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Use of leguminous cover crop and banana bio-mat mulch for quality production of guava cv. Sardar (L-49)

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ABSTRACT

The experiment was carried out at ICAR-AICRP on Fruits, BCKV during 2016-17 to investigate the effects of leguminous cover crop (LCC)+banana bio-mat mulch (BBM, webbed leaf sheath of banana) and black polythene mulch (BPM) on growth, yield and fruit quality of 3 years old guava plant cv. Sardar (L-49), compared with conventional practice (CP, no LCC & BBM) as control. Treatments with LCC+BBM and BPM showed significantly better plant growth, yield and fruit quality of guava over control. The plants recorded increase in height (142.74%) and girth (122.73%) due to LCC+BBM treatments over control, while BPM treatment recorded increase in canopy volume (494.87%) over control. Maximum yield (26.53 kg plant^{-1}) with an increase of 7.84 kg plant^{-1} over control and improvement of quality of fruit were recorded due to BPM and LCC+BBM and the effects of both the treatments were statistically at par. The estimated benefit:cost ratio was higher (3.15) due to LCC+BBM, compared to BPM(3.09). Both LCC and BBM were bio-degradable and added organic matter and nutrients to the soil, suppressed weed growth and conserved soil moisture, while the BMP was effective for weed growth suppression and moisture conservation but was non-degradable and could not add organic matter and nutrients to soil. Therefore, leguminous cover crop + banana bio-mat (webbed leaf sheath) was recommended as an eco-friendly, viable and organic mulching practice for better plant growth, yield and fruit quality of guava grown in the Gangetic Alluvial region of West Bengal.

Keywords: Banana bio-mat mulch, leguminous cover crop, fruit quality, guava, plant growth and yield

Guava (*Psidium guajava* L.) is the fourth important fruit crop of India after mango, banana and citrus and considered as one of the nutritionally valuable and remunerative crops (Singh, 2007). One of the most important issues of guava orchard floor management in humid-subtropical region of West Bengal is the suppression of weed growth, which is directly related with the plant growth, yield and economics of production. The inorganic mulching with black polythene in guava was reported effective for weed growth suppression (Reddy and Khan, 2000, Patra *et al*., 2004, Maji and Das, 2008). However, the use of plastic mulches might have environmental concerns mainly due to its non-degradable nature. Whereas, the organic mulches act as environment-friendly tools for weed suppression and increase of the production (Ghorai, 2004, Jayasinghe, 2008, Mahata *et al*., 2008). In view of the above important issues related to guava cultivation, the present study was carried out to investigate the effects of eco-friendly approach of using leguminous cover crop and banana bio-mat mulch (*i.e*., chopped or webbed leaf or leaf sheath of banana) on plant growth, yield and quality of fruits and benefit: cost ratio of guava cultivation, compared with the use of plastic mulch and conventional practices, *viz*., no use of organic mulch and cover crop.

MATERIALS AND METHODS

The experiment was carried out at ICAR-AICRP on Fruits, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia, West Bengal, during the year 2016-2017. The location of experiment is situated at 9.75 m above mean sea level, latitude 22^{0}56’10.90" N and longitude 88^{0}30’31.55" E. The soil was loamy in texture and moderately fertile (Sand-55.40%, Silt-23.00%, Clay-21.60%) and field capacity (% v/v)- 26.37, pH- 6.80, available N- 0.06%, available P- 29 ppm, available K- 42 ppm and organic C- 0.65%.The site belongs to the agro-ecological region of Assam and Bengal Plains, hot humid (as per NBSSLUP); sub-tropical climate. There were 11treatments under this experiment *viz*., T_1: Banana biomat (BBM)-webbed leaf (WL), T_2 :BBM-webbed leaf sheath (WLS), T_3 : BBM-chopped leaf (CL), T_4 : BBM- chopped leaf sheath (CLS), T_5 : Leguminous cover crops (LCC), T_6 : LCC + WL, T_7 : LCC + WLS, T_8 : LCC + CL, T_9 : LCC + CLS, T_{10} : Black polythene and T_{11} : Control - Conventional practice (no use of organic mulch and cover crop). The experiment was laid out in randomized block design (RBD) with 11 treatments, 3 replications and 4 plants per replication. Here, the organic mulching material called “banana bio-mat” was applied in different forms, like a mat prepared by webbing the leaf or leaf sheath or chopping the leaf or leaf sheath of banana plant.Raw biomass of banana

