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Studies on effect of planting geometry on growth and yield of *Musa paradisiaca* L.

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Abstract

The experiment on “Effect of planting geometry on growth and yield of banana (*Musa paradisiaca* L.) Cv. Grand Naine” was carried out at the Banana Research Station in Nanded (MH) during the 2023-2024. The experiment was laid out in Randomized Block Design with five spacings and four replications viz S₁-1.2×1.2×2.0 m, S₂-1.5×1.5×2.0m, S₃-1.8×1.8×2.0 m, S₄-2.0×2.0×2.0 m, S₅-1.5×1.5 m (control). The growth attributes viz. maximum girth of stem (66.33 cm), number of leaves per plant (13.03) and number of suckers per plant (6.55) was recorded in wider spacing i.e., S₄-2.0×2.0×2.0 m. while maximum height of the plant (209.92 cm) was recorded by spacing S₁ i.e., 1.2×1.2×2.0 m. The yield attributes viz. maximum numbers of hand per bunch (12.01), number of fingers per bunch (140.14), weight of bunch (24.40 kg) was recorded in spacing S₄ i.e., 2.0×2.0×2.0 m. Maximum yield per hectare (100.65 Mt per ha) was recorded by spacing S₅ i.e., 1.5×1.5 m. The highest benefit: cost (3.15) ratio was recorded by spacing S₂ i.e., 1.5×1.5×2.0 m.

Keywords: Banana, planting geometry, grand naine, spacing

Introduction

Banana (*Musa paradisiaca* L.) popularly known as apple of paradise, ranks as India's second most significant fruit crop, following mango. Its consistent availability throughout the year, affordability, diverse varieties, delightful taste, and nutritional and medicinal benefits renders it a beloved fruit across all classes of people. Banana is a healthy and salt-free fruit as compare to other fruit, hence known as wholesome fruit. It belongs to Musaceae family and Musa genus to the order Zingiberales.

Bananas have been interlinked with the history and cultures of several civilizations and societies of southeast Asia from prehistoric times. This has been particularly so in countries that had been influenced in the past by Hindu and Buddhist cultures. The generic name Musa is originated from the Sanskrit word Moca and possibly derive directly from the Arabic mouz or mauwz. The earliest reference of bananas in India are in the two epics, Mahabharata and Ramayana, and the Pali Buddhist canon, both of the fifth and sixth century BCE. ((Nayar, 2010) ^[8]).

Bananas evolved in the humid tropical regions of south east Asia with India as one of its centres of origin. Current famous edible varieties have evolved from the two species – *Musa acuminata* and *Musa balbisiana* and their natural hybrids, primarily found in the rain forests of South east Asia. During the seventh century AD, Banana spread to Egypt and Africa. Now banana is being cultivated in the warm tropical regions between 300 N and 300 S of the equator.

A double row planting system is a form of technological engineering to optimize crop productivity through the spacing between rows. when distance between rows is more than distance within row of plants then this is pair row planting system in this system two rows of plants planted closely than single row planting system and there is much gap between the two rows than single row planting system The distance between the two double rows is narrower (compared to the distance between the two rows in the single row system), while the empty row gives an open space of 25-50%, so that each plant in the row is considered a border plant that receives relatively more light than a single row planting (conventional). Any method of layout should aim at providing maximum economic benefits per hectare, adequate space for proper development of the trees and ensuring convenience in orchard cultural practices.

The main goal of commercial fruit farming is to achieve a sustainable rise in productivity in order to meet the demand for fruits per head for human nutrition. It was discovered that the altering planting geometry in bananas directly affected the metrics of growth and yield, such as bunch weight, productivity, absorption of solar light, leaf number, girth, and pseudostem height. So, keeping all the above points in view, we conducted experimental work on Effect of planting geometry on growth and yield of banana (*Musa paradisaica* L.) Cv. Grand Naine.

