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Effect of planting densities on fruiting characteristics of Pineapple [*Ananas comosus* (L.) Merr.] cv. Mauritius

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Abstract
Pineapple [*Ananas comosus* (L.) Merr.] is one of the most important commercial fruit crops of the family Bromeliaceae in the world. In West Bengal, Kew is being grown as commercial cultivar mainly for Processing purpose. Monoculture with one cultivar since a long time invites different problems of cultivation. So, a cultivar Mauritius exclusively grown for table purpose has been introduced to West Bengal. The density of the planting stands to be the one of the most important factors in India. Though much work has been carried out on optimum spacing of pineapple cv Kew, in West Bengal mainly in Terai zone, no reference has been reported for the spacing of Pineapple cv. Mauritius. To standardise spacing for pineapple cv. Mauritius in Terai zone of West Bengal, the present experiment was conducted in instructional farm of Pomology and Post-harvest Technology, UBKV, Pundibari during 2016-2018. Results revealed that when different spacing's ranging from 64000 plants/ha to 29,630 plants/ha were used, there was significant difference among 7 treatments for yield and quality. Highest fruit yield with crown (52.59t/ha) was observed in the treatment with higher spacing of 64,000 plants/ha (T_1) and highest fruit weight with crown (1290g) was observed in the treatment with lower spacing of 29,630 plants/ha (T_7).

Keywords: Pineapple, *Ananas comosus*, density, Terai region

Introduction
Pineapple [*Ananas comosus* (L.) Merr.] is one of the most important commercial fruit crops of the family Bromeliaceae in the world. Ananas is typically diploid with a chromosome number of 2n= 50. It is a xerophytic, succulent, herbaceous, perennial, monocotyledonous plant. Due to presence of crown at top pineapple is also called as 'King of Fruits'. In some areas, it is known as the queen of fruits due to its excellent flavour and taste (Baruwa, 2013) [1]. Pineapple is a good source of carotene(vitamin A) and ascorbic acid (vitamin C) and fairly rich in vitamins B and B_2 (Lal and Pruthi, 1995) [6]. Besides, it is also a source of digestive enzyme, bromelein (Lodh *et al*., 1973) [5]. In India major pineapple producing state is West Bengal with an area of 10.70 thousand hectares and 316 thousand tonnes of production. It shares 18.26% in total production of Pineapple in India (NHB Data base 2013-14). Pineapple is mainly grown in Darjeeling, Uttar Dinajpur, Jalpaiguri, and Coochbehar Districts of West Bengal. In West Bengal mainly Kew is being grown as commercial cultivar. Kew is under Smooth Cayenne group mainly for processing purpose. Recently a table purpose variety, Mauritius has been introduced in to West Bengal. Therefore present investigation was undertaken to standardise spacing for pineapple cv. Mauritius in Terai zone of West Bengal.

Materials and Methods
The present investigation was carried out in Instructional Farm of Pomology and Post-harvest Technology and in the laboratory of the Department of Pomology and Post-harvest Technology, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal during the year 2016 to 2018. The area lies under the Terai agro-climatic zone of West Bengal at 26°19'86" N latitude and 89°23'53" E longitude (measured with GPS Garmin-72). The statistical design used in the experiment was Randomised Block Design (RBD) having 3 replications and 7 treatments. Pineapple variety Mauritius was planted in different. The experimental site was ploughed and levelled. Trenches were made at the specified spacing. Suckers of uniform size in terms of weight, length and number of leaves of

Mauritius pineapple were planted in the trenches at the given spacing as per the treatments in double row planting systems during last week of November 2016.

