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EFFECT OF DIFFERENT PLANTING METHODS AND HIGH-DENSITY PLANTING ON VEGETATIVE CHARACTERISTICS IN BANANA CV. WILLIAMS

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ABSTRACT

Banana is fourth important food crop in terms of gross value after paddy, wheat and milk products. In India, banana is the second most important commercial fruit crop next to mango. It is known as wholesome fruit, as it provides a more balanced diet than any other fruits. The experiment was conducted at ICAR- All India Coordinated Research Project on Fruits, Kittur Rani Channamma College of Horticulture, Arabhavi to study effect of different planting methods on vegetative characteristic of banana cv. Williams during 2021-22. It was laid out in Randomized Complete Block Design with three replications and eight treatments. The results revealed that the effect of different planting methods shows statistically significant different among treatments. The maximum pseudostem girth (71.83 cm), the number of functional leaves (16.27), leaf area (18.71 m^2) and the number of suckers (7.97) was recorded in wider spacing T_4 (Single row - 2.4×1.8 m) at shooting stage. With respect to highest pseudostem height (1.93 m) was achieved in the treatment closer spacing T_1(Single row – 1.5×1.5 m).

Keyword: Banana, Williams, Planting methods, Vegetative characteristic

Introduction

Banana is a monocotyledonous and monocarpic plant in the genus *Musa* belongs to family Musaceae having a chromosome number X=11. Originated in the tropical regions of South East Asia. It is an antique fruit crop of the world. Other synonyms are Apple of paradise, Adam's fig, Kalpataru, Queen of the tropical fruits, Tree of wisdom and most commonly referred as the "Kalpataru" or the "Plant of all virtues". Banana is known as wholesome fruit, as it provides a more balanced diet than any other fruits. In India, banana is the second most important commercial fruit crop next to mango. The global production of banana is around 125 million tonnes, of which India contributes 26.40 per cent. In India, banana is cultivated in an area of 9.59 lakh ha with production of 35.13 million tonnes and productivity of 36.67 tonnes per hectare. In Karnataka, it is cultivated in an area of about 1.02 lakh hectares and total production of 3.71 million tonnes with an average productivity of 28.64 tonnes per hectare (Anon, 2021). The cultivar Williams (AAA) is one of the Giant Cavendish types in the Cavendish subgroup. The plants grow up to height of 2.4-3.7 m. The pseudostem of Williams has dark brown, black or red streaks. It has a very lager, cylindrical bunch, with 300 evenly sized fruits. Bunch weight of fruit is 25-28 kg and fruits are 15-23 centimeters in length and 12-13 centimeters in circumference which are slightly curved. Duration of Williams's cultivar is twelve months (Sarrwy *et al.*, 2012).

There is a need to focus on standardization of improved production technologies suitable for different systems of cultivation to realize potential yields in banana

production. Selection of high yielding varieties, healthy and disease-free planting material, choosing the right planting density, need-based and timely application of irrigation water, nutrients, maintenance of weed-free conditions etc. are significant factors to bridge the gap between actual yield and potential yield per unit area (Panjavarnam *et al*., 2018). In that spacing of banana is a topic of extreme complexity and with no general recommendations that can be adapted to all situations. It plays vital role in determinants of annual yield per hectare. For the highest possible yields of good quality fruit, there is an optimum plant density, which should be maintained for sustaining the economic life of the plantation. The optimum planting density also determines the gross margin per hectare per annum (Behera *et al*., 2016). There is a need to undertake the research programme on effect of various planting densities with different spacing and number of plants per hill to observe the response of growth characteristics such as pseudostem height, girth, number of leaves, leaf area and number of suckers.

Material and Methods

The experiment was conducted at ICAR- All India Coordinated Research Project on Fruits, Kittur Rani Channamma College of Horticulture, Arabhavi, Belagavi district, Karnataka during 2021-22. The experiment was laid out in Randomized Complete Block Design with three replications and eight treatments *viz.*, T_1 (Single row – 1.5×1.5 m), T_2 (Single row -1.8×1.8 m), T_3 (Single row - 2.1×1.8 m) T_4 (Single row - 2.4×1.8 m), T_5 (2 plants per hill - 2.7×1.8×0.3 m), T_6 (3 plants per hill - 2.7×1.8×0.3 m) T_7 (Paired row system- 2.4x1.2x1.0 m) and T_8 (Paired row with zig zag system- 2.1x1.2x1.2 m).

Measurements were taken for various growth aspects such as the width and height of the plants, the count of leaves on each plant, number of suckers, as well as the length, breadth and overall area of the leaves. Leaf area was determined by multiplying the measured leaf length, breadth and number of leaves at recording stage with a constant factor of 0.80, in accordance with Murray's method (1960). The number of suckers per plant that had sprouted around the pseudostem was manually counted and documented. These observations were taken at specific time intervals like 30, 60, 90, 120, 150, 180, 210 days after planting and during the shooting stage. The obtained data which are related to growth parameters were organized into tables and statistically analyzed in a randomized complete block design (RCBD) by using analysis of variance by Fisher and Yates (1963). When the F-test showed significance in comparing treatment means, critical differences (C.D. at 5%) were calculated.

