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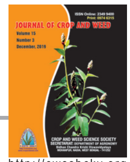

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Effect of branch bending time on induction of shoot and flower bud, productivity and quality of guava var. Sardar (L-49)

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ABSTRACT

The effect of monthly branch bending on off-season guava (var. Sardar) production was investigated during 2017-18 to 2018-19 at ICAR-AICRP on Fruits, Bidhan Chandra Krishi Viswavidyalaya, West Bengal. Branch bending treatment (T_1 to T_{12}) was imposed on 4 years old 'Sardar' guava plants grown under HDP system (3 x 3 m, 1111 ha^{-1}) and designed a RBD experiment with 3 replications. No bending imposed on control plants for comparison with time of bending at monthly interval from January (T_1) to December (T_{12}). Findings indicated a normal tendency (no bending) of 'Sardar' guava plant to produce 92% of fruit in main season (ambe bahar) and only 8.27% in off-season (mrig bahar). While, bending treatments during October to February significantly increased the off-season production up to 60%, with improved fruit quality and higher B:C ratio of 4.72 to 4.02, compared with the control (2.99). Bending during May to August caused mostly non-flowering shoot flush and was not profitable (B:C ratio below 2.99).

Keywords: Crop regulation, fruit quality, guava, off-season production, time of bending, yield

Guava (*Psidium guajava*), popularly known as "poor man's fruit" or "apple of the tropics", is one of the most delicate and valuable fruit of tropics and sub tropics belongs to the family Myrtaceae. The fruits harvested during rainy season (ambe bahar) are significantly attacked by fruit fly (Stonehouse *et al*., 2002), resulting in considerable losses in fruit production as well as unsatisfactory nutritive value and storage quality (Sarkar *et al*., 2005). In contrast to the rainy season harvest, the winter season crop is of superior quality, free from pest and diseases, has a prolonged storage period, and fetches better market prices (Rathore and Singh, 1976). So, the regulation of flowering and fruiting is needed in guava in order to decrease fruiting during rainy season and to promote flowering and fruiting during winter season. In West Bengal shoot bending technique has been a successful method of crop regulation in guava to increase the yield in winter season and it is achieved by bending the branches down at the base level of the plant. Most of the guava growers in West Bengal prefer winter crop and regulate flowering by bending of shoots in the month of August-September (Mitra *et al*., 2008). However, the information on the effect of branch bending time in different months of a year is not available with respect to shoot and flower bud induction, fruit yield and quality and profit of cultivation. It appeared interesting to study the response of guava plant to bending operations done in different months of a year, with respect to shoot growth, flower bud induction and crop regulation. Based on the above background, the present investigation was conducted to assess the effect of branch bending time on induction of shoot and flower bud, productivity and quality of 'Sardar' guava and to understand suitable time for bending to obtain higher off-season yield, better fruit quality and maximum profit margin.

MATERIALS AND METHODS

The experiment was carried out at ICAR-AICRP on Fruits, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia, West Bengal for consecutive two years (2017-18 to 2018-19). 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 (Sand-55.40%, Silt-23.00%, Clay-21.60%), moderately fertile (available N- 0.06%, available P- 29 ppm, available K- 42 ppm and organic C- 0.65%) with field capacity (% v/v)- 26.37, pH- 6.80. The site belongs to the agro-ecological region of Assam and Bengal Plains, hot humid (as per NBSSLUP); sub-tropical climate. The experiment was conducted on 4 years old guava plants var. Sardar (L-49), planted at 3x3m spacing in square system under high density planting (1111 ha^{-1}). Recommended dose of fertilizer (@ 260g N, 320g P_2O_5 and 260g K_2O plant-^{1}year^{-1}) was applied in two equal split doses once in the month of January and thereafter in August, followed by irrigation and other cultural operations including plant protection measures as per package of practices (POP) of BCKV. The experiment included thirteen treatments i.e., time of bending in 12 consecutive months from January to

