



Physio-morphological characters, yield, fruit quality and leaf nutrient status of filler plant guava (*Psidium guajava*) as influenced by mango (*Mangifera indica*) based intercropping systems

S C SWAIN¹, D K DORA², S K PADHI³ and RANVIR SINGH⁴

Regional Research and Technology Transfer Station, Semiliguda, Orissa University of Agriculture and Technology, Sunabeda, Koraput, Odisha

Received: 23 June 2011; Revised accepted: 23 September 2013

ABSTRACT

A mango based intercropping experiment comprising of nine treatments such as mango ginger (*Curcuma amada* Roxb.), turmeric (*Curcuma longa* L.), tomato (*Solanum lycopersicum* L.), cowpea (*Vigna unguiculata* (L.) Walp.), frenchbean (*Phaseolus vulgaris* L.), ragi (*Eleusine coracana* Gaertn.), niger (*Guizotia abyssinica* Cass.), upland paddy (*Oryza sativa* L.) and control (without intercrop) along with filler crop guava (*Psidium guajava* L.) was laid out in Randomized Block Design with three replications to assess the effect of various intercrops on the performance of filler crop guava in the rainfed uplands of Odisha. The results of the study revealed that the growth of guava plants has been appreciably influenced by the intercropping systems tried in the study which was evident from the incremental growth measured in terms of height, girth, and canopy area of the concerned trees. The fruit setting percentage, fruit retention, fruit weight and fruit yield of guava was recorded highest in mango + guava + cowpea intercropping system closely followed by mango + guava + frenchbean system. The leaf analysis result after completion of the investigation indicated that the N, P and K content of guava leaf were found to be maximum under the above mentioned treatment. The quality parameters such as TSS and acidity were not significantly affected by intercropping during both the years of study.

Key words: Filler crop-guava, Intercropping systems, Rainfed, Upland

The mango plants start bearing 4 to 5 years after planting and reach their maximum bearing capacity within 10-12 years after planting. The mango plants when planted at a spacing of 10 m × 10 m provide an ample scope for growing of short duration crops as intercrops and filler crops during initial years. The inter row space in mango remains underutilized in the early growing period and during which short duration, location specific and market driven crops may be grown as intercrops and filler crops, thus allowing one to grow more than one crop and also to efficiently utilize the space and other natural resources. The intercrops not

only generate an extra income but the practice also helps to check the soil erosion through ground coverage and improves the physico-chemical properties of the soil. Intercropping is one of the techniques of land utilization for optimum production (Bhattachanagar *et al.* 2007). Experimental evidences have also proved that yield stability is greater with intercropping than sole cropping. Selection of suitable intercrops and filler crops in mango orchard for maximum return as well as to improve the soil fertility status mainly depends upon the agro-climatic condition of the area where the crop is grown. Although lot of research work has been done on fruit based intercropping system under irrigated conditions but information on mango based intercropping systems with filler crop guava in rainfed upland is lacking. Hence, an experiment on intercropping was carried out in a junior adult bearing mango orchard under rainfed upland situation to study the effect of intercropping systems on filler crop guava and to select the most appropriate intercropping system.

MATERIALS AND METHODS

The experiment was conducted during 2005-06 and 2006-

¹Associate Professor (Horticulture) (e mail: suvam_swain28@rediffmail.com), College of Agriculture, Orissa University of Agriculture and Technology, Bhanwanipatna, Kalahandi, Odisha, 766001; ²Professor (Horticulture) (e mail: dilipk_dora@yahoo.com), Principal Investigator, Precision Farming Development Centre, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha 751 003; ³Director (e mail: skpsoa@gmail.com), IBCS, S'O'A University, Bhubaneswar, Odisha 751 030; ⁴Principal Scientist (e mail: mvr.sngh123@gmail.com), Horticulture Division, Krishi Anusandhan Bhawan-II, ICAR, New Delhi 12.

