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Influence of Number of Suckers in Ratoon Crop on Yield and Quality of Malbhog (AAB) Banana

Rupshree Borah[1*], D. N. Hazarika[1], Supriya Langthasa[1] and Hemanga Das[2]

[1]Department of Horticulture, Biswanath College of Agriculture, Assam Agricultural University, Assam, India.
[2]APART, KVK, Borpeta, Assam, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors RB and DNH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RB, DNH and SL managed the analyses of the study. Author HD managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was carried out at instructional cum experimental farm, Department of Horticulture, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali to study the effect of number of suckers per hill on yield and quality of banana cv. Malbhog (AAB) in ratoon crop by maintaining different numbers of suckers per hill as-T_1 (one sucker per hill), T_2 (two suckers per hill), T_3 (three suckers per hill), and T_4 (four suckers per hill). Plants for each treatment were planted in two spacing as S_1 (2.1 m x 2.1 m) and S_2 (2.5 m x 2.5 m). One treatment with recommended package of practice (one sucker retain with mother plant at shooting) was also included in the experiment as control. The treatment combinations were laid out in factorial Randomized Block Design with three replications. Finger length (15.22 cm), finger girth (12.05 cm), finger volume (84.44cc) and finger weight (83.65 g), number of fingers (92.75/bunch), hands (7.27/bunch), bunch weight (9.41 kg/bunch and yield (15.05 t/ha), were highest in S_2T_1 (2 suckers per hill in 2.5 m x 2.5 m spacing). Lowest duration from harvesting of first crop to harvesting of first ratoon crop (68.50 days) observed in S_2T_1. Yield of banana was significantly lower in wider spacing of 2.5 m x 2.5 m (S_2) than S_1 (2.1 m x 2.1 m). There was no significant effect on quality attributing parameters of fingers.

**Corresponding author: E-mail: borahrupshree@gmail.com;*

Keywords: Malbhog; ratoon crop; suckers; treatment; yield; quality.

1. INTRODUCTION

Banana (*Musa* spp.) is one of the most important staple food and starchy fruit crops of the world, produced in India, which is ranked first in both area of cultivation and production, globally. Though area under banana production has been increasing in India the total productivity and quality of the fruits have been found to be declining, particularly in the Assam region. This might be due to cultivation of low yielding variety, poor management of suckers, inappropriate spacing, the type of fertilizer used, irrigation priority, pests and diseases. In recent years, more emphasis has been given to higher productivity of banana per unit area with better quality by adopting various technologies and methodologies. One of such methods is high density planting which depends on variety, method of cultivation, the height and spread of banana plant. Among the different cultural practices, de-suckering is one of the important practices which influence the size of the fingers and bunch weight of banana. Nalina et al. [1] remarked that wider spacing recorded higher length, girth and volume of fingers as compared to the closer spacing. The commercial cultivation of banana in Assam has gained momentum since last one decade. The majority of the farmers in Assam allow all the suckers to grow along with the mother plants. If all the suckers which arise from the stool are allowed to grow, bunches become smaller with poor quality and some plants may not bear fruit at all [2]. Chattopadhayay et al. [3] and Reddy [4] recorded higher total sugar in banana with low plant density. All HDP treatments registered a reduction in bunch weight compared with the normal density of plants. This reduction in bunch weight with increment in plant density may be due to excessive interception of light by enhanced canopy under HDP, which might have helped to increase in vegetative characters but probably not the bunch characters. Bunch weight was increased significantly with increasing plant distances, this true in both first and second ratoon plants. In the research study, plants under low density exhibited superior fruit quality and had a tendency to decrease with increase in plant density [5]. As per opinion of banana growers of Assam, if de-suckering is practiced then the period from harvesting of first crop to harvesting of ratoon crop become longer and it affects the economic condition of the small and marginal growers. Therefore, the growers allow the suckers to grow along with the mother plants to get return earlier from the subsequent ratoon crops.

1.1 Aim and Objective of the Study

1) Study on the effect of number of suckers per hill on yield and quality of first ratoon crop.
2) Study on the effect of number of suckers per hill on harvesting gap between first crop and first ratoon crop and yield of first ratoon crop.