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plants was collected from waste biomass of banana plantation after harvesting of fruits. The waste biomass of banana plantation was a cheap source of raw material for preparing banana bio-mat mulch (BBM), which was compared as low-cost organic mulch against the conventional use of polythene mulching. The treatments were imposed twice (*i.e*., on 25th January, 2017 and 12th May, 2017) on 3 years old uniform guava plants cv. Sardar (L-49), planted at square system (3 × 3m) under high density planting (1111plants ha^{-1}) with main objective to observe the effects of treatments on soil moisture conservation during summer months and suppression of weed growth during rainy season. The orchard soil was cultivated by power tiller in second week of January, 2017. Recommended dose of fertilizer (RDF) was applied, followed by irrigation. The overnight soaked seeds of leguminous cover crop were sown @ 3gm^{-2}of ground area to cover 4 m^2 of ground area of each plant as per treatment. Black gram cv. Kalindi was sown in winter, while mung bean cv. Samrat was sown in summer. The LCC was incorporated in soil during 50-60 days after sowing. Different forms of fresh BBM were applied @ 30 kg m^2 of ground area to cover 4m^2 of ground area of each plant as per treatment. Fruit was harvested in July, 2017 (ambebahar) and October, 2017 (mrigbahar). Observations were recorded on plant growth, flowering, fruit set, fruit weight, yield plant^{-1}, productivity, B:C ratio and fruit quality (TSS, acidity, Vit. C). The data obtained from the experiment were analyzed statistically by the analysis of variance method for Randomized Block Design (RBD) (Gomez and Gomez, 1983).

RESULTS AND DISCUSSION

The data presented in table-1 revealed that the plant growthparameters showed significant increase in response to different combinations of cover crops and mulching treatments compared with unmulched control [T_{11}] during the period of investigation. The maximum plant height (2.84 m) and girth (24.50 cm) were recorded due to leguminous cover crop (LCC) + banana bio-mat (BBM) (webbed leaf sheath-WLS) [T_7] followed by black polythene mulch (BPM) [T_{10}] as compared with 2.12 m height and 20.85 cm girth, respectively in control plants [T_{11}]. However, maximum increase in canopy volume (494.87%) over initial canopy volume was obtained from black polythene mulch [T_{10}] followed by 489.74% due to combined application of cover crop and banana bio-mat (leaf sheath) [T_7] and it was minimum (223.08%) in control (T_{11}) (Table 1). Similar effect of mulching on plant growth were also recorded earlier by Patra *et al*. (2004) and Maji and Das (2008) in guava, Manoj *et al*. (2015) in Kinnow mandarin and Hussain *et al*. (2017) in apple.

Significant effects of LCC + BBM were also recorded on yield characters of guava *viz*., number of flower bud plant^{-1}, fruit set plant^{-1}, individual fruit weight (g), yield (kg plant^{-1}) and productivity (t ha^{-1}). The maximum number of flower bud (240.08), fruit set (200.04), fruit yield (26.53 kg plant^{-1}) and productivity (29.47 t ha^{-1}) were recorded due to BPM mulching [T_{10}], which were statistically at par with LCC+BBM (WLS) mulching [T_7] (Table 2, 3, 4). However, the maximum individual fruit weight (195.88 g) was obtained from LCC+BBM (Webbed leaf, WL) mulching [T_6], followed by 191.90 g under LCC+BBM (Webbed leaf sheath, WLS) mulching [T_7] (Table 3). Treatment with BPM mulch [T_{10}] resulted in advanced flowering by 5 days in ambebahar and by 7 days in mrigbahar, followed by 4 days and 5 days earlier flowering, respectively in ambe and mrigbahar with LCC+BBM (WLS) mulch [T_7], compared with the unmulched control [T_{11}] [Table 2]. The results are in full conformity with the findings of Rajput *et al*. (2014) and Patra *et al*. (2003) in guava, Chattopadhyay and Patra (1993) in pomegranate and Ghosh and Tarai (2007) in ber.

The observations recorded on fruit quality, with respect to total soluble solids (TSS), acidity and ascorbic acid (vitamin C) content of fruit indicated that the mulching treatments significantly improved the fruit quality parameters. The LCC+BBM and BPM treatments caused increase in TSS and ascorbic acid content but reduced the acidity percentage of fruit as compared with no mulching treatment. The black polythene mulching [T_{10}] resulted in highest TSS (11.50^0 Brix), maximum ascorbic acid content (156.83 mg100^{-1}g pulp) and minimum acidity (0.23%) of the fruit, followed by 11.23^0 Brix TSS and 148.65 mg100^{-1}g pulp ascorbic acid content due to mulching treatment with LCC+BBM (WLS)[T_7]. Whereas, minimum TSS (9.65^0 Brix) and ascorbic acid content (107.93 mg 100^{-1} g pulp) and maximum acidity (0.36%) of fruit were obtained from the conventional practice (without mulching) as control [T_{11}] (Table 5). Our present finding regarding the effect of mulch and cover crop on fruit quality confirms the earlier findings by Das *et al*. (2010) in guava, Mandal and Chattopadhyay (1993) in custard apple and Tachibana and Yahata (1998) in Satsuma mandarin.