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December and one that of naturally grown plants (no bending). Bending treatments were imposed on the 3rd week of each month during morning hours (8:00 to 10:00 A.M.). Bending was executed by defoliation of shoots and the defoliated branches were forced for bending with the help of ropes tied in pegs on the soil till the emergence of new flushes. Observation was recorded on time taken for bud break after bending operation, number and length of shoot emerged, inter-node length, number of flower bud initiated, flowering duration, fruit set, fruit growth, number of harvested fruits, yield, fruit quality, B:C ratio. From shoot apex, 3rd leaf pair were collected @ 10 number per replication to estimate average leaf area and it was multiplied by average number of leaf per shoot to record the photosynthetic leaf area per shoot (sq. cm). To study the physico-chemical parameters of fruit, ten representative samples from each replication were used for chemical analysis of fruit quality parameters. The juice was extracted from fully mature fruits and passed through a fine cotton cloth. The total soluble solids (TSS) content of fruit was determined with the help of a hand refractometer, calibrated at 20^0C. Total and reducing sugar contents of the fruit were estimated by titrating against Fehling's A and Fehling's B reagents, using methylene blue as an indicator (AOAC, 1984). Total acidity was determined by titrating against 0.1 N NaoH using phenolpthalin as an indicator (AOAC, 1984). Statistical inference of the data was obtained by the analysis of variance (ANOVA) method for Randomized Block Design (RBD). Percent shoot bearing flower bud (%) was analysed after subjecting the original data to the arcsine transformation (Gomez and Gomez, 1983).

RESULTS AND DISCUSSION

Vegetative growth parameters

The time of bending treatment caused significant variations in shoot growth viz., number of shoots emerged per branch, length of shoot (cm), number of leaf pair per shoot, length of leaf (cm), width of leaf (cm), photosynthetic leaf area per shoot (sq.cm) and length of internodes (cm) [Table 1]. Bending in the month of April, May, June, July, August and September significantly increased the vegetative growth of shoots produced in the bent branch, i.e., number of shoots emerged per branch, length of shoot, leaf pair per shoot, length of leaf, width of leaf, photosynthetic leaf area per shoot as well as length of internodes as compared to bending done in other months. High temperature and humidity prevailing during April to September was supposed to result in increased shoot growth compared to rest of the months having lower temperatures. Similar findings was reported by Rathore (1976) that the high range of average temperature, relative humidity and rainfall appeared responsible for more vegetative shoot growth due to bending time in the month of July to September.

Significant effects of time of bending treatment were also recorded on flowering characteristics**.** The percentage of induced shoot bearing flower bud was lower (38.91 to 45.20%) due to bending time in the month of July to September, compared to 56.58 to 67.66% for the bending time in the rest of the months [Table 2]. Most of shoots induced by branch bending in the month of July to September having higher length of internode and a greater number of leaf pairs, remained vegetative and failed to produced flower bud. Flowering and cropping efficiency of evergreen fruit trees depends on resource allocation and vegetative-reproductive competition. Higher vegetative growth of shoot during July to September might have resulted in failure of flowering (Wolstenholme, 1990). Time of bending in the months of December and January took more days for breaking of bud (29.50 days and 27.00 days, respectively) and also took more time for flower bud formation (22.50 days and 17.40 days, respectively).

In control plants (no bending treatment), spring flush recorded bud breaking on 3rd week of January, 2018 which took 14.60 days for flower bud initiation, 15.90 days for 50% flowering and 78.5% shoots were bearing flower buds. Again, bud breaking was observed in the rainy season flush during 3rd week of June, 2018 and it took 9.30 days for flower bud initiation, 11.20 days for 50% flowering and only 9.2% shoots were bearing flower buds. It was clearly observed from the data depicted in Table 3 and 4 that in control (no bending) plants, the vegetative growth of the spring flush shoots (Ambe bahar) was lower than that of rainy season flush shoots (Mrig bahar). The spring flush produced 8.70 ± 0.22 number of shoots per branch with 15.40 ± 0.36 cm length of shoot, 4.50 ± 0.35 leaf pair per shoot, 321.93 ± 2.45 sq.cm photosynthetic leaf area per shoot and 3.42 ± 0.44 cm internode length; whereas, the rainy season flush produced 14.20 ± 0.74 number of shoots per branch with 26.00 ± 1.33 cm length of shoot, 6.90 ± 0.44 leaf pair per shoot, 584.15 ± 2.45 sq.cm photosynthetic leaf area per shoot and 3.77 ± 0.20 cm of internode length.