1.2 Geographical Location of the Experimental Site

The experimental site is situated at 26°15′ N and 27°45′ S latitude and 91°42′ E and 95°30′ W longitude having an altitude of 104 m above mean sea level. The prevailing climatic condition of Biswanath Chariali is subtropical with prominent summer and cold winter seasons. The rainy season and the summer season are overlapping and rainfall starts from March and quantum of rainfall as well as number of rainy days increases and reaches maximum in the month of August and then rainfall gradually decreases up to December. Summer is experienced from May to August and the cold winter from December to January, whereas a mild winter is experienced during September to November and February to April.

2. MATERIALS AND METHODS

The experiment was carried out at instructional cum experimental farm, Department of Horticulture, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali with nine treatment combinations. The treatments combination were S_1T_1 (2.1m x 2.1 m with one sucker /hill), S_1T_2 (2.1m x 2.1 m with two suckers/hill), S_1T_3 (2.1m x 2.1 m with three suckers/hill),S_1T_4 (2.1m x 2.1 m with four suckers/hill), S_2T_1 (2.5 m x 2.5 m with one sucker /hill), S_2T_2 (2.5m x 2.5 m with two suckers/hill), S_2T_3 (2.5m x 2.5 m with three suckers/hill), S_2T_4 (2.5m x 2.5 m with four suckers/hill) and One treatment with recommended package of practices (control). There were two spacing categaries - S_1 (2.1 m x 2.1 m) and S_2 (2.5 m x 2.5 m) for all the treatments .Nine treatment combinations were laid out in Randomized Block Design (1365 m^2) with three replications.

Malbhog is a medium tall, most preferred indigenous table purpose hybrid variety that bears fruit in 18 months. Suckers were collected from Amlighat near Jagirod in Morigaon district, Assam. The bunch was weighed along with the peduncle and the yield was calculated out on the basis of number of plants accommodated per hectare as per spacing. The physical parameters of fingers *viz.,* length, girth, volume, weight, number of fingers were recorded after harvesting the bunch. Total soluble solids (TSS) was determined by Pocket Refractometer PAL-1. Titratable acidity, reducing sugars, total sugars and non-reducing sugars of the first ratoon were estimated by adopting the standard methods of AOAC [6].

2.1 Field Experimental Design

The field experiment was done following the standard methods.

2.2 Quality Parameters of Fingers

2.2.1 Laboratory procedures

Titratable acidity, reducing sugars, total sugars and non-reducing sugars were estimated by adopting the standard methods of AOAC [6].

2.2.1.1 Titratable acidity

For estimation of titratable acidity, 25 g of pulp was ground in mortar, added 250 ml of distilled water and filtered. Ten ml of filtrate was titrated against 0.1 N NaOH using phenolphthalein as indicator and the light pink color was considered as the indication of the end point. Titratable acidity was expressed in percentage in terms of anhydrous malic acids as follows.

$$\textbf{Titratable acidity}\ (\%) = \frac{\textbf{Titre value} \times \textbf{Normality of alkali} \times \textbf{Volume made up} \times \textbf{Equivalent weight of malic acid} \times 100}{\textbf{Weight of the sample} \times \textbf{Aliquot} \times 1000}$$