Results and Discussion

The data on pseudostem height and girth of banana cv. Williams was influenced by different planting density which shows a statistically significant difference among the various treatments. Among the different treatments, the maximum pseudostem height of 0.29, 0.46, 0.71, 0.92, 1.25, 1.41, 1.67 and 1.93 m was recorded in T_1 (Single row – 1.5×1.5 m) and greatest pseudostem grith (15.77, 24.40, 32.37, 39.60, 48.20, 59.07, 63.50 and 71.83 cm) respectively found in treatment T_4 (Single row - 2.4×1.8 m). Whereas, the minimum pseudostem height of 0.17, 0.27, 0.47, 0.71, 0.92, 1.14, 1.28 and 1.59 m and pseudostem girth of 11.80, 16.23, 21.83, 29.37, 33.33, 38.07, 42.37 and 47.13 cm respectively was observed in T_6 (3 plants per hill - 2.7×1.8×0.3 m) at 30, 60, 90, 120, 150, 180, 210 days after planting and during shooting stage.

The increased pseudostem height in closer planting may be the result of reduced spacing while low canopy increased interplant competition for light within a plot as growth stages advanced and more nutrients were

Table 1: Effect of different planting methods and high-density planting on pseudostem height (m) in banana cv. Williams.

Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	At shooting
T_1 (1.5×1.5 m)	0.28	0.46	0.71	0.92	1.25	1.41	1.65	1.93
T_2 (1.8×1.8 m)	0.21	0.38	0.61	0.80	1.10	1.27	1.52	1.79
T_3 (2.1×1.8 m)	0.24	0.36	0.53	0.74	0.96	1.19	1.45	1.73
T_4 (2.4×1.8 m)	0.23	0.37	0.59	0.79	1.04	1.26	1.50	1.78
T_5 (2.4×1.8×0.3 m)	0.19	0.30	0.51	0.72	0.95	1.14	1.44	1.68
T_6 (2.7×1.8×0.3 m)	0.17	0.27	0.47	0.71	0.92	1.17	1.42	1.72
T_7 (2.4×1.2×1.0 m)	0.26	0.39	0.60	0.81	1.16	1.29	1.53	1.81
T_8 (2.1×1.2×1.2 m)	0.25	0.32	0.49	0.73	0.94	1.18	1.43	1.75
S. Em. ±	**0.01**	**0.02**	**0.04**	**0.04**	**0.03**	**0.04**	**0.04**	**0.04**
CD @ 5 %	**0.02**	**0.07**	**0.10**	**0.11**	**0.09**	**0.12**	**0.12**	**0.12**
CV %	**4.03**	**11.38**	**11.26**	**8.13**	**5.23**	**5.59**	**4.71**	**3.89**

T_1– High density planting; **T_2** - Single row system; **T_3** - Single row system; **T_4** - Single row system; **T_5** - Two plants per hill; **T_6** - Three plants per hill; **T_7** - Paired row system; **T_8** - Paired row with zig-zag system; **DAP – Days after planting**

Table 2: Effect of different planting methods and high density planting on pseudostem girth (cm) in banana cv. Williams.

Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	At shooting
T_1 (1.5×1.5 m)	13.15	20.60	28.33	31.63	39.20	47.20	51.40	61.63
T_2 (1.8×1.8 m)	13.74	20.57	29.30	33.73	42.23	49.50	53.77	65.83
T_3 (2.1×1.8 m)	13.86	21.67	29.47	36.77	44.03	53.67	57.13	66.13
T_4 (2.4×1.8 m)	15.77	24.40	32.37	39.60	48.20	59.07	63.50	71.83
T_5 (2.4×1.8×0.3 m)	12.67	18.33	26.20	31.30	38.40	48.37	50.43	52.20
T_6 (2.7×1.8×0.3 m)	11.80	16.23	21.83	29.37	33.33	38.07	42.37	47.13
T_7 (2.4×1.2×1.0 m)	13.60	19.93	27.37	31.17	37.67	47.07	49.73	60.20
T_8 (2.1×1.2×1.2 m)	13.20	21.03	27.97	32.27	38.73	46.57	49.80	61.67
S. Em. ±	**0.50**	**0.87**	**0.94**	**0.76**	**1.39**	**1.56**	**1.73**	**1.85**
CD @ 5 %	**1.52**	**2.65**	**2.85**	**2.29**	**4.21**	**4.72**	**5.25**	**5.60**
CV %	**6.44**	**7.44**	**5.85**	**3.96**	**5.98**	**5.52**	**5.73**	**5.26**