Yield parameters

Significant differences were recorded in yield characters of guava viz., number of flower bud plant^{-1}, fruit set plant^{-1}, fruit retention plant^{-1}, yield (kg plant^{-1}) and productivity (t ha^{-1}) due to different time of branch bending. The branch bending during the month of October to February significantly improved off-season bearing by means of induction of higher number of flower buds plant^{-1}, followed by higher fruit set plant^{-1}

Table 1: Variation in shoot growth due to monthly bending treatment of guava var. Sardar (L-49) at 63 days after bending

Treatment* (Time of bending operation)	No. of shoot emerged branch^{-1}	Length of shoot (cm)	No. of leaf pair shoot^{-1}	Length of leaf (cm)	Width of leaf (cm)	Photosyn-thetic leaf area shoot^{-1} (cm^2)	Length of internodes (cm)
T_1-January	11.50	15.20	5.30	6.90	4.60	336.44	2.87
T_2-February	11.90	16.50	5.60	7.40	4.90	406.11	2.95
T_3-March	12.40	17.70	5.90	7.50	5.00	442.50	3.00
T_4-April	14.50	20.30	6.50	7.80	5.10	517.14	3.12
T_5-May	14.20	21.20	6.70	7.90	5.20	550.47	3.16
T_6-June	15.80	23.90	7.50	8.30	5.40	672.30	3.19
T_7-July	16.20	25.40	7.90	8.60	5.60	760.93	3.22
T_8-August	16.70	27.90	8.60	8.80	5.70	862.75	3.24
T_9-September	14.30	28.50	8.80	9.20	6.10	987.71	3.24
T_{10}- October	11.30	25.90	8.70	6.50	4.20	475.02	2.98
T_{11}-November	10.20	15.40	5.20	6.30	4.20	275.18	2.96
T_{12}-December	10.60	14.90	5.10	6.20	4.10	259.28	2.92
SEm (±)	0.06	0.22	0.05	0.06	0.04	0.78	0.04
LSD(0.05)	0.17	0.65	0.14	0.19	0.12	2.77	0.11

Table 2: Variation in flowering characteristics due to monthly bending treatment of guava var. Sardar (L-49) at 63 days after bending

Treatment* (Time of bending operation)	Days taken for bud break after bending	Days taken for flower initiation after bud break	Percent shoot bearing flower bud (%)	Days taken for 50% flowering after flower bud initiation	Days taken from bending to 50% flowering
T_1-January	27.00	17.40	66.23(83.70)	9.10	83.70
T_2-February	20.00	14.20	67.66(85.50)	8.70	85.50
T_3-March	18.50	11.50	66.66(84.10)	8.20	84.10
T_4-April	16.50	10.10	64.01(80.80)	8.20	80.80
T_5-May	16.00	12.40	60.42(75.60)	8.50	75.60
T_6-June	15.50	13.60	56.89(70.10)	9.60	70.10
T_7-July	16.00	13.90	40.70(42.50)	9.80	39.70
T_8-August	16.00	14.10	38.91(39.40)	10.20	40.30
T_9-September	17.00	14.20	45.20(50.30)	10.50	41.70
T_{10}- October	17.50	15.90	56.58(69.50)	10.80	44.20
T_{11}-November	19.00	18.30	62.67(78.90)	11.40	48.70
T_{12}-December	29.50	22.50	66.13(83.60)	12.50	64.50
SEm (±)	0.27	0.15	0.67	0.08	0.22
LSD(0.05)	0.78	0.43	1.91	0.23	0.63

**Data in parentheses is original and transformed by arcsine transformation*

and fruit retention plant^{-1}. Off-season yield per plant was much higher (15 kg plant^{-1}) from the plants bended in the months of October, November, December, January and February, compared with no branch bending in control plants (3.15 kg plant^{-1}) [Table 5 and 6]. The shoots induced by bending during October, November, December, January and February recorded lower shoot growth and internode length compared to those induced by bending during March to September. There might had a better balance of resource allocation and vegetative-reproductive competition which resulted in higher flowering and cropping efficiency (Wolstenholme, 1990).