07 in the mango orchard of Gopalput, an adopted village of Regional Research and Technology Transfer Station (RRTTS), Orissa University of Agriculture and Technology, Semiliguda, Koraput, Odisha. The mean maximum and mean minimum temperature during the period of investigation were 29.3°C and 16.9°C, respectively, with a total annual rainfall of 1877.8 mm and relative humidity of 88.3%. The experiment was carried out on a 6-year-old existing bearing mango orchard (cv. Totapori) along with 5-year-old filler tree guava (*Psidium guajava* L.) (cv Allahabad safeda). The main tree mango (*Mangifera indica* L.) was planted with a spacing of 10 m × 10 m and the filler tree guava was planted in between the lines of mango trees. The experimental area was divided into 27 plots of 20 m × 20 m and each plot consisted of 4 bearing mango trees and 4 guava trees, thus accommodated 108 main trees mango and 108 filler trees guava in an area of 1.08 ha under the experiment. The experiment was laid out as per Randomized Block Design consisting of nine treatments with three replications. The location specific various profitable intercrops were grown in the mango orchard as treatments. The intercrops such as mango ginger (*Curcuma amada* Roxb.), turmeric (*Curcuma longa* L.), tomato (*Solanum lycopersicum* L.), cowpea (*Vigna unguiculata* (L.) Walp.), frenchbean (*Phaseolus vulgaris* L.), ragi (*Eleusine coracana* Gaertn.), niger (*Guizotia abyssinica* Cass.), upland paddy (*Oryza sativa* L.) were taken as treatments in mango orchard along with control (a treatment without intercrop). The treatment combinations are as follows:

- T₁ : Mango + Guava + Mango ginger
- T₂ : Mango + Guava + Turmeric
- T₃ : Mango + Guava + Tomato
- T₄ : Mango + Guava + Cowpea
- T₅ : Mango + Guava + French bean
- T₆ : Mango + Guava + Ragi
- T₇ : Mango + Guava + Niger

T₈ : Mango + Guava + Paddy

T₉ : Mango + Guava + No intercrop

The experimental site was prepared during first week of May of each year. The intercrops were sown 1.5 m away from mango tree and 1 m away from guava tree in either side of the trunk leaving an area of 9 m² and 4 m² around each mango and guava tree, respectively. The recommended packages of practices were followed for the main crop, filler crop and intercrops. Besides natural incorporation of the foliage, the remaining biomass of the intercrops was incorporated immediately after harvest in the respective treatments. The bio-metric observations on filler crop guava as influenced by the intercropping were recorded during the experimentation period, i.e. May 2005 to July 2007. The total soluble solids was found out by using ERMA hand refractometer of 0-32% range calibrated at 20°C. The acidity of the fruit pulp samples were estimated by alkali titration method (AOAC 1984). Leaf samples collected before flowering from each treatment were used for study of the nutrient status of the filler plant guava during end of the experiment. Leaf samples from middle of shoots were collected in rainy and winter seasons for estimation of nutrient status of guava tree and analyzed as per the recommendation of Sanyal and Mitra (1990). The data recorded on various characteristics of bio-metrics and bio-chemicals were subjected to Fisher's method of analysis of variance and interpretation of data was taken up as per Sukhatme and Amble (1995).

RESULTS AND DISCUSSION

Plant growth of guava

The data presented in Table 1 revealed that different intercropping systems had a significant effect on tree height, girth and canopy area of guava. Among the intercropping

Table 1 Effect of intercropping on tree height, girth and canopy area of guava

Treatment	Percentage increase in tree height		Percentage increase in tree girth		Percentage increase in tree canopy area	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T ₁	19.4	20.7	9.8	12.0	22.1	25.6
T ₂	19.0	20.6	9.2	12.1	22.5	24.3
T ₃	18.6	20.1	9.5	11.7	22.6	24.0
T ₄	20.3	21.4	10.0	12.6	23.6	27.4
T ₅	20.6	22.8	10.2	13.7	25.2	29.4
T ₆	18.3	19.3	8.7	11.2	22.0	23.4
T ₇	18.2	19.0	8.6	11.1	21.6	23.0
T ₈	18.9	19.6	9.7	11.8	23.0	25.4
T ₉	14.1	15.2	7.0	8.3	16.2	18.2
SE (m) ±	0.43	0.83	0.44	0.34	1.03	0.79
CD (P = 0.05)	1.28	2.47	1.32	1.02	3.09	2.38
CV (%)	3.98	7.18	8.26	5.09	8.13	5.61