The estimated benefit:cost (B:C) ratio revealed that the mulching treatments had significant impact on B:C ratio and all mulching treatments improved the return (B:C ratio) over control (2.53). The cost of treatment for black polythene mulching (T_{10}) was maximum (Rs. 83292.00 ha^{-1}), followed by Rs. 1500.00 ha^{-1}for sole cover crop and no cost was required for unmulched control (T_{11}). The estimated B:C ratio was highest (3.15) due to mulching with LCC+BBM (WLS)mulch [T_7],

Table 1: Effect of leguminous cover crop and organic mulching (BBM) on growth parameters of guava plant cv. Sardar (L-49)

Treatments*	Plant height (m)			Plant girth (cm)			Canopy volume (m^3)		
	Initial (Nov, 2016)	Final (July, 2017)	Increase over initial (%)	Initial (Nov, 2016)	Final (July, 2017)	Percent increase over initial (%)	Initial (Nov, 2016)	Final (July, 2017)	Percent increase over initial (%)
T_1		2.45	109.40		21.96	99.64		1.60	310.26
T_2		2.52	115.38		22.04	100.36		1.62	315.38
T_3		2.28	94.87		21.34	94.00		1.42	264.10
T_4		2.32	98.29		21.40	94.55		1.47	276.92
T_5		2.61	123.08		22.60	105.45		1.76	351.28
T_6	1.17	2.72	132.48	11.00	23.55	114.09	0.39	2.15	451.28
T_7		2.84	142.74		24.50	122.73		2.30	489.74
T_8		2.66	127.35		23.09	109.91		1.89	384.62
T_9		2.67	128.21		23.11	110.09		2.01	415.38
T_{10}		2.78	137.61		24.03	118.45		2.32	494.87
T_{11}		2.12	81.20		20.85	89.55		1.26	223.08
SEm (±)	**-**	**0.02**	**-**		**0.18**	**-**	**-**	**0.05**	**-**
LSD (0.05)	**-**	**0.04**	**-**		**0.46**	**-**	**-**	**0.12**	**-**

*Note: *T_1- Mulching with banana bio-mat (webbed leaf-WL), T_2- Mulching with banana bio-mat (webbed leaf sheath-WLS), T_3- Mulching with chopped leaf of banana (CL), T_4- Mulching with chopped leaf sheath of banana (CLS), T_5- Cover crop (CC), T_6- CC + WL, T_7- CC + WLS, T_8- CC + CL, T_9- CC + CLS, T_{10}- Mulching with black polythene (BP), T_{11}- No mulching and no cover crop (Control).*

Table 2: Effect of leguminous cover crop and organic mulching (BBM) on flowering and fruit set of guava plant cv. Sardar (L-49)

Treatments*	Number of flower bud plant^{-1}			Date of 50% flowering (2017)		Fruit set per plant (FS/P)				Total FS
						Ambe (May, 2017)		Mrig (August, 2017)		
	Ambe (Apr, 2017)	Mrig (Jul, 2017)	Total	Ambe (Apr, 2017)	Mrig (Jul, 2017)	FS/P	FS (%)	FS/P	FS (%)	
T_1	112.00	81.05	193.05	6th	19th	86.77	77.47 (8.80)*	66.05	81.50 (9.03)	152.82
T_2	115.40	84.33	199.73	6th	19th	90.16	78.12 (8.84)	68.64	81.39 (9.02)	158.80
T_3	94.25	78.77	173.02	7th	20th	72.34	76.75 (8.76)	62.86	79.80 (8.93)	135.19
T_4	104.30	80.65	184.95	6th	20th	81.18	77.83 (8.82)	65.34	81.02 (9.00)	146.52
T_5	125.65	85.40	211.05	7th	18th	98.82	78.65 (8.87)	70.05	82.02 (9.06)	168.87
T_6	137.25	89.21	226.46	5th	17th	110.53	80.53 (8.97)	73.92	82.86 (9.07)	184.45
T_7	142.00	92.30	234.30	4th	16th	116.53	82.06 (9.06)	77.48	83.95 (9.16)	194.01
T_8	134.50	88.13	222.63	6th	17th	107.58	79.99 (8.94)	72.60	82.38 (9.08)	180.18
T_9	132.00	87.25	219.25	6th	17th	88.88	67.33 (8.21)	71.68	82.15 (9.06)	160.56
T_{10}	145.50	94.58	240.08	3rd	14th	119.90	82.41 (9.08)	80.14	84.74 (9.21)	200.04
T_{11}	90.60	77.02	167.62	8th	21st	69.52	76.73 (8.76)	60.86	79.02 (8.89)	130.38
SEm (±)	**0.88**	**1.63**	**3.60**	**-**	**-**	**0.80**	**0.14**	**0.63**	**0.09**	**3.49**
LSD (0.05)	**2.86**	**4.58**	**7.49**	**-**	**-**	**1.95**	**0.44**	**1.88**	**0.36**	**8.56**