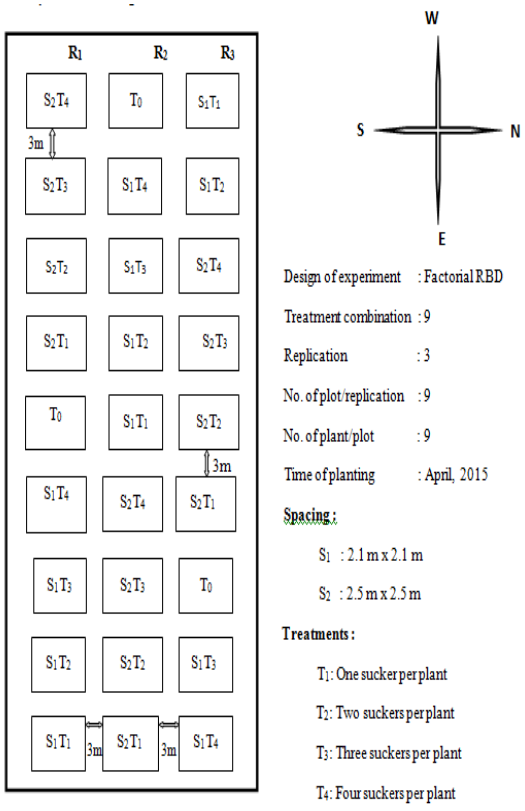

Fig. 1. Layout of the experimental plot

2.2.1.2 Reducing sugars

Ten ml of standard lead acetate solution and 5 ml of sodium oxalate were added to 25 g of already ground pulp and the volume was made up to 250 ml with distilled water, centrifuged and then filtered. The filtrate was titrated against 10 ml boiling Fehling's solution mixture (5.0 ml of Fehling's solution A + 5.0 ml of Fehling's solution B) using methylene blue as indicator. Deep brick red colour of the solution indicated the end point and percentage of reducing sugar was calculated as follows.

$$\text{Reducing Sugars (\%)} = \frac{\text{Factor} \times \text{Volume made up}}{\text{Titre value} \times \text{Weight of sample}} \times 100$$

Where the factor was 0.05 (mg of invert sugar)

2.2.1.3 Total sugars

From the solution of 250 ml made up for estimation of reducing sugars, 50 ml of the solution was taken and 5.0 ml of concentrated HCL was added to it and kept for overnight. The solution was neutralized on the next day with 1N NaOH and volume was made up to 150 ml with distilled water and titrated against 10 ml boiling Fehling's solution mixture using methylene blue as indicator. From the titre value, percentage of total sugars was calculated out as follows:

Total sugars % = (% Sucrose + % Reducing sugars)

Sucrose % = (% Total invert sugars - % Reducing sugars) x 0.95

$$\text{\% of Total invert Sugars} = \frac{\text{Factor} \times \text{Volume made up} \times \text{Volume of stock}}{\text{Titre value} \times \text{Weight of sample} \times \text{Aliquot taken}} \times 100$$

Factor = 0.05 (mg of invert sugar)

2.2.1.4 Non-reducing sugars

Non-reducing sugars were calculated out from the differences of total sugars and non-reducing sugars as following.

Non - reducing sugars (%) = (% total sugars - % reducing sugars)

3. RESULTS AND DISCUSSION

3.1 Fruit and Yield Parameters

The longest finger (14.90 cm) and highest girth (11.49 cm) were recorded in T_1 (mother plant + one sucker) followed by 14.46 cm length and 11.24 cm girth in T_2 (mother plant + two suckers) while T_4 (mother plant + four suckers) recorded the shortest finger (13.87 cm) and lowest girth (10.54 cm) (Table 1). Finger girth was found to be significant between the control and other treatments and in it was 12.27 cm control. Volume of fingers differed significantly due to spacing and it was significantly higher (81.16 cc) in S_2 (2.5 m x 2.5 m) as compared to 76.93 cc in S_1 (2.1 m x 2.1 m) (Table 1). Among the treatments, T_1 (mother plant + one sucker) recorded the maximum weight of fingers (82.96 g) and differed significantly from the rest of the treatments (Table 2). The highest (91.25) number of fingers per bunch was recorded in T_1 (mother plant + one sucker) while it was lowest (84.68) in T_4 (mother plant + four suckers) (Table 2). In the present investigation, the physical parameters of the fruits *i.e.* length, girth and volume of the fingers decreased gradually with the increase in the number of suckers per plant. Longer, heavier, and thicker fingers were borne by the plants in lower plant population (control) compared to higher plant population. It might be due to utilization of available nutrients and moisture by the increasing number of suckers as well as the application of same doses of fertilizers recommended for one plant in Assam.