systems studied, the mango + guava + frenchbean had shown the best result with increase in height, girth and canopy areas to the extent of 20.6%, 10.2%, and 25.2% during 2005-06 and 22.8%, 13.7% and 29.4% during 2006-07, respectively. The growth of guava tree in respect of above parameters under mango + guava + cowpea intercropping system showed almost similar results during both the years of study. Intercropping with legume crops particularly with cowpea or frenchbean in guava orchard was more effective which might have helped in substantial increase in nitrogen content of the soil as well as other physico-chemical properties of soil resulting in better vegetative growth in guava crop. The significant increase in growth parameters such as height, girth and canopy areas of guava tree due to intercropping has been reported by Swain and Patro (2006). The large amount of biomass produced by the intercrops are recycled in the

soil which increase the organic matter content and builds up the soil fertility, which might be the reason for improvement in the vegetative growth of guava. Similar findings on increase in tree height, girth and canopy area due to intercropping was reported by Bhuvu *et al.* (1988), Singh *et al.* (1996), Vishalnath *et al.* (2003) and Swain and Patro (2007) in mango.

Flowering and fruit retention of guava

The initial fruit set and the retention of fruits till harvest was found to be influenced by the intercropping (Table 2). The mango + guava + cowpea (T₄) intercropping system had a significant effect in increasing the initial fruit set to 74.3% and 69.4% during 2005-06 and 79.1% and 77.4% during 2006-07 rainy and winter season, respectively. The pooled mean of initial fruit setting over the two seasons (rainy and winter) was found to be maximum in the aforesaid treatment

Table 2 Effect of intercropping on fruit setting of guava

Treatment	Initial fruit setting (%) (2005-06)			Initial fruit setting (%) (2006-07)		
	Rainy	Winter	Mean	Rainy	Winter	Mean
T ₁	69.4 (56.52)	64.0 (53.14)	66.70 (54.77)	73.3(59.23)	69.4 (56.42)	71.35 (57.44)
T ₂	70.3 (56.98)	65.5 (54.04)	67.90 (55.52)	74.3(59.54)	72.3 (58.25)	73.30 (58.89)
T ₃	67.3 (55.13)	61.0 (51.35)	64.15 (53.23)	62.3(52.12)	65.3 (53.92)	63.80 (53.03)
T ₄	74.3 (59.55)	69.4 (56.42)	71.85 (57.75)	79.1(62.80)	77.4 (61.64)	78.25 (62.22)
T ₅	72.4 (58.32)	67.3 (55.13)	69.85 (56.73)	78.2(62.26)	76.3 (60.87)	77.25 (61.56)
T ₆	65.1 (53.80)	58.0 (49.61)	61.55 (51.69)	69.4(56.42)	65.3 (53.91)	67.35 (55.16)
T ₇	57.4 (49.27)	57.0 (49.03)	57.20 (49.16)	70.4(57.11)	62.4 (52.18)	66.40 (54.60)
T ₈	66.5 (54.68)	63.3 (52.73)	64.90 (53.71)	75.4(60.37)	72.3 (58.27)	73.85 (59.30)
T ₉	56.3 (48.63)	52.0 (46.15)	54.15 (47.41)	63.4(52.78)	58.4 (49.84)	60.90 (51.30)
SE (m) ±1.45	0.83	0.73	1.35	0.86	0.89	
CD (P = 0.05)	NS	2.49	2.20	4.06	2.59	2.66
CV (%)	4.58	2.77	2.38	4.04	2.67	2.69