Table. Treatment details are given below:

	Treatment Details	
	Spacing	**Plant population (per ha)**
T_1	25 cm×35cm×90cm	64,000
T_2	30 cm×45cm ×75cm	55,555
T_3	30 cm ×45cm ×90cm	49,382
T_4	35cm×35cm×90cm	45,714
T_5	30 cm× 60cm× 90cm	44,444
T_6	45cm× 45cm× 75cm	37,037
T_7	45cm× 60cm ×60cm	29, 630

Fruit physical characteristics like fruit weight with crown (g) and fruit weight without crown (g) was recorded by weighing individual fruit by a digital balance and the weight (g) was recorded. Fruit length (cm), crown length (cm) and fruit circumference (cm) were measured with measuring tape and expressed in cm. Pulp weight, peel weight, core weight and crown weight of individual fruit were recorded with digital balance and expressed in (g). Pulp percentage (%), peel percentage (%), core percentage (%) and crown percentage (%) were calculated by dividing the pulp weight (g), peel weight (g), core weight (g) and crown weight (g) with the fruit weight with crown respectively. Yield (t/ha) was calculated by multiplying the individual fruit weight with flowering percentage.

Biochemical parameters like TSS content of fruit Juice was estimated using digital refractometer and expressed in (°Brix). The procedure followed for measuring TSS of the fruit was as described by (Ranganna, 2010) [8]. Total sugar and reducing sugar of the fruit juice was measured by following the procedure described by (Ranganna, 2010) [8]. and expressed in (%). Titrable acidity of the fruit was measured by following procedure described by (Ruck, 1969) [10] and expressed in (%). Ascorbic acid content of the fruit was measured by following the procedure described by (Ranganna, 2010) [8]. TSS/acid ratio was calculated by dividing TSS with the Titrable acidity. Statistical analysis was performed by using RBD at 5 and CD at 5% level of significance

Results and Discussion

The data was presented in Table 1. The highest fruit weight with crown was recorded in the treatment T_7 (1290.33g), followed by T_6 (1084.46g) and the lowest was recorded in the treatment T_1 (821.9g) followed by T_2 (865.46)

The data shows that the highest fruit weight without crown was recorded in the treatment T_7 (1087.26 g), followed by T_6 (907.66 g) and the lowest was recorded in the treatment T_1 (694.93 g) followed by T_2 (729.03).

The reason behind increase in fruit weight with decrease in plant density might be due to the fact that at lower number of plants per unit area, growth of plants will be higher due to better accessibility to light, fertilizer, nutrients and water, thereby increasing the accumulation of nutritive ingredients in the fruits and the results were in conformity with the findings of (Su, 1969) [12] and (Das *et al*. 1978) [2].

The data regarding the effect of plant densities on fruit length was shown in the Table1. The highest Fruit length was recorded in the treatment T_7 (16.06 cm), followed by T_6 (14.01) and the lowest was recorded in the treatment T_5 (13.02 cm) followed by T_3 (13.46 cm).

Highest fruit length was observed in the fruits harvested from lower plant density, this may be due to increase in length of the fruits due to increase in fruit size.

Results for effect of density on crown length were showed in Table 1. Indicated that highest length of the crown was recorded in the treatment T_6 (14.01 cm), followed by T_7 (13.10 cm) and the lowest was recorded in the treatment T_1 (12.52 cm) followed by T_4 (12.92cm)

Results shows that highest fruit circumference was recorded in the treatment T_6 and T_7 (28.75 cm) and the lowest was recorded in the treatment T_1 (25.35 cm) followed by T_4 (25.69 cm).

Fruit circumference also plays in important role in the appearance of the fruit and for market value. Fruits obtained from lower densities have more fruit circumference compared with the high density fruits. This might be due to the reason that at lower densities more accumulation of fresh matter in fruits may occur due to accumulation of more photosynthetic assimilates production in plant at lower densities due to less competition. Highest number of eyes were recorded in T_7 (121.63) and lowest (107) were recorded in T_1. Number of eyes is an important quality parameter of pineapple. Lower number of eyes leads to boldness of eyes which was described as desirable quality of the fruit (Ray, 1999) [9]. The maximum number of eyes recorded in T_7 probably associated with the size of fruits.