Table 3: Variation in shoot growth of spring flush (Ambe bahar) of control plants (no bending treatment) of guava var. Sardar (L-49)

Treatment* (Control-No bending)	No. of shoot emerged branch^{-1}	Length of shoot (cm)	No. of leaf pair shoot^{-1}	Length of leaf (cm)	Width of leaf (cm)	Photosyn-thetic leaf area shoot^{-1} (sq.cm)	Length of internodes (cm)
Feb 1st week	4.10±0.33	2.10±0.48	1.30±0.24	2.65±0.23	1.50±0.17	10.34±0.36	1.62±0.12
Feb 2nd week	6.60±0.41	3.40±0.37	1.70±0.28	4.25±0.29	3.50±0.25	50.58±1.02	2.00±0.31
Feb 3rd week	6.90±0.34	6.10±0.23	2.20±0.21	5.00±0.25	3.75±0.18	82.50±0.64	2.77±0.16
Feb 4th week	7.30±0.36	8.80±0.31	3.10±0.39	5.55±0.34	4.00±0.24	137.64±1.30	2.84±0.17
March 1st week	7.50±0.35	10.20±0.36	3.50±0.45	6.00±0.28	4.15±0.43	174.30±1.62	2.91±0.37
March 2nd week	8.20±0.28	13.50±0.80	4.30±0.29	6.35±0.23	4.30±0.25	234.82±1.55	3.14±0.50
March 3rdweek	8.50±0.28	14.00±0.29	4.40±0.38	6.50±0.24	4.40±0.48	251.68±2.62	3.18±0.31
March 4th week	8.70±0.22	15.40±0.36	4.50±0.35	7.30±0.37	4.90±0.45	321.93±2.45	3.42±0.44

* Bud breaking – 3rd Week of January, 2018, * Days taken for flower bud initiation = 14.60 days,
* Days taken for 50% flowering =15.90 days, * % shoot bearing flower buds = 78.5%

Table 4: Variation in shoot growth of rainy season flush (Mrig bahar) of control plants (no bending treatment) of guava var. Sardar (L-49)

Treatment* (Control-No bending)	No. of shoot emerged branch^{-1}	Length of shoot (cm)	No. of leaf pair shoot^{-1}	Length of leaf (cm)	Width of leaf (cm)	Photosyn-thetic leaf area shoot^{-1} (sq.cm)	Length of internodes (cm)
June 4th week	5.60±0.40	2.50±0.54	1.60±0.33	2.10±0.61	1.40±0.18	9.41±0.51	1.56±0.12
July 1th week	7.90±0.42	5.90±0.47	1.90±0.25	3.20±0.50	1.90±0.24	23.10±1.91	3.11±0.28
July 2nd week	8.70±0.35	8.70±0.49	2.50±0.28	4.50±0.55	2.20±0.38	49.50±1.64	3.48±0.32
July 3rd week	11.20±0.68	11.50±0.79	3.20±0.51	5.70±0.33	3.10±0.50	115.07±3.81	3.59±0.34
July 1th week	13.50±0.66	16.10±0.63	4.40±0.49	6.40±0.41	3.40±0.32	191.49±4.18	3.66±0.36
Aug 2nd week	13.90±0.68	20.30±1.04	5.50±0.55	7.60±0.78	3.90±0.24	326.04±1.82	3.69+0.45
Aug 3rd week	14.00±0.90	25.10±1.68	6.70±0.70	8.00±0.63	4.50±0.45	482.40±2.40	3.75±0.42
Aug 4th week	14.20±0.74	26.00±1.33	6.90±0.44	8.30±0.63	5.10±0.44	584.15±2.45	3.77±0.20

* Bud breaking – 3rd Week of June, 2018, * Days taken for flower bud initiation = 9.30 days
* Days taken for 50% flowering = 11.20 days, * % shoot bearing flower bud = 9.2%