The figures in parentheses indicate the corresponding angular values

Table 3 Effect of intercropping on fruit retention of guava

Treatment	Initial fruit setting (%) (2005-06)			Initial fruit setting (%) (2006-07)		
	Rainy	Winter	Mean	Rainy	Winter	Mean
T ₁	40.1 (39.28)	41.0 (39.82)	40.58 (39.57)	49.0 (44.43)	41.4 (40.04)	45.2 (42.26)
T ₂	40.3 (39.41)	40.0 (39.21)	40.15 (39.32)	48.5 (44.14)	43.0 (40.97)	45.7 (42.57)
T ₃	39.0 (38.64)	40.6 (39.96)	39.50 (38.94)	47.3 (43.45)	40.3 (39.40)	43.8 (41.46)
T ₄	43.3 (41.15)	45.4 (42.36)	44.35 (41.76)	51.3 (45.74)	44.3 (41.73)	47.8 (43.75)
T ₅	42.4 (40.61)	44.3 (41.72)	43.35 (41.19)	52.3 (46.32)	45.3 (42.30)	48.8 (44.33)
T ₆	38.3 (38.23)	37.0 (37.46)	37.65 (37.86)	42.0 (40.40)	38.0 (38.06)	40.0 (39.25)
T ₇	37.4 (37.69)	38.4 (38.27)	38.19 (38.17)	43.0 (40.98)	36.4 (37.10)	39.7 (39.11)
T ₈	39.6 (38.99)	40.3 (39.40)	39.67 (39.06)	47.3 (43.45)	40.3 (39.31)	43.8 (41.46)
T ₉	35.0 (36.25)	34.1 (35.70)	34.55 (35.99)	41.0 (39.81)	39.4 (38.88)	40.2 (39.37)
SE (m) ±	1.06	1.35	0.82	0.70	0.52	0.52
CD (P = 0.05)	NS	N.S.	2.44	2.10	1.56	1.54
CV (%)	4.73	5.92	3.60	2.81	2.27	2.15

The figures in parentheses indicate the corresponding angular values

during both the years of study as compared to other treatments. The incorporation of biomass in the soil as well as the cultural operations carried out due to the intercropping was helpful in the availability of more nutrients to the filler tree guava, which might be the reason in increasing the setting percentage. This corroborates with the findings of Swain and Patro (2006).

It is interesting to note here that even though the initial fruit sett was significantly influenced by intercropping in both the seasons but the final fruit retention was not significantly affected by the intercropping during 2005-06 (Table 3). However, the mean final fruit retention of guava in both the seasons during 2005-06 was observed to be highest (44.35%) under mango + guava + cowpea system (T_4) and a similar significant effect was obtained in mango + guava + frenchbean (T_5) system (43.35%). So far as the mean final fruit retention of guava during 2006-07 is concerned, both the treatments T_4 (mango + guava + cowpea) and T_5 (mango + guava + frenchbean) recorded almost similar results with the corresponding values of 47.8% and 48.8% as against 40.2% in control (mango + guava system without intercropping). This might be due to physical improvement of soil which facilitated the increased availability of nutrients from the soil pool to the tree as reported by Maheswarappa *et al.* (1998). Similar finding on increase in fruit retention due to intercropping was reported by Swain and Patro (2006) in guava and Rath and Swain (2006) and Swain *et al.* (2012) in mango.

Fruit weight and yield of guava

The fruit weight of guava was significantly improved by the various intercropping practices (Table 4 and 5) with the maximum fruit weight of 103.5 and 101.3 g during 2005-06, and 105.6 and 99.9 g during 2006-07 in rainy and winter season, respectively, was recorded when cowpea was intercropped with mango + guava system (T_4). The pooled mean average fruit weight of both the seasons under both the years of study was also observed to be significantly maximum in the above treatment. In guava, fruit size is considered to be the important consideration for getting premium price, hence, intercropping with leguminous crops helped to achieve that goal. Lowest fruit weight was measured from the sole plants during both the seasons of both the years. This corroborates with the findings of Swain and Patro (2006). Similar studies on effect of intercropping in increasing the fruit weight in other fruit crops like banana and mango was reported by Rao and Edmunds (1984) and Rath and Swain (2006), respectively. As regards fruit yield per tree, the treatment T_4 (mango + guava + cowpea) and T_5 (mango + guava + frenchbean) recorded almost similar results having maximum yield of 18.4 kg. and 17.5 kg during rainy and 9.1 kg and 8.9 kg during winter season of 2005-06, respectively. Similarly, the fruit yield per tree of the above treatments was also found to be highest with the values of 20.1 kg and 19.2 kg in rainy