The significantly heaviest bunch weight (9.41 kg/plant) was recorded in S_2T_1 (wider spacing with one sucker/mother plant) while the lowest (6.16 kg/plant) in S_1T_4 (recommended spacing with four suckers/mother plant) and was at par with S_1T_3 (6.22 kg/plant), S_1T_2 (6.28 kg/plant) and S_2T_4 (6.24 kg/plant) in first ratoon crop. Among the treatments, significantly highest yield was observed in T_1 (one sucker per hill) and the lowest in T_4 (four suckers per hill) in both the first crop and first ratoon crop (Table 3). However, significantly higher yield were recorded in control under the study. The economic character of a banana plant is the bunch which is influenced by the number of hands and fingers per bunch, weight of fingers, length, girth and volume of fingers. The result of the present study revealed that weight of fingers, number of hands, bunch weight and yield were significantly influenced by the different treatments in first ratoon crop. Among the different treatments, bunch weight per plant and corresponding yield per hectare were highest in plants with retention of only one sucker with mother plant (T_1) and bunch weight and yield gradually decreased with the increase in number of suckers per plant (Table 3). It could also be associated with the higher number of

Table 1. Length, girth and volume of banana fingers of first ratoon crop

Treatment	Length of fingers (cm)			Girth of fingers (cm)			Volume of fingers (cc)		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	14.58	15.22	14.90	10.92	12.05	11.49	79.19	84.44	81.82
T_2	14.25	14.67	14.46	10.83	11.64	11.24	78.94	82.45	80.69
T_3	14.00	14.19	14.10	10.20	11.07	10.64	75.02	80.83	77.93
T_4	13.81	13.93	13.87	10.12	10.97	10.54	74.58	76.93	75.76
Mean	14.16	14.50	---	10.52	11.43	---	76.93	81.16	---
Control	---	---	15.22	---	---	12.27	---	---	84.16
CD (P=0.05)	T: 0.61 NS	S: NS C vs T: NS	T x S:	T: 0.51 C vs T: 0.72	S: 0.36	T x S: NS	T: NS S: NS	S: 3.45 C vs T: NS	T x

Table 2. Weight of fingers, numbers of fingers and hands per bunch of first ratoon crop

Treatment	Weight of fingers (g)			Number of fingers per bunch			Number of hands per bunch		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	82.27	83.65	82.96	89.75	92.75	91.25	7.08	7.27	7.18
T_2	73.91	75.40	74.65	86.74	89.50	88.12	6.61	7.06	6.83
T_3	70.84	74.58	72.71	83.87	87.94	85.91	6.35	6.75	6.55
T_4	69.80	72.13	70.96	82.00	87.36	84.68	6.25	6.67	6.46
Mean	74.21	76.44	---	85.59	89.39	---	6.57	6.94	---
Control	---	---	83.96	---	---	93.72	---	---	7.59
CD (P=0.05)	T: 3.91 C vs T: NS	S: NS	T x S: NS	T: 3.88 vs T: 0.51	S: 2.74	T x S: NS C	T: 0.40 C vs T: NS	S: 0.28	T x S: NS