Table 1: Effect of planting density on fruit physical parameters

Treatment	Fruit weight with crown (g)	Fruit weight without crown (g)	Fruit length (cm)	Length of the crown (cm)	Fruit circumference (cm)	No of eyes (No)	Fruit yield with crown t/ha	Fruit yield without crown t/ha
$T_{1(64,000plants/ha)}$	821.9	694.93	13.62	12.52	25.35	107.23	52.59	44.76
$T_{2(55,555plants/ha)}$	865.46	729.03	13.64	13.01	25.69	109.13	48.04	40.49
$T_{3(49,382plants/ha)}$	911.76	760.73	13.46	13.06	27.32	112.13	45.02	37.56
$T_{4(45,714plants/ha)}$	936.63	778.03	13.45	12.92	26.86	110.6	42.82	35.56
$T_{5(44,444plants/ha)}$	977.2	813.43	13.02	12.96	27.62	111.2	43.42	36.26
$T_{6(37,037plants/ha)}$	1084.46	907.66	14.01	14.01	28.75	113.73	40.16	33.61
$T_{7(29,630plants/ha)}$	1290.33	1087.26	16.06	13.10	28.75	121.63	38.24	32.21
S.Em(±)	8.81	7.79	0.19	0.20	0.17	0.50	0.37	0.40
C.D, at 5%	27.14	23.99	0.57	0.61	0.53	1.53	1.14	1.24

Table 2: Effect of planting density on fruit physical parameters

Treatment	Pulp weight (g)	Peel weight(g)	core weight (g)	crown weight(g)	Pulp%	Peel%	Core%	Crown%
$T_{1(64,000plants/ha)}$	481.05	150.86	65.26	133.33	57.75	18.27	7.91	16.23
$T_{2(55,555plants/ha)}$	509.5	153.43	67.36	143.23	58.15	17.61	7.72	16.46
$T_{3(49,382plants/ha)}$	521.16	160.8	72.76	151.03	57.18	18.27	7.98	16.72
$T_{4(45,714plants/ha)}$	530.36	172.4	74.93	158.93	56.63	18.40	7.97	16.97
$T_{5(44,444plants/ha)}$	553.66	179.6	82.06	163.76	56.65	18.35	8.38	16.75
$T_{6(37,037plants/ha)}$	619.76	203.8	88.83	176.8	56.68	18.79	13.23	16.31
$T_{7(29,630plants/ha)}$	745.3	238	104.03	202.93	57.72	18.41	10.52	15.70
S. Em(±)	9.33	3.19	0.94	4.23	0.49	0.30	1.99	0.34
C.D, at 5%	N.S	N.S	N.S	N.S	1.52	0.91	6.13	1.04

Table 3: Effect of planting density on fruit biochemical parameters

Treatment	Total Soluble Solids (%Brix)	Ascorbic acid content (mg/100g of fruit pulp).	Total sugars%	Reducing sugars%	Titratable acidity (%)	TSS /Acid ratio
$T_{1(64,000plants/ha)}$	15.97	35.53	11.16	2.34	0.65	24.89
$T_{2(55,555plants/ha)}$	15.92	35.73	11.04	2.03	0.61	26.62
$T_{3(49,382plants/ha)}$	15.88	36.13	10.87	2.04	0.59	27.49
$T_{4(45,714plants/ha)}$	16.02	35.82	11.16	2.21	0.61	27.13
$T_{5(44,444plants/ha)}$	15.99	35.84	11.03	2.05	0.65	26.9
$T_{6(37,037plants/ha)}$	16.44	35.35	11.93	2.37	0.61	26.85
$T_{7(29,630plants/ha)}$	16.32	35.75	12.56	2.82	0.61	26.86
S. Em(±)	0.12	0.26	0.14	0.13	0.02	0.42
C.D, at 5%	0.36	N.S	0.44	0.41	N.S	1.30

Results for effect of densities on fruit yield in Table 1. Shows that highest fruit yield without crown is observed in T_1 (44.76/ha) and lowest fruit yield is observed in T_7 (32.21t/ha). Highest fruit yield with crown is observed in T_1 (52.59t/ha) and lowest fruit yield is observed in T_7 (38.24t/ha)

Results obtained clearly indicate that with the increase in density, total yield with and without crown increased and at low densities even though fruit size is more, total yield obtained was less. In general, increasing a plant population produces a greater yield per unit land area for most crops up to some upper limit or threshold density for the species, after which further increases in plant density either maintain the same yield or cause yield decline (Sanders *et al*. 1999) [11].