Table 4 Effect of intercropping on fruit weight of guava

Treatment	Average fruit weight (g)					
	2005-06			2006-07		
	Rainy	Winter	Mean	Rainy	Winter	Mean
T_1	98.3	96.8	97.55	100.5	96.0	98.25
T_2	99.4	98.3	98.85	99.6	95.0	97.30
T_3	97.5	97.0	97.25	100.3	97.3	98.80
T_4	103.5	101.3	102.40	105.6	99.9	102.75
T_5	102.6	100.6	101.60	103.7	98.8	101.15
T_6	98.1	91.0	94.55	98.7	90.3	94.50
T_7	96.3	88.3	92.30	97.4	89.0	93.20
T_8	99.0	95.0	97.00	100.6	93.5	97.05
T_9	89.0	84.0	86.50	92.3	90.3	91.30
SE (m) \pm	1.43	1.52	1.07	1.45	1.04	0.89
CD ($P = 0.05$)	NS	4.56	3.21	4.36	3.12	2.69
CV (%)	2.53	2.78	1.92	2.52	1.91	1.60

Table 5 Effect of intercropping on fruit yield of guava

Treatment	Average fruit weight (g)					
	2005-06			2006-07		
	Rainy	Winter	Mean	Rainy	Winter	Mean
T_1	16.3	8.1	24.4	17.8	10.6	28.4
T_2	16.8	8.8	25.6	18.6	10.8	29.4
T_3	15.6	7.3	22.9	17.3	9.8	27.1
T_4	18.4	9.1	27.5	20.1	11.8	31.9
T_5	17.5	8.9	26.4	19.2	11.5	30.7
T_6	14.3	7.8	22.1	16.8	9.6	26.4
T_7	13.8	7.0	20.8	16.3	8.3	24.6
T_8	15.3	7.8	23.1	17.8	9.7	27.5
T_9	12.6	6.7	19.3	13.1	7.2	20.3
SE (m) \pm	0.38	0.20	0.41	0.60	0.26	0.71
CD ($P = 0.05$)	NS	0.61	1.23	1.81	0.78	2.14
CV (%)	4.20	4.46	3.01	5.59	4.55	4.51

season and 11.8 kg and 11.5 kg during winter season of 2006-07. The pooled mean fruit yield of both the seasons was also noticed to be maximum in the said treatment. The higher yield advantages particularly average fruit weight and fruit yield under intercropping systems were mainly attributed to efficient utilization of natural resources like solar radiation, soil moisture and nutrients because of complementary interaction between the component crops (Panda *et al.* 2003). The increase in fruit weight and yield as observed under different systems may be explained from the fact that leguminous intercrops like cowpea and frenchbean have the capacity of fixing the atmospheric nitrogen to the soil and there by main crop would have got additional nitrogen, which agrees well to the findings of Ghosh (2001) in guava. The other non-leguminous intercrops helped the filler crop guava through indirect way like creating a micro climate that may have resulted in improvement of fruit yield. Besides,