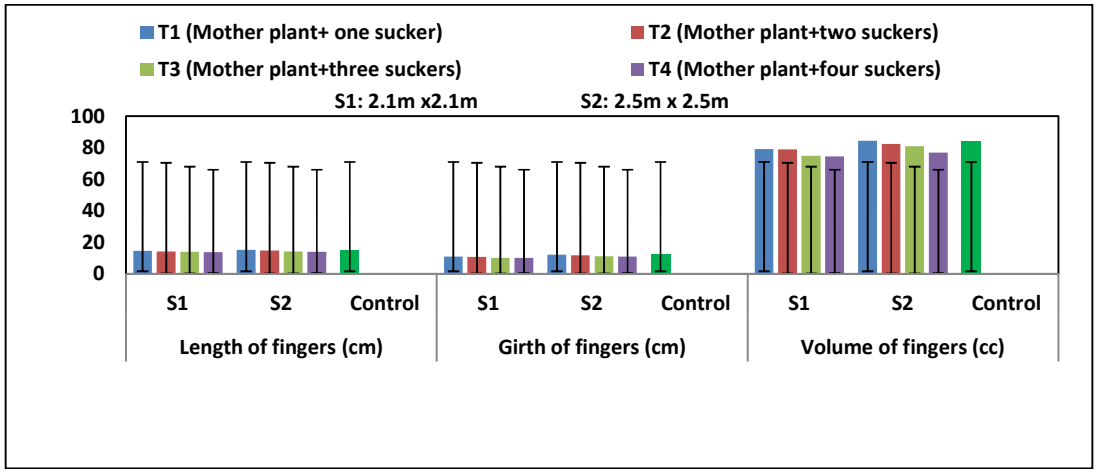

Fig. 2. Length, girth and volume of banana fingers of first ratoon crop

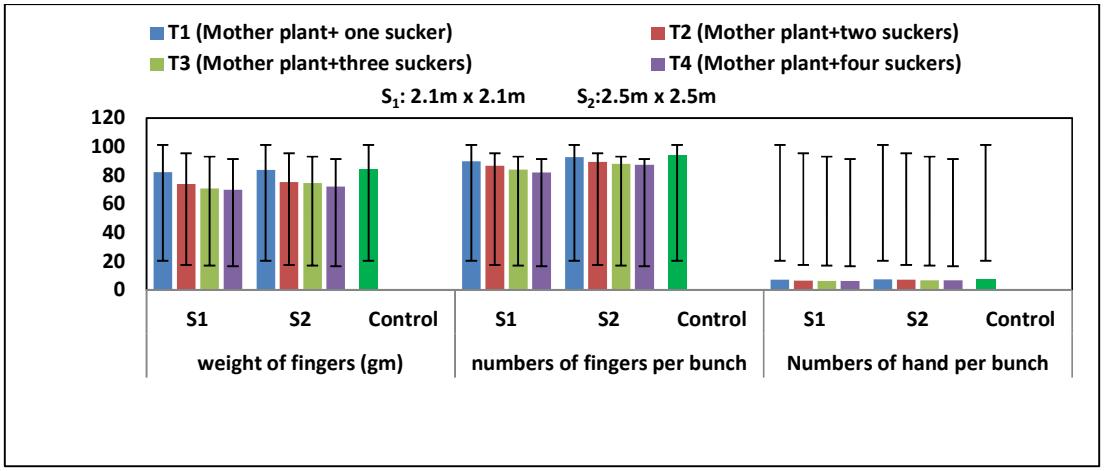

Fig. 3. Weight of fingers, numbers of fingers and hands per bunch of first ratoon crop

hands and fingers per bunch, longest fingers, higher girth and volume of fingers as recorded in this treatment. Similar results were also observed by Irizarry et al. [7], Lichtemberg et al. [8] and Martiney [9] in different varieties and locations. It was interesting to note that though the bunch weight per plant was found to be higher in wider spacing but the total yield per hectare was reduced in wider spacing. It might be due to more numbers of plants accommodated per unit area with closer spacing (S_1). Similar results were obtained by Kesavan et al. [10]; Nalina et al. [1]; Abdullah et al. [11]; Sarrwy et al. [12].

The plants cultivated as per recommended package of practices (control) produced the heaviest bunches which might be due to adequate spacing, plant population and nutrient supply resulting higher values of number of fingers, girth of fingers, length of finger, weight of second hand and peduncle.

3.2 Duration from Harvesting of First Crop to Harvesting of First Ratoon Crop

In research study the duration from harvesting of first crop to harvesting of first ratoon crop revealed that there was no significant differences among the treatments. However, duration from the harvesting of first crop to harvesting of first ratoon crop varied significantly between the treatments and the control. The control recorded the longest period of 159.95 days between harvesting of first crop to harvesting of first ratoon crop (Table 4).