The estimated productivity of off-season (induced) guava fruit was maximum (20.58 t ha^{-1}) due to branch bending in the month of October and minimum (3.48 t ha^{-1}) in August bending. The productivity of off-season crop ranged between 17.25 to 20.58 t ha^{-1} for bending time in the month of December, January, February, November and October. Endogenous hormone levels and bio-molecular transformations occurring within the guava shoots in response to bending had also been positively correlated with induced flowering, fruiting and yield in guava (Bagchi *et al.*, 2008) and Japanese pear plants (Ito *et al.*, 1999; Ito *et al.*, 2004). Bagchi *et al.* (2008) reported that bending treatment influenced the amount of total free amino acid, tryptophan, peroxidase, catalase and polyphenoloxidase activity in the leaves and barks of the guava plants. In the stressed plants (bent), proline biosynthesis was stimulated which in turn resulted in profuse flowering and fruiting (Adhikari and Kandel, 2015). Bending in the month of July to September coincided with prevailing high atmospheric temperature, rainfall, relative humidity and soil moisture and temperature of respective months, hence most of the induced shoots having increased inter-node length with higher number of leaf pairs per shoot and failed to produce flower bud, remained vegetative. On the other hand, bending in the months of October, November, February, January, December and March induced more flower bud resulting in higher fruit set,

Table 5: Variation in number of flower bud produced both in off-season (induced) and ambe bahar due to monthly bending treatment of guava var. Sardar (L-49)

Treatment* (Time of bending operation)	Flower bud plant^{-1}		Fruit set plant^{-1}		Fruit retention plant^{-1}	
	Off-season	Ambe bahar	Off-season	Ambe bahar	Off-season	Ambe bahar
T_1-January	165.00	99.00	133.76	54.10	92.14	45.98
T_2-February	171.00	113.00	117.90	61.75	95.49	52.49
T_3-March	115.00	175.00	79.29	95.75	64.22	81.29
T_4-April	91.00	225.00	62.74	122.95	50.82	104.51
T_5-May	71.00	190.00	48.95	103.83	39.65	88.25
T_6-June	55.00	170.00	37.92	92.90	30.71	78.96
T_7-July	45.00	165.00	31.03	90.17	25.13	76.64
T_8-August	40.00	180.00	27.58	98.36	22.34	83.61
T_9-September	125.00	135.00	86.18	73.77	69.81	62.71
T_{10}- October	189.00	97.00	130.31	54.65	105.55	46.45
T_{11}-November	175.00	97.00	120.65	53.01	97.73	45.06
T_{12}-December	160.00	95.00	110.31	51.91	89.35	44.13
T_{13} (Control)	23.54	295.00	27.68	259.00	22.42	181.30
SEm (±)	0.13	0.21	0.19	0.22	0.34	0.36
LSD(0.05)	0.39	0.61	0.56	0.64	1.00	1.06

Table 6: Variation in fruit maturity period and yield both in off-season (induced) and ambe bahar due to monthly bending treatment of guava var. Sardar (L-49)

Treatment* (Time of bending operation)	Days required for harvest after bending		Harvest time (month)		Yield (kg plant^{-1})		Total
	Off-season	Ambe bahar	Off-season	Ambe bahar	Off-season	Ambe bahar	
T_1-January	151.50	97.80	May	July-Aug	16.05	8.10	24.15
T_2-February	137.90	95.50	May-June	July-Aug	16.67	9.39	26.06
T_3-March	131.20	93.10	June	July-Aug	10.88	15.09	25.98
T_4-April	124.80	92.40	July	July-Aug	8.40	19.69	28.09
T_5-May	125.90	92.10	Aug	July-Aug	6.34	16.47	22.81
T_6-June	126.70	91.60	Sept	July-Aug	4.68	14.63	19.32
T_7-July	131.70	91.30	Oct-Nov	July-Aug	3.65	14.17	17.82
T_8-August	139.30	91.10	Nov-Dec	July-Aug	3.13	15.55	18.69
T_9-September	142.70	90.50	Dec-Jan	July-Aug	11.91	11.42	23.33
T_{10}- October	152.20	93.70	Feb	July-Aug	18.53	8.20	26.72
T_{11}-November	161.70	94.60	March	July-Aug	17.08	7.92	25.00
T_{12}-December	182.50	95.20	April-May	July-Aug	15.53	7.74	23.27
T_{13} (Control)	NA	93.20	July-Aug	July-Aug	3.15	34.90	38.05
SEm (±)	0.37	0.26	--	--	0.13	0.15	0.23
LSD(0.05)	1.08	0.75	--	--	0.37	0.44	0.66