Table 6 Effect of intercropping on TSS and acidity content of guava fruits

Treatment	TSS (^o brix)				Acidity %			
	2005-06		2006-07		2005-06		2006-07	
	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter
T ₁	11.3	11.4	11.4	12.4	0.30	0.31	0.31	0.32
T ₂	11.2	12.0	11.2	12.4	0.30	0.30	0.32	0.32
T ₃	11.1	11.5	11.3	12.2	0.34	0.30	0.33	0.33
T ₄	11.4	12.1	11.6	12.8	0.30	0.30	0.30	0.31
T ₅	11.0	12.0	11.3	12.6	0.30	0.29	0.30	0.32
T ₆	11.3	11.5	11.4	12.3	0.34	0.31	0.33	0.31
T ₇	11.2	11.3	11.3	12.1	0.34	0.32	0.32	0.32
T ₈	11.3	11.9	11.4	12.5	0.31	0.30	0.30	0.32
T ₉	11.2	11.3	11.2	12.0	0.35	0.33	0.33	0.33
SE (m) ±	0.19	1.04	0.18	0.18	0.02	0.01	0.01	0.01
CD (P = 0.05)	NS	N S	N S	N S	N S	N S	N S	N S
CV (%)	2.96	3.25	2.69	2.54	4.50	4.64	4.97	3.61

floor management for the intercrops like land preparation for sowing, weeding, etc. seemed to be beneficial for higher production of fruits. The intercropping that helped to improve the fruit production of the main crop was also reported by Ghosh *et al.* (1997) in sweet orange, Ghosh (2001) in guava, Rath and Swain (2006) and Swain *et al.* (2012) in mango.

Fruit quality of guava

The effect of various intercropping systems on quality of guava fruits has been presented in Table 6. The result indicated that TSS and acidity were not significantly affected by intercropping during both the years of study. This is in conformity with the findings of Ghosh (2001). Similar finding on the effect of intercropping on fruit quality were reported by Kanwar *et al.* (1993) in mango, Ghosh *et al.* (1997) in citrus and Swain *et al.* (2012) in mango.

Leaf NPK status of filler crop guava

The leaf analysis result after completion of the study (Table 7) indicated that the N, P and K content of guava leaf were found to be maximum, i.e. 1.71%, 0.28% and 1.52%, respectively under mango + guava + cowpea intercropping system (T₄) as against of 1.40%, 0.16% and 1.31% under control, i.e. mango + guava + no intercropping (T₉). The increase in NPK status of guava leaf might be due to increased availability of nutrients in the soil because of *in situ* incorporation of huge amount of bio-mass produced under the above treatments. It was observed that the N, P and K content in leaves of guava was found higher with leguminous group of crops and lower in case of non-legume crops. The incorporation of bio-mass of intercrops might helpful in improving the soil physical, chemical and biological environments which favoured the higher uptake from the nutrient pool in the soil, which agreed well to the findings of Maheswarappa *et al.* (1998) and Ghosh and Hore (2007).

The results of the investigation revealed that the intercropping was found effective in increasing the plant growth, fruit retention, fruit weight and fruit yield of filler crop guava. However, the maximum plant growth, fruit retention, fruit weight and fruit yield of guava was observed in mango + guava + cowpea intercropping system closely followed by mango + guava + frenchbean system. The leaf analysis result after completion of the study indicated that the N, P and K content of guava leaf were found to be maximum under mango + guava + cowpea intercropping system. Fruit quality of guava was not affected by the different intercropping systems. The study will help the farmers/scientists to select the appropriate intercropping systems in the risk prone rainfed uplands. However, further studies are necessary for inclusion of various other intercrops which are location specific and to confirm the long term effect of intercropping as suggested above.

Table 7 Effect of intercropping on leaf NPK status of filler crop guava

Treatment	Leaf nutrient status of guava (% dry wt.)		
	N	P	K
T ₁	1.66	0.25	1.47
T ₂	1.60	0.24	1.50
T ₃	1.67	0.23	1.49
T ₄	1.71	0.28	1.52
T ₅	1.69	0.26	1.50
T ₆	1.52	0.23	1.46
T ₇	1.50	0.20	1.44
T ₈	1.55	0.22	1.50
T ₉	1.40	0.16	1.31
SE (m) ±	0.03	0.01	0.05
CD (P = 0.05)	0.10	0.04	0.14
CV (%)	3.57	9.22	5.55

ACKNOWLEDGEMENTS

The authors are thankful to the Agro-Ecosystem Directorate, CRIDA, Hyderabad for providing financial assistance through NATP-RRPS-8 for the study.