Table 3. Bunch weight and yield of banana of first ratoon crop

Treatment	Bunch weight (kg/plant)			Yield (t/ha)		
	S_1	S_2	Mean	S_1	S_2	Mean
T_1	8.71	9.41	9.06	19.73	15.05	17.39
T_2	6.28	8.24	7.26	14.67	13.18	13.93
T_3	6.22	7.49	6.85	14.09	11.97	13.03
T_4	6.16	6.33	6.24	14.33	10.12	12.23
Mean	6.84	7.87	---	15.71	12.58	---
Control	---	---	10.08	---	---	22.84
CD (P=0.05)	T: 0.29 T x S: 0.41		S: 0.21 C vs T: 0.35	T: 0.66 T x S: 0.93		S: 0.46 C vs T: 0.71

Table 4. Duration from harvesting of first crop to harvesting of first ratoon crop

Treatments	Duration from harvesting of first crop to harvesting of first ratoon crop (days)		
	S_1	S_2	Mean
T_1 : (mother plant + one sucker)	77.34	68.50	72.92
T_2 : (mother plant + two suckers)	69.61	69.23	69.42
T_3 : (mother plant + three suckers)	77.37	73.44	75.41
T_4 : (mother plant + four suckers)	95.20	79.18	87.19
Mean	79.88	72.59	---
Control : (Recommended practice)	---	---	159.95
CD (P=0.05)	T: NS S: NS T x S: NS C vs T: 29.88		

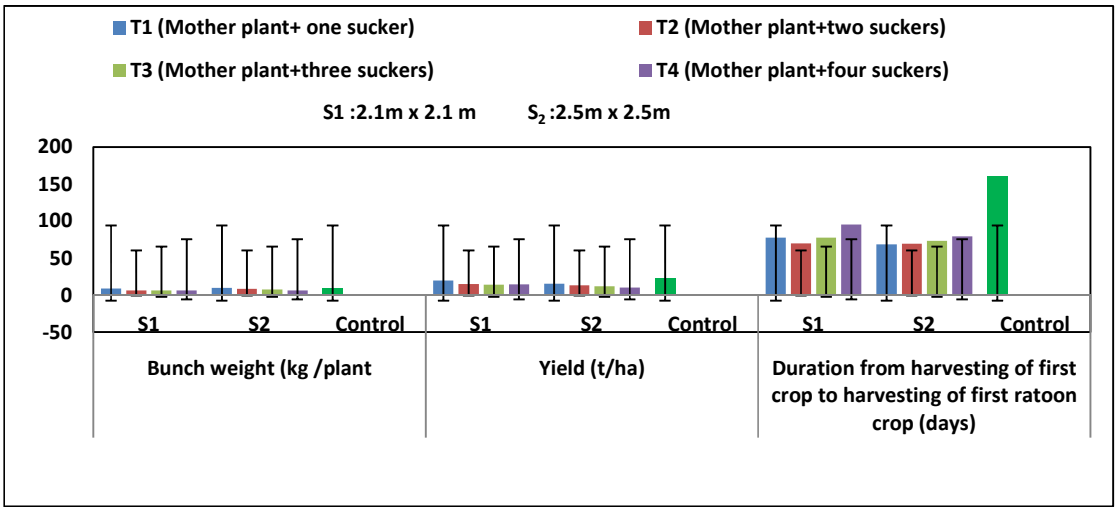

Fig. 4. Bunch weight, yield and duration from harvesting of first crop to harvesting of first ratoon crop

3.3 Fruit Quality Parameters

TSS and titratable acidity did not differ significantly due to treatments, spacing and their interaction effects. Higher TSS (26.28^0 Brix) and higher titratable acidity (0.35%) were recorded in T_1 (one sucker per hill) but the fingers produced under control recorded higher TSS of 26.31^0Brix and titratable acidity of 0.38 percent than other treatments (Table 5). Total sugars, reducing sugars and non- reducing were not influenced by treatments but spacing had a positive influence on sugar contents. Fingers under wider spacing (S_2) recorded higher total sugars (15.03%), reducing sugars (7.99%) and non-reducing sugars (7.71%) than that of 14.27 percent, 7.33 percent and 6.28 percent of total sugars, reducing sugars and non-reducing, respectively

in recommended spacing (S_1) (Table 6). Total soluble solids, titratable acidity, sugar contents determine the quality of fruits. In the present study, the differences in total soluble solids (TSS) and titratable acidity contents in fruits were found to be non-significant due to different treatments and spacing. The gradual decreasing trend of TSS and titratable acidity with the increase in number of suckers per plant might be due to the lesser exposure to the sunlight resulting in lesser accumulation of sugars and other soluble components from hydrolysis of protein and oxidation of ascorbic acid [13]. Similarly, lower total sugars and reducing sugars in high density treatments might be due to less conversion of sugar from starch. The present study gets ample support from the work of Chundawat et al. [14].

