show significant differences due to intercropping of vegetables. However, the maximum length of guava fruit was observed due to intercropping of turmeric (5.13 cm), followed by arvi (5.10 cm) in rainy season crop, while in winter season guava, the length of guava fruit was 6.07 cm with intercropping of arvi followed by 6.01 cm by growing suran, which did not show significant variations among the treatments. The maximum diameter of rainy season guava fruit was observed in sole crop (5.53 cm) followed by bunda (5.44 cm) and turmeric (5.25 cm); while, in winter season guava, maximum diameter was observed in turmeric (6.12 cm), followed by arvi (6.06 cm) as compared to other treatments.

The average weight of fruits varied from 83.50 to 85.75 g and 99.98 to 103.13 g during rainy and winter season, respectively; which did not show significant variations among the cropping systems. However, there was more weight of fruits due to intercropping of suran (85.75 g), followed by bunda (85.25 g) and arvi (84.88 g) in rainy season guava, while intercropping of arvi (103.13 g) followed by suran (102.38 g) and turmeric (102.13 g) in winter season as compared to sole crop of guava (83.50 and 99.98 g). Non-significant influence of intercropping was reported on fruit volume in both rainy and winter season guava, which varied from 82.16 to 84.00 ml and 97.52 to 101.13 ml, respectively. The maximum volume of fruit was observed in bunda (84.00 ml) followed by intercropping of arvi (83.88 ml) and suran (83.25 ml), in rainy season guava; whereas, in winter season guava fruits, the volume of fruits was more due to intercropping of arvi (101.13 ml) followed by turmeric (100.50 ml) and suran (100.38 ml) in comparison to other intercropping systems. The specific gravity of fruits was reported to be non-significantly

influenced due to intercropping which ranged from 1.012g/ml to 1.030g/ml and 1.014g/ml to 1.020g/ml in rainy and winter season guava, respectively. However, maximum specific gravity of fruit was recorded (1.030g/ml) due to growing of suran in rainy season crop and 1.020g/ml by growing arvi in winter season guava as compared to other intercropping.

Data recorded on physical attributes of both rainy and winter season guava crops revealed that there was non-significant variations on quality of fruits of rainy and winter season due to effects of intercropping. However, the average size, fresh weight, fruit volume and specific gravity of guava fruits were observed more in winter guava fruits in comparison to rainy season guava. Availability of sufficient moisture and nutrients along with maximum utilization of solar energy by terminal part of guava trees might be responsible for better photosynthetic activity and normal flowering and fruiting which is in conformity with findings of Singh *et al.* (2014a) and is in accordance with Shyamal and Verma (1982)

Table.2.Physical attributes of guava fruits as function of intercropping of tuber crops

Treatments (Intercropping systems)	Length of fruits (cm)		Diameter of fruits (cm)		Average fruit weight (g)		Fruit volume (c.c.)		Specific gravity (g/cc)	
	Rainy season	Winter season	Rainy season	Winter season	Rainy season	Winter season	Rainy season	Winter season	Rainy season	Winter season
Guava + Arvi	5.10	6.07	5.20	6.06	84.88	103.13	83.88	101.13	1.012	1.020
Guava +Bunda	5.04	5.92	5.44	5.99	85.25	101.35	84.00	99.50	1.015	1.019
Guava +Suran	5.00	6.01	5.23	6.04	85.75	102.38	83.25	100.38	1.030	1.020
Guava + Turmeric	5.13	5.81	5.25	6.12	83.75	102.13	82.63	100.50	1.014	1.016
Guava sole crop	5.03	5.53	5.53	5.94	83.50	99.980	82.16	97.52	1.017	1.014
Mean	5.06	5.87	5.33	6.03	84.63	101.79	83.18	99.81	1.018	1.018

Table.3.Chemical composition of guava fruits as function of intercropping of tuber crops