retention and yield. The present results are corroborated with the earlier reported findings on bending technique which was found effective for increasing off-season production (Sarkar *et al*., 2005; Sarkar and Ghosh, 2006; Bagchi *et al.,* 2008; Sarkar *et al*., 2017).

As of normal tendency of Sardar guava plant, the control (no bending) plant produced almost 92% of its total fruit production in ambe bahar (rainy season) and only 8.27% in off-season (mrig bahar). Bending time treatments showed successful regulation on rainy season (ambe bahar) fruit production and thereby the fruit production in off-season (induced) was increased. Production of off-season (induced) fruits up to 60% of total production was achieved by imposing bending

Table 7: Variation in estimated productivity, crop regulation percent and B:C ratio both in off-season (induced) and ambe bahar due to monthly bending treatment of guava var. Sardar (L-49)

Treatment* (Time of bending operation)	Estimated productivity (t ha^{-1})			Regulation%	B:C ratio
	Off-season	Ambe bahar	Total		
T_1-January	17.83	9.00	26.83	66.44	4.17
T_2-February	18.52	10.44	28.95	63.95	4.40
T_3-March	12.09	16.77	28.86	41.89	3.54
T_4-April	9.33	21.88	31.21	29.90	3.33
T_5-May	7.04	18.30	25.34	27.77	2.63
T_6-June	5.20	16.26	21.46	24.24	2.12
T_7-July	4.05	15.75	19.80	20.47	1.86
T_8-August	3.48	17.28	20.76	16.76	1.85
T_9-September	13.24	12.68	25.92	51.07	3.49
T_{10}- October	20.58	9.11	29.69	69.32	4.72
T_{11}-November	18.98	8.80	27.78	68.31	4.38
T_{12}-December	17.25	8.60	25.85	66.74	4.02
T_{13} (Control)	3.50	38.77	42.27	8.27	2.99
SEm (±)	0.18	0.16	0.29	0.34	0.04
LSD(0.05)	0.53	0.46	0.84	1.00	0.10

Table 8: Variation in TSS, acidity and ascorbic acid content both in off-season (induced) and ambe bahar due to monthly bending treatment of guava var. Sardar (L-49)

Treatment* (Time of bending operation)	TSS (^{0}Brix)		Acidity (%)		Ascorbic acid content (mg per100g pulp)	
	Off-season	Ambe bahar	Off- season	Ambe bahar	Off-season	Ambe bahar
T_1-January	11.10	9.30	0.29	0.37	145.60	137.50
T_2-February	10.80	9.40	0.30	0.36	142.30	134.60
T_3-March	10.50	9.30	0.31	0.36	140.10	134.20
T_4-April	9.70	9.50	0.31	0.35	138.40	136.50
T_5-May	9.70	9.20	0.32	0.37	138.10	136.90
T_6-June	9.50	9.20	0.33	0.36	137.30	134.20
T_7-July	10.10	9.50	0.34	0.35	137.10	136.40
T_8-August	10.30	9.40	0.34	0.36	136.40	136.40
T_9-September	10.60	9.30	0.30	0.34	139.20	135.70
T_{10}- October	12.30	9.30	0.27	0.36	146.70	137.40
T_{11}-November	12.10	9.20	0.28	0.36	148.20	135.50
T_{12}-December	11.80	9.40	0.29	0.35	145.70	134.90
T_{13} (Control)	11.10	9.30	0.30	0.36	141.50	134.80
SEm (±)	0.03	0.03	0.00	0.00	0.26	0.21
LSD(0.05)	0.10	0.10	0.01	0.01	0.77	0.62

treatments in the month October, November, December, January and February. The estimated B:C ratio was above control (2.69) for bending in the month of October (4.72), November (4.38), January (4.40), February (4.17), December (4.02), March (3.54) and April (3.33). However, bending in the months of May, June, July and August was not profitable as the estimated B:C ratio for these months was much below that of control (2.99) [Table 7].