*Note: *Square root transformed value in bracket*

Table 3: Effect of leguminous cover crop and organic mulching (BBM) on fruit weight and yield of guava plant cv. Sardar (L-49)

Treatments*	Fruit weight (g) at harvest			Yield plant^{-1} (kg)		
	Ambe (Jul, 2017)	Mrig (Oct, 2017)	Avg.	Ambe (Jul, 2017)	Mrig (Oct, 2017)	Total
T_1	172.50	174.00	173.25	12.45	9.49	21.94
T_2	173.25	174.50	173.88	12.62	9.93	22.55
T_3	169.00	170.25	169.63	11.37	9.75	21.12
T_4	169.50	171.00	170.25	11.22	8.98	20.20
T_5	176.50	177.25	176.88	13.94	9.27	23.21
T_6	195.25	196.50	195.88	14.97	11.21	26.18
T_7	180.55	203.25	191.90	14.89	11.30	26.19
T_8	181.91	183.50	182.71	13.94	10.31	24.25
T_9	183.00	184.00	183.50	13.68	9.98	23.66
T_{10}	181.74	195.25	188.50	15.08	11.45	26.53
T_{11}	173.62	174.50	174.06	10.21	8.48	18.69
SEm (±)	**0.87**	**0.74**	**-**	**0.41**	**0.34**	**0.05**
LSD (0.05)	**2.57**	**2.19**	**-**	**1.32**	**1.28**	**0.21**

Table 4: Effect of leguminous cover crop and organic mulching (BBM) on productivity and benefit : cost ratio (B:C) of guava plant cv. Sardar (L-49)

Treatments*	Productivity (t ha^{-1})			Cost of treatment (Rs. ha^{-1})	B:C ratio
	Ambe (Jul, 2017)	Mrig (Oct, 2017)	Total		
T_1	13.83	10.54	24.38	10184.00	2.81
T_2	14.02	11.03	25.05	10184.00	2.83
T_3	12.63	10.83	23.46	10184.00	2.69
T_4	12.47	9.98	22.44	10184.00	2.76
T_5	15.49	10.30	25.79	1500.00	2.86
T_6	16.63	12.45	29.09	11684.00	3.02
T_7	16.54	12.55	29.10	11684.00	3.15
T_8	15.49	11.45	26.94	11684.00	2.92
T_9	15.20	11.09	26.29	11684.00	2.95
T_{10}	16.75	12.72	29.47	83292.00	3.09
T_{11}	11.34	9.42	20.76	0.00	2.53
SEm (±)	**0.12**	**0.15**	**0.54**	**-**	**0.00**
LSD (0.05)	**0.31**	**0.34**	**1.63**	**-**	**0.01**

followed by 3.09 in BPM mulch [T_{10}] treatment (Table 4). Rajput *et al*. (2014) and Nath and Sharma (1992) also recoded the maximum B:C ratio from organic mulching and leguminous cover crop in their investigation.