Table 5. TSS and titratable acidity of banana fruits of first ratoon crop

Treatment	Total soluble solids (^{0}Brix) of fingers			Titratable acidity (%) of fingers		
	S_1	S_2	Mean	S_1	S_2	Mean
T_1	26.50	26.05	26.28	0.33	0.37	0.35
T_2	23.80	25.46	24.63	0.38	0.32	0.35
T_3	23.58	24.63	24.11	0.37	0.30	0.34
T_4	21.38	22.22	21.80	0.30	0.31	0.31
Mean	23.82	24.59	---	0.35	0.33	---
Control	---	---	26.32	---	---	0.38
CD (P=0.05)	T: NS T x S: NS	S: NS C vs T: NS		T: NS T x S: NS	S: NS C vs T: NS	

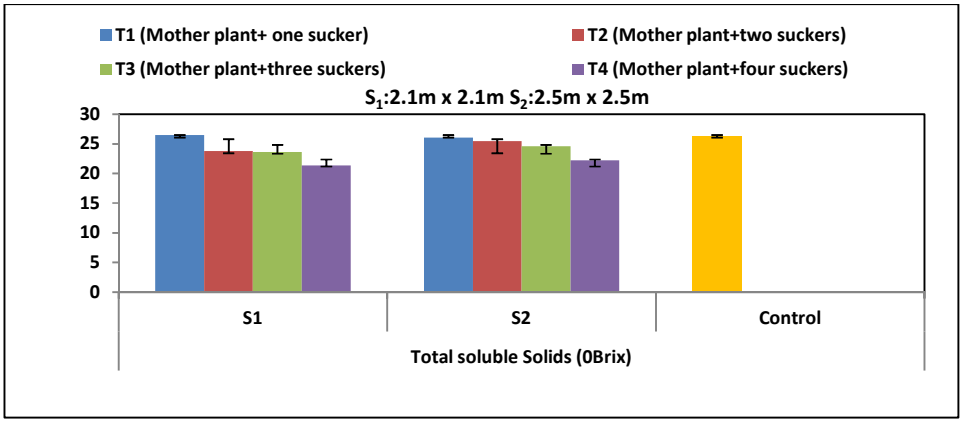

Fig. 5. TSS of banana fruits of first ratoon crop

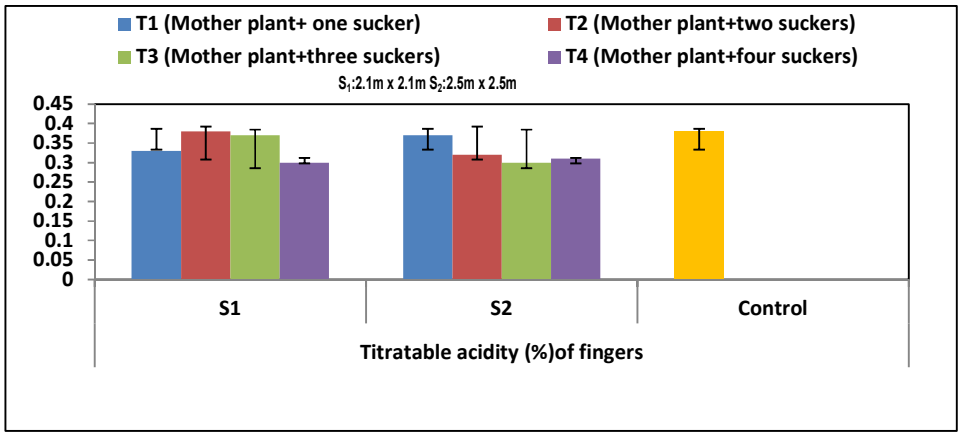

Fig. 6. Titratable acidity of banana fruits of first ratoon crop

Table 6. Sugar contents of banana fruits of first ratoon crop

Treatment	Reducing sugars (%) of fingers			Total sugars (%) of fingers			Non-reducing sugars (%) of fingers		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	7.49	8.45	7.97	14.62	15.67	15.14	6.17	8.17	7.17
T_2	7.38	8.22	7.80	14.45	15.23	14.84	6.22	7.86	7.04
T_3	7.22	7.96	7.59	14.23	14.98	14.61	6.27	7.76	7.01
T_4	7.21	7.33	7.27	13.79	14.24	14.02	6.46	7.04	6.75
Mean	7.33	7.99	---	14.27	15.03	---	6.28	7.71	---
Control	---	---	8.99	---	---	15.52	---	---	6.53
CD (P=0.05)	T: NS S: 0.44 T x S: NS C vs T: NS			T: NS S: 0.47 T x S: NS C vs T: NS			T: NS S: 0.74 T x S :NS C vs T: NS		

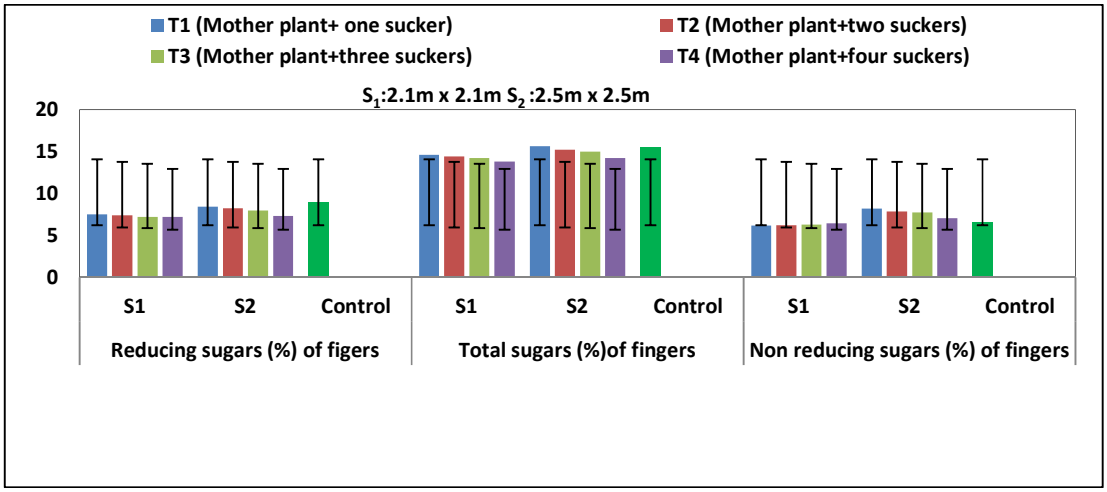

Fig. 7. Sugar contents of banana fruits of first ratoon crop

4. CONCLUSION AND RECOMMENDATION