Treatments (Intercropping of vegetables)	TSS (%)		Ascorbic acid (mg/100 g)		Acidity (%)		Reducing sugar (%)		Non-reducing sugar (%)		Total sugar (%)	
	Rainy season	Winter season	Rainy season	Winter season	Rainy season	Winter season	Rainy season	Winter season	Rainy season	Winter season	Rainy season	Winter season
Guava + Arvi	8.58	9.56	107.19	128.50	0.42	0.38	3.33	3.40	3.44	3.78	6.77	7.18
Guava + Bunda	9.00	9.59	102.81	124.56	0.53	0.47	3.33	3.50	3.70	4.09	7.03	7.59
Guava + Suran	9.03	9.68	105.00	128.81	0.45	0.41	3.70	3.90	3.73	4.27	7.43	8.17
Guava + Turmeric	8.55	9.49	102.14	126.16	0.50	0.45	3.28	3.45	3.56	3.93	6.84	7.38
Guava sole crop	8.45	9.40	101.84	122.45	0.45	0.37	3.20	3.40	3.44	3.89	6.64	7.29
	8.72	9.54	103.80	126.10	0.47	0.42	3.37	3.53	3.51	3.99	6.88	7.12

Chemical composition of guava fruits: The data pertaining to chemical quality parameters of guava fruits harvested during the both rainy and winter season crops is presented in Table-3. TSS content of fruits of rainy and winter season guava fruits ranged from 8.45 to 9.03% and 9.40 to 9.68%, respectively. The maximum TSS content of fruits was observed in intercropping of suran (9.03 % and 9.68 %) followed by bunda (9.00 % and 9.59 %) as compared to other treatments in both rainy and winter season guava, respectively. The Vitamin-C content of fruits was found better in winter guava in comparison to rainy guava fruits, which ranged from 122.45 to 128.81 mg/100g and 101.84 to 107.19 mg/100 g of edible part, respectively, which did not show much significant differences on increase of Vitamin-C in both rainy and winter season guava due to intercropping. However, the higher amount of Vitamin-C was observed due to intercropping of arvi (107.19 mg/100 g) followed by suran (105.00 mg/100 g) in rainy season crop; whereas, intercropping of suran (128.81 mg/100 g) followed by arvi (128.50 mg/100 g), in winter season crop in comparison to other intercropping systems. The acidity content of fruits during rainy and winter season guava ranged from 0.42 to 0.58% and 0.37 to 0.47%, respectively due to intercropping of vegetables.

The reducing sugar content in guava fruits ranged from 3.20% to 3.70% in rainy season and 3.40% to 3.90% in winter season guava crops. However, the maximum reducing sugar content in rainy and winter season guava fruits was observed due to intercropping of suran (3.70% to 3.90%, respectively) followed by bunda (3.33% and 3.50%, respectively) as compared to other intercropping systems, respectively. The non-reducing sugar ranged from 3.44% to 3.70% in rainy season guava fruits and from 3.78% to 4.27% in winter season guava fruits. However, the maximum percentage of non-reducing sugar was recorded by intercropping of suran (3.73% and 4.27%) followed by bunda (3.70% and 4.09%) as compared to other intercropping systems in both rainy and winter season guava, respectively.

The total sugar content in guava fruits were also not influenced by intercropping of seasonal summer vegetable crops and ranged from 6.64% to 7.43% in rainy season guava fruits and 7.18% to 8.17% in winter season guava fruits. However, the maximum sugar content was observed due to intercropping of suran (7.43% and 8.17%) followed by bunda (7.03% and 7.59%), in guava fruits harvested during rainy and winter crops, respectively.

Although, the chemical composition of guava fruits had not been significantly influenced due to intercropping, the growing of suran had shown slightly better effect on improvement of quality of fruits, which might be probably due to additional nutrient application and less uptake of nutrients by the intercrops. The growing of these seasonal vegetables did not show adverse effect on fruit quality because of their restricted growth and less requirement of nutrients and is in conformity with findings of Swain (2016). Similarly, Nelliate *et al.* (1974) had also reported no any adverse effect of growing suran, cassava, sweet potato, ginger and turmeric, rice, green gram, black gram and horse gram, on the quality of nuts.

4. CONCLUSION

The growth characteristics, flowering, fruiting and fruit drop of both rainy and winter season guava crop have not been affected by intercropping of seasonal summer vegetables. The physical and chemical characteristics of fruits, harvested during the both rainy and winter season guava crop did not show much variation in physico-chemical characteristics of fruits. The slight better quality of fruit was recorded due to intercropping of suran followed by bunda and arvi. Among the different cropping systems, the most feasible cropping system were found to be (i) Guava + turmeric (ii) Guava + suran and (iii) Guava + bunda, which were estimated in respect to growth, flowering, fruiting, fruit drops and fruit quality, which were found to be improved with intercropping of vegetables in guava orchard.

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