In the present experiment, the treatments with banana bio-mat mulch (BBM) + leguminous cover crops (LCC) as well as black polythene mulch (BPM) were supposed to cause effective suppression of weeds in guava orchard (Bhattacharjee and Debnath, 2019, Kumari and Khare, 2019, Agreda *et al*., 2006, Abou Sayed- Ahmed *et al*., 2005, Timothy, 2007, Nath *et al*., 1992, Reddy and Khan, 2000) and conservation of soil moisture (Bhattacharjee and Debnath, 2019, Farre *et al*., 1993, Kumar *et al*., 2008, Prakash *et al*., 2007, Das *et al*., 2010, Bakshi *et al*., 2015, Nath *et al*., 1992) due to reduced growth of weeds and evaporative loss of soil moisture, resulting in reduced competition between crop and weeds and hence, better plant growth, higher fruit yield and B:C ratio, compared with conventional practice (control).The BPM were found more effective with immediate effective after application for weed growth suppression and moisture conservation, compared to LCC and BBM, which might have resulted in better plant growth and yield and quality of fruit over LCC and BBM treatments. However, the BBM was used as organic mulch (@ 30 kg fresh m^{-2})

Table 5: Effect of leguminous cover crop and organic mulching (BBM) on fruit quality of guava plant cv. Sardar (L-49)

Treatments*	TSS (^{0}Brix)			Acidity (%)			Vitamin C (mg100^{-1} g)		
	Ambe (Jul, 2017)	Mrig (Oct, 2017)	Avg.	Ambe (Jul, 2017)	Mrig (Oct, 2017)	Avg.	Ambe (Jul, 2017)	Mrig (Oct, 2017)	Avg.
T_1	9.30	10.71	10.01	0.31	0.34	0.32	106.20	129.00	117.60
T_2	9.35	11.10	10.23	0.30	0.30	0.30	114.60	135.15	124.88
T_3	9.16	10.45	9.81	0.32	0.37	0.35	105.00	119.85	112.43
T_4	9.24	10.88	10.06	0.30	0.33	0.32	111.60	129.60	120.60
T_5	9.42	11.23	10.33	0.29	0.28	0.28	123.00	141.75	132.38
T_6	9.65	11.55	10.60	0.28	0.26	0.27	132.60	145.50	139.05
T_7	10.40	12.05	11.23	0.26	0.23	0.24	144.60	152.70	148.65
T_8	10.20	11.75	10.98	0.28	0.25	0.26	141.00	146.40	143.70
T_9	10.25	11.91	11.08	0.27	0.25	0.26	142.20	147.00	144.60
T_{10}	10.60	12.40	11.50	0.25	0.21	0.23	147.00	166.65	156.83
T_{11}	9.04	10.25	9.65	0.33	0.39	0.36	101.40	114.45	107.93
SEm (±)	**0.03**	**0.04**	**-**	**0.00**	**0.01**	**-**	**0.012**	**0.058**	**-**
LSD (0.05)	**0.09**	**0.15**	**-**	**0.01**	**0.03**	**-**	**0.037**	**0.172**	**-**

which in due course of time was decomposed in the orchard soils and thereby, served as a source of soil organic carbon (Blanco-Canqui and Lal, 2007) and plant nutrients (Blanchart *et al*., 2006). It also might had been a good source of nutrients for soil microorganisms, available plant nutrients and a very important substance in humus (Bharadwaj *et al*., 1981), which could have improved the physical and biological properties of orchard soils. The leguminous crops were also grown as cover crops (LCC) and those were incorporated in soil of the guava orchard between 50-60 days after sowing, and hence, it was considered to add 30-40 kg nitrogen per ha (Peoples *et al*., 2009; Frame, 2005).

Therefore, it appeared that the effects of LCC and BBM caused suppression of weed growth, better conservation of soil moisture and increased content of organic carbon and available plant nutrient (nitrogen) in the soils of guava orchard due to fixation of atmospheric nitrogen by leguminous crops and release of essential plant nutrients after decomposition of both organic mulch and leguminous cover crops, resulting in increased plant growth, higher flowering, fruiting, yield, improved fruit quality and higher B:C ratio of guava cultivation, compared with black polythene mulch (which could not add nutrients in soil) and conventional practice of no use of leguminous cover crop and organic mulching (which could not suppress weeds, conserve soil moisture and add nutrients in soil).

It may be concluded that the guava growers of the Gangetic alluvial region of West Bengal may apply leguminous cover crops (Black gram cv. Kalindi in winter, mung bean cv. Samrat in summer @ 3 g seeds m^{-2} ground area) and banana bio-mat mulch (webbed leaf sheath of harvested banana plant @ 30 kg fresh m^{-2} ground area) twice a year (winter and summer months, *viz*., January and May) for suppression of weed growth, better conservation of soil moisture and increased content of soil organic carbon and available plant nutrients resulting in better plant growth, higher yield, improved fruit quality and higher B:C ratio of guava cultivation, compared with black polythene mulch as well as conventional practice of no use of leguminous cover crop and organic mulch.

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