The findings of the present investigation revealed that retention of suckers with mother plant influenced yield as well as quality of fruits. With the increased in number of suckers per mother plant yield characters like number of hand, fingers number, fingers girth, length and weight, bunch weight, yield gradually decreased from T_1 (mother plant + one sucker) to T_4 (mother plant + four suckers). Plants under wider spacing (S_2) recorded higher total sugars, reducing sugars, non-reducing sugars, TSS than recommended spacing (S_1-2.1 m x 2.1 m). In first ratoon crop, bunch weight (10.08 kg/bunch) and yield (22.84 t/ha) were significantly higher in control (Recommended desuckering practice) over all other treatments. Among the treatments, higher yield (19.73 t/ha) were recorded in S_1T_1 (mother plant + one sucker/plant with spacing of 2.1 m x 2.1 m). It is learnt that small and marginal farmers are always interested to harvest ratoon crops within shorter gap between two crops and therefore, the farmers do not follow the recommended desuckering practice particularly in Assam. In the present investigation, the duration from harvesting of first crop to harvesting of first ratoon crop was longest (159.95 days) in control which was more than 3 months longer than that of other treatments. Considering higher yield and short duration between harvesting of first crop to first ratoon crop, the treatment (S_1T_1: mother plant + one sucker/plant with spacing of 2.1 m x 2.1 m) might be suggested for the farmers who grow banana organically.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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