Materials and Methods

The experiment on “Effect of planting geometry on growth and yield of banana (*Musa paradisiaca* L.) Cv. Grand Naine” was carried out at the Banana Research Station in Nanded (MH) during the 2023-2024. The experiment was laid out in Randomized Block Design with five spacings and four replications viz S₁-1.2×1.2×2.0 m, S₂-1.5×1.5×2.0m, S₃-1.8×1.8×2.0 m, S₄-2.0×2.0×2.0 m, S₅-1.5×1.5 m (control). Five plants from each plot were randomly selected and labelled. These plants were used for recording all morphological observations in respect of growth and yield of crop.

Results and Discussion

Result presented in table number 1 and 2 revealed that the “Effect of planting geometry on growth and yield of banana (*Musa paradisiaca* L.) Cv. Grand Naine”.

Growth attributes

The data regarding height of the plant (cm), girth of stem (cm), number of leaves per plant, number of suckers per plant was recorded in present study. It was observed that different planting geometry had significant influence on growth attributes of banana.

Height of plant (cm)

The maximum height of plant (209.92 cm) was recorded in spacing S₁ (1.2×1.2×2.0 m) over rest of the treatment. However, it was at par with spacing S₂ (1.5×1.5×2.0 m) and S₅ (1.5×1.5 m) with height (206.35 cm) and (203.48 cm) respectively. The spacing S₄ (2.0×2.0×2.0 m) recorded minimum plant height (194.46 cm) of banana. Result indicated that the height of pseudostem increased with decrease in spacing between plant and decrease with increasing spacing. The pair-row planting strategy has a considerable impact on plant growth, as seen by the effect it has on the height of banana plants. Because bananas are planted in closely spaced clusters under the pair-row technique, there may be more competition for water, light, and nutrients. Similar results were recorded by, Pujari, *et al.*, (2011) [9].

Girth of the stem (cm)

The data revealed that the different planting geometry used significantly influenced the girth of the banana stem. The maximum girth of the stem (66.33 cm) was recorded in spacing S₄ (2.0×2.0×2.0 m) over the rest of the spacings in the present study. However, it was followed by spacing S₃ (1.8×1.8×2.0 m) with girth (63.31 cm). The spacing S₁ (1.2×1.2×2.0 m) recorded the minimum girth of the stem (56.15 cm). The result indicated that the girth of the stem increased with an increase in spacing between plants and decreased with a decrease in spacing. In comparison to other spacings, the wider spacing S₄ (2.0×2.0×2.0 m) have the maximum pseudostem girth because of the reduced plant height, which increased stem girth due to greater availability of space and nutrients. The diversion of assimilates

to raise heights at the expense of girth caused the plant's height to increase, which in turn caused the decrease in girth in S₁ (1.2×1.2×2.0 m). The current findings are consistent with those of Sarrwy *et al.* (2012) [11].

Number of leaves per plant

The data revealed that the different planting geometry used significantly influenced the number of leaves per plant of the banana. The maximum number of leaves per plant (13.03) was recorded in spacing S₄ (2.0×2.0×2.0 m) over the rest of the spacings in the present study. However, it was at par with spacing S₃ (1.8×1.8×2.0 m) with number of leaves (12.70). The spacing S₁ (1.2×1.2×2.0 m) recorded the minimum number of leaves (11.41). The result indicated that the number of leaves per plant increased with an increase in spacing and decreased with a decrease in spacing. The increased number of leaves per plant at wider spacings could be the result of sufficient nutrients being available to encourage more leaves, as well as sufficient space for better air movement and light interception in tropical climates. In contrast, fewer leaves were observed in high density planting. Similar results were recorded by Athani *et al.* (2000) [2], and Sarrwy *et al.* (2012) [11].

Number of suckers per plant

The data revealed that the different planting geometry used significantly influenced the number of suckers per plant of the banana. The maximum number of suckers per plant (6.55) was recorded in spacing S₄ (2.0×2.0×2.0 m) over the rest of the spacings in the present study. However, it was at par with spacing S₃ (1.8×1.8×2.0 m) with suckers (6.32). The spacing S₁ (1.2×1.2×2.0 m) recorded the minimum number of suckers (5.00).