Data obtained from Table 2. clearly indicate that density did not manifest any significance in pulp weight. However highest pulp weight (745.3g) is seen in T_7 and lowest pulp weight is obtained in T_1 (481.05g)

From the results obtained, it is known that planting density does not have any significant role in peel weight of the fruit. However lowest peel weight (150.86g) is obtained in T_1 and higher peel weight (230g) is obtained in T_7

Lowest peel weight along with high yield is a desirable character which was observed in treatment with more density (T_1)

Results pertaining to core weight in Table 2. indicate that plant density did not manifest significant results on the core weight. Generally less core weight in pineapple is a desirable feature and less core weight (65.26g) was obtained in T_1 and highest core weight (104.09g) was observed in T_7

Effect of density on crown weight of the fruit was not significant. Highest crown weight was recorded in T_7 (202g) and lowest crown weight was recorded in T_1 (133g)

The highest pulp percentage was recorded in the treatment T_2 (58.15%) followed by T_1 (57.755) and lowest was recorded in T_5 (56.65%) followed by T_6 (56.68%).

Highest pulp percentage in T_2 (58.15%) may be due to less peel percentage due to lower size of the fruits due to less accumulation of nutritive ingredients under high densities.

The highest peel percentage was recorded in the treatment T_6 (18.75%) followed by T_7 (18.41%) and lowest was recorded in T_2 (17.61%) followed by T_1 (18.27%).

The highest core percentage was recorded in the treatment T_6 (13.23%) followed by T_7 (10.52%) and lowest was recorded in T_2 (7.72%) followed by T_1 (7.91%). Less core percentage is more desirable character and it was seen in fruits from higher densities. This may be due to less size of the fruits.

The highest crown percentage was recorded in the treatment T_4 (16.97%) followed by T_5 (16.75%) and lowest was recorded in T_7 (15.70%) followed by T_1 (16.23%).

Results from Table 3. revealed that there is a significant impact of density on TSS of the fruit. The highest total soluble solids (°brix) was recorded in treatment T_6 (16.44%) followed by T_7 (16.32° brix) and the lowest was in T_3 (15.88° brix) followed by T_2 (15.92° brix). High TSS content is a desirable fruit characteristic for fruits for processing (Ercisli, 2007)[3]. as well as for table purpose. Low TSS in the fruits obtained from higher densities probably due to the less accumulation of sugars in fruits due to high competition among plants. These results were also conformed to the similar findings of Su (14). Results pertaining to the total sugars percentage (%) was shown in Table 3 and highest percent was observed in treatment T_7 (12.56%) followed by T_6 (11.93%) and the lowest was in T_3 (10.87%) followed by T_5. This may be due to more conversion of photosynthetic assimilates such as starch in to sugars in fruits obtained from less density due to more availability of sunlight and nutrients. The results were also conformed to the findings of Su (14).

From the Table 3. highest reducing sugar (%) was recorded in treatment T_7 (2.82%) followed by T_6 (2.37%) and the lowest was in T_3 (2%) followed by T_2 (2.03%).Highest ascorbic acid content was recorded in T_3 (36.13mg/100g pulp) and lowest ascorbic acid (35.53mg/100g) content was recorded in T_1. The effect of plant densities did not manifest significant differences in the titrable acidity of the fruits and findings were in line with the findings of (Mwaule, 1885) [7] High titrable acidity in pineapple contributes to its distinct sour taste and flavour (Yamaki, 1989)[13]. (George *et al.*2016)[4]. The highest TSS/Acid ratio was recorded in treatment T_3 (27.49%) followed by T_4 (27.13%) and the lowest was in T_1 (24.89%) followed by T_2 (26.62%).

Conclusion

It is concluded that for pineapple cv Mauritius, density of

64,000 plants/ha is suitable for highest yield and density of 29,630 plants/ha is suitable for highest fruit size. But to compromise with the spacing and fruit size with aim for better intercultural operations recommended spacing for pineapple cv Mauritius for Terai region of West Bengal may be in between the highest and lowest density i.e., 45714 plants/ha where both the fruit yield and fruit size were satisfactory.

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