Fruit quality parameters

The present findings on fruit quality such as total soluble solids [TSS] (^{0}Brix), acidity (%), ascorbic acid content (mg per 100g pulp), total sugar (%) and reducing sugar (%) of fruit revealed that the different time of bending treatments had significant effect on the fruit quality parameters [Table 8 and 9]. In case of off-season crop, the [T_{10}] October bending recorded the highest total soluble solids (12.30^0 Brix), followed by [T_{11}]

Table 9: Variation in total sugar and reducing sugar both in off-season (induced) and ambe bahar due to monthly bending treatment of guava var. Sardar (L-49)

Treatment* (Time of bending operation)	Total sugar (%)		Reducing sugar (%)	
	Off- season	Ambe bahar	Off- season	Ambe bahar
T_1-January	6.50	6.20	4.00	3.30
T_2-February	6.30	6.10	3.90	3.30
T_3-March	6.20	6.10	3.80	3.20
T_4-April	6.20	6.10	3.70	3.10
T_5-May	6.20	6.00	3.70	3.10
T_6-June	6.20	6.10	3.60	3.10
T_7-July	6.10	5.90	3.50	3.00
T_8-August	6.10	6.00	3.40	2.90
T_9-September	6.30	6.00	3.90	2.90
T_{10}- October	6.90	6.30	4.20	3.50
T_{11}-November	6.80	6.30	4.10	3.40
T_{12}-December	6.60	6.20	4.10	3.30
T_{13} (Control)	6.20	6.10	3.70	3.20
SEm (±)	0.02	0.03	0.04	0.03
LSD(0.05)	0.07	0.09	0.11	0.03

November bending (12.10^0 Brix), whereas, the lowest (9.50^0 Brix) total soluble sugar in fruit was recorded due to bending in the month of June (T_6). The highest ascorbic acid content of fruit was recorded in case of branch bending in the month of [T_{11}] November (148.20 mg per100 g pulp), followed by bending in the month of [T_{10}] October (146.70 mg per 100 g pulp), December (145.70 mg per100g pulp), January (145.60 mg per 100g pulp) and February (142.30 mg per100g pulp), which was higher than [T_{13}] control (141.50 mg per100g pulp). The time of bending during the month of [T_{10}] October resulted in highest total sugar content (6.90%) of fruit, followed by the fruit of [T_{11}] November bended plant (8.80%). From the above discussion, it was clearly seen that bending in the month of October, November, December, January and February significantly improved the fruit quality in off-season crop. The better fruit quality from bending treatments imposed during October, November, December, January and February was attributed to major factors viz., (1) prevailing cooler climate and less rainfall or humidity during those months, (2) better light penetration due to branch bending, (3) better reallocation of photosynthates and resources. The lower minimum (night) temperatures prevailing during the winter months (Oct-Feb) also might have contributed to the better fruit quality (TSS, total sugar etc) (Radler, 1965; Rathore, 1976). Kliewer and Lider (1970) found that besides retarding the loss of respiratory substrates, low temperature also enhanced photosynthate translocation from leaves to other plant parts. Due to decrease in temperature vegetative growth in guava slowed down throughout the winter season allowing the plant to accumulate more food reserves, notably in the fruits (Rathore, 1976). As branch bending boosted the photosynthesis rate by increasing light penetration inside the canopy, that might have resulted in improvement of fruit quality (physico-chemical properties) of off-season (induced) guava fruits (Samant *et al*., 2016) and that was already reported by earlier workers (Sarkar *et al*., 2005, Sarkar *et al*., 2017).

On the basis of the results obtained in the present investigation, it may be concluded that crop regulation for off-season (induced) fruit production of guava cv. Sardar (L-49) may be achieved up to 60% of total production, with higher B:C ratio and better fruit quality by practicing the bending operation in the month October, November, December, January and February in the Gangetic alluvium region of West Bengal.

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