The result indicated that the number of suckers per plant increased with an increase in spacing and decreased with a decrease in spacing.

In comparison to other spacings, a wider spacing S₄ (2.0×2.0×2.0 m) recorded a higher number of suckers per plant. It's possible that more space encouraged the growth of more suckers in these spacings. The lowest number of suckers was observed in spacing S₁ (1.2×1.2×2.0 m), which could be due to reduced growing space, increased competition for resources, and less sunshine. Chattopadhyay *et al.*, (1980) [4] have observed similar results in cv. Grand Naine.

Yield attributes

The data regarding yield (Mt/ha) attributes was recorded in the present study. It was observed that different planting geometry had significant influence on yield attributes of bananas, such as Number of hands per bunch, Numbers of finger per bunch, Bunch weight (kg) and Yield (Mt/ha).

Numbers of hands per bunch

The maximum numbers of hands (12.01) were recorded by the spacing S₄ (2.0×2.0×2.0 m) However it was found statistically at par with spacing S₃ (1.8×1.8×2.0 m) with (11.24) hands per bunch. The minimum numbers of hands per bunch (8.89) was recorded by the spacing S₁ (1.2×1.2×2.0 m).

The result indicated that the numbers of hands per bunch increased with an increase in spacing and decreased with a decrease in spacing.

The maximum number of hands per bunch in the current study was found in wider spacing and minimum plant density. This may due to low plant density maximizes the exposure of the plant and its organ to different resources, such as nutrients,

space, air, and sunlight, which in turn increases the number of hands per bunch. Mandal and Sharma (1999)^[7].

Numbers of finger per bunch

The maximum numbers of fingers (140.14) were recorded by the spacing S₄ (2.0×2.0×2.0 m). However it was found statistically at par with Spacing S₃ (1.8×1.8×2.0 m) with 137.02 fingers per bunch. The minimum Numbers of fingers per bunch (120.09) was recorded by the spacing S₁ (1.2×1.2×2.0 m). The result indicated that the number of fingers per bunch increased with an increase in spacing and decreased with a decrease in spacing. The findings indicated that the highest number of fingers per bunch was recorded with the wider spacing. It might be the result of early on, more vigorous vegetative growth, as seen by larger leaf counts and total leaf area. This led to increased food material synthesis, which was generated into more fingers per bunch. Similar results were recorded by Chundawat *et al.*, (1983)^[5].

Bunch weight (kg)

The highest bunch weight (24.40 kg) was recorded in the spacing S₄ (2.0×2.0×2.0 m). However, it was found statistically at par with spacing S₃ (1.8×1.8×2.0 m) with weight (23.90 kg), S₂ (1.5×1.5×2.0 m) with weight (22.03 kg), and S₅ (1.5×1.5 m) with weight (22.65 kg). The lowest bunch weight (17.53 kg) was recorded by the spacing S₁ (1.2×1.2×2.0 m).

Closer spacing was associated with a lower bunch weight per plant. The lower levels could be a result of a larger plant population that partially blocked sunlight availability due to an expanded canopy. Similar results were observed by Mahmoud, H. (2013)^[6].

Yield (Mt/ha)

The data regarding bunch yield (Mt/ha) showed significant difference between all planting geometry.

The highest yield (100.65 Mt/ha) was recorded in the spacing S₅

(1.5×1.5 m). However, it was followed by spacing S₁ (1.2×1.2×2.0 m) with yield (91.29 Mt/ha). The lowest yield (61.00 Mt/ha) was recorded by the spacing S₄ (2.0×2.0×2.0 m). In present experimental study there were five types of spacing viz., S₁, S₂, S₃, S₄, and S₅ and in that spacing first two spacings S₁ and S₂ have the highest plant density per hectare in comparison to S₃ and S₄. However, they also show less physiological and morphological growth, which has an impact on yield. Contributing to the spacing's characteristics and ultimately resulted in lower yields than S₅. However, in this experimental trial, a wider spacing, or S₄, recorded the greatest morphological and physiological features. As a result, it gives maximum yield attributing characters in individual levels of plants. However, the number of plants occupied in each hectare area is low. Because of that total yield per hectare is low as compared to all spacing in this experimental trial. The combination of both *i.e.*, adequate plant population and good physiological and morphological characters was found in S₅, due to this combination S₅ gives highest yield among the all spacings. Similar results were observed by Raskar (2003)^[10], and Badgujar (2004)^[3].