REFERENCES

- AOAC. 1984. *Official Methods of Analysis*, 14th edn. Association of Official Analytical Chemists, Washington, DC.
- Bhatnagar P, Kaul M K and Singh J. 2007. Effect of intercropping in Kinnow based production system. *Indian Journal of Arid Horticulture* **2**: 15–7.
- Bhuva H P, Katrodia J S, Patel G L and Chundawat B S. 1988. Response of intercropping on economics and effects on main crop of mango under South Gujarat condition. *Acta Horticulturae* **231**: 316–20.
- Ghosh D K and Hore J K. 2007. Effect of coconut based cropping system on yield of coconut and nutrient status of leaf and soil. *Journal of Plantation Crops* **35**(2): 76–9.
- Ghosh S N, Besra K C, Pal D and Bera P S. 1997. Intercropping in Sweet Orange cv. Mosambi orchard under rainfed laterite soils. *Proceedings of National Symposium on Citriculture*, Nagpur, pp 183–5.
- Ghosh S N. 2001. Intercropping in guava orchard in watershed area. *Horticulture Journal* **14**(3): 36–40.
- Kanwar J S, Brar S S and Chopra H R. 1993. Status of intercropping of orchards in Punjab. *Punjab Horticulture Journal* **34**(2): 1 163–76.
- Maheswarappa H P, Hegda M B, Dhanapal R and Biddappa C. 1998. Mixed forming in coconut garden – Its impact on soil physical, chemical properties, coconut nutrition and yield. *Journal of Plantation Crops* **26**(2): 139–43.
- Panda M M, Nandi A, Bhoi N, Senapati N, Barik K C, Sahu S K and Sahoo B C. 2003. Studies on identification of suitable intercrops for degraded land management in the North Central Plateau Agro-climatic Zone of Orissa. *Journal of Research Orissa University of Agriculture & Technology* **21**(1): 62–6.
- Rao M M and Edmunds J E. 1984. A review of banana / plantain cropping systems. *Fruits* **39**(2): 79–88.
- Rath S and Swain S C. 2006. Performance of intercrops in bearing mango orchards in Eastern Ghat High land zones of Orissa. *Indian Journal of Dryland Agricultural Research & Development* **21**(1): 12–5.
- Sanyal D and Mitra S K. 1990. Standardization of leaf sampling technique for mineral composition of guava (*Psidium guajava* L) cv. Lucknow-49. *Indian Journal of Horticulture* **47**: 154–8.
- Singh J, Kashyap R and Sharma D P. 1996. Effect of cultural practices and intercropping on growth and economic yield of mango orchard cv. Langra. *Indian Journal of Horticulture* **53**(4): 290–4.
- Sukhatme P V and Amble V N. 1995. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi.
- Swain S C and Patro L. 2006. Intercropping in guava orchard- A Holistic farming system approach for sustainable development of environment and society. *Proceedings of National Conference on Biodiversity Conservation for Sustainable Society*, August 26–27 August 2006. Nayagarh College, Nayagarh, Odisha, pp 78–83.
- Swain S C and Patro L. 2007. Horticulture based cropping system- A strategy for sustainable development in rainfed upland. *Environmental Hazards*, pp 44–69. Patro L and Tripathy S N(Eds). Sonali Publication, New Delhi.
- Swain S C, Sahoo S C and Mishra P J. 2012. Effect of intercropping systems on growth, yield, fruit quality and leaf nutrient status of mango under rainfed situation. *International Journal of Agricultural Sciences* **8**(1): 174–8.
- Vishalnath, Das B, Rai M, Dey P, Kumar S and Kumar M. 2003. Mango based cropping system for uplands of sub-humid plateau region of Eastern India. *Progressive Horticulture* **35**(2): 142– 5.