B:C ratio

The data regarding benefit: cost ratio revealed that the highest benefit: cost ratio (3.15) was recorded by the spacing S₂ *i.e.*, (1.5×1.5×2.0 m) and it was close with (2.94) S₅ *i.e.*, (1.5×1.5 m). While the lowest benefit: cost ratio (2.14) was recorded by the spacing S₁ *i.e.*, (1.2×1.2×2.0 m).

Due to the highest number of plants, spacings S₁ and S₅ require more cost for cultivation compared to S₂ (1.5×1.5×2.0 m). Conversely, spacings S₃ (1.8×1.8×2.0 m) and S₄ (2.0×2.0×2.0 m), which accommodate fewer plants, result in lower yield and income. Therefore, S₂ (1.5×1.5×2.0 m), with its combination of adequate plant population and good physiological and morphological characteristics, was found to have the best B:C ratio of (3.15).

Table 1: Effect of different planting geometry on growth attributes of Banana.

Treatment number	Treatment Details	Height of the plant (cm)	Girth of stem (cm)	Number of leaves/plants	Number of suckers/plants
S ₁	1.2×1.2×2.0 m	209.92	56.15	11.41	5.00
S ₂	1.5×1.5×2.0 m	206.35	61.92	12.03	6.05
S ₃	1.8×1.8×2.0 m	201.92	63.31	12.70	6.32
S ₄	2.0×2.0×2.0 m	194.46	66.33	13.03	6.55
S ₅	1.5×1.5 m	203.48	60.64	11.90	5.95
	S.E. m±	2.29	0.67	0.27	0.15
	C.D. at 5%	7.07	2.06	0.85	0.47

Table 2: Effect of different planting geometry on yield attributes of Banana.

Treatment number	Treatment Details	Number of hands per bunch	Number of fingers per bunch	Bunch weight (kg)	Yield (Mt/ha)	B:C Ratio
S ₁	1.2×1.2×2.0 m	8.89	120.09	17.53	91.29	2.14
S ₂	1.5×1.5×2.0 m	10.67	132.71	22.03	89.92	3.15
S ₃	1.8×1.8×2.0 m	11.24	137.02	23.90	69.88	2.85
S ₄	2.0×2.0×2.0 m	12.01	140.14	24.40	61.00	2.82
S ₅	1.5×1.5 m	10.06	134.51	22.65	100.65	2.94
	S.E. m±	0.33	1.25	1.00	1.10	
	C.D. at 5%	1.04	3.86	3.10	3.39	

Conclusion

Based on the summarized findings, it can be concluded that among all the spacings tested, spacing S₄ (2.0 × 2.0 × 2.0 m) recorded the maximum growth attributes, including stem girth, number of leaves per plant, and number of suckers per plant, as well as highest bunch and finger attributes. This spacing also

resulted in the minimum days to flowering, shortest total crop duration, and lowest intensity of Sigatoka.

In contrast, spacing S₅ (1.5 × 1.5 m, the control) recorded the highest yield at (100.65 MT/ha) among all the spacings tested. But, the maximum benefit-cost (B:C) ratio of (3.15) was observed in spacing S₂ (1.5 × 1.5 × 2.0 m). From an economic

perspective, spacing S₂, with a B:C ratio of (3.15), is superior over the other tested spacings.

Since the present experiment was conducted over a single year, further studies are needed to confirm these findings.

Conflict and Interest

The authors declare no conflict of interest. They bear sole responsibility for the content and composition of the paper.

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