T_1– High density planting; T_2 - Single row system; T_3 - Single row system; T_4 - Single row system; T_5 - Two plants per hill; T_6 - Three plants per hill; T_7 - Paired row system; T_8 - Paired row with zig-zag system; **DAP – Days after planting**

available than in other treatments which results in taller and more lanky growth. These results are in agreement with Athani *et al*., (2009) banana cv. Rajapuri, Sarrwy *et al*. (2012) in cv. Williams, Behera *et al.,* (2016) in cv. Bantala, Naik (2016a) in cv. Grand Naine, Sindhupriya *et al.,* (2018) in cv. Nendran and Kumar *et al*., (2020) in cv. Ney Poovan. Under wider spacing, there was highest pseudostem girth was achieved due to good canopy architecture which was benefited for maximum photosynthetic assimilation and improved metabolic activity. The increased plant height in closed spacing causes reduced girth. The stem girth and height are universely proportional to each other. The reduced plant density and increased plant girth may have resulted from plants having less competition for sunshine and moisture when spaced farther apart. These findings are well supported by previous reports of Athani *et al*., (2009) banana cv. Rajapuri, Sarrwy *et al*., (2012) in cv. Williams, Behera *et al.,* (2016) in cv. Bantala, Naik (2016a) in cv. Grand Naine, Sindhupriya *et al.,* (2018) in cv. Nendran, Kumar *et al.,* (2020) in cv. Ney Poovan and Naika *et al.,* (2022) in cv. Williams (1st Ratoon).

Among the different treatments at 30, 60, 90, 120, 150, 180, 210 days after planting and during shooting stage, the highest number of functional leaves (11.07, 12.23, 13.13, 14.17, 14.90, 15.30, 15.87 and 16.27) and the highest leaf area (0.89, 2.25, 4.41, 7.23, 9.90, 12.82, 13.86 and 18.71 m^2) was found in T_4 (Single row -2.4×1.8 m) at all stages of plant growth. Whereas, the least number of functional leaves (7.97, 9.34, 9.30, 9.76, 10.03, 10.57, 10.84 and 11.53) and the lowest leaf area (0.46, 1.09, 1.93, 2.87, 3.42, 4.96, 5.25 and 6.41 m^2) was obtained respectively in T_6 (3 plants per hill - 2.7×1.8×0.3 m)

In this experiment, there was a highest number of functional leaves are recorded in low denstity planting compare to closer spacing. There is higher overcrowding and mutual shading in closer spacing causes slower rate of leaf emergence. This slower rate of leaf emergence might be significantly influenced by lower temperature inside the canopy and due to competition of sunlight. These suggestions are in accordance with Murugan (2003) in

Table 3: Effect of different planting methods and high density planting on number functional leaves per plant in banana cv. Williams.

Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	At shooting
T_1 (1.5×1.5 m)	9.33	10.20	10.57	11.47	12.03	12.80	13.13	14.07
T_2 (1.8×1.8 m)	9.47	10.43	11.03	11.83	12.80	13.40	13.80	14.53
T_3 (2.1×1.8 m)	9.60	10.63	11.37	12.20	13.13	13.53	14.03	14.67
T_4 (2.4×1.8 m)	11.07	12.23	13.13	14.17	14.90	15.30	15.87	16.27
T_5 (2.4×1.8×0.3 m)	8.80	9.87	10.13	10.93	11.60	12.10	12.37	12.87
T_6 (2.7×1.8×0.3 m)	7.97	9.34	9.30	9.76	10.03	10.57	10.84	11.53
T_7 (2.4×1.2×1.0 m)	9.13	9.90	10.40	11.33	11.80	12.33	12.40	13.33
T_8 (2.1×1.2×1.2 m)	9.27	10.03	10.47	11.37	11.93	12.67	12.80	13.60
S. Em. ±	**0.47**	**0.48**	**0.33**	**0.40**	**0.44**	**0.51**	**0.46**	**0.50**
CD @ 5 %	**1.42**	**1.44**	**0.99**	**1.22**	**1.35**	**1.55**	**1.39**	**1.52**
CV %	**8.66**	**7.98**	**5.22**	**5.96**	**6.27**	**6.88**	**6.02**	**6.25**

T_1– High density planting; T_2 - Single row system; T_3 - Single row system; T_4 - Single row system; T_5 - Two plants per hill; T_6 - Three plants per hill; T_7 - Paired row system; T_8 - Paired row with zig-zag system; **DAP – Days after planting**

Table 4: Effect of different planting methods and high density planting on leaf area (m^2) in banana cv. Williams.

Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	At shooting
T_1 (1.5×1.5 m)	0.61	1.58	3.27	4.89	6.87	9.42	10.23	12.51
T_2 (1.8×1.8 m)	0.76	1.85	3.60	5.54	7.68	10.22	11.52	15.60
T_3 (2.1×1.8 m)	0.78	2.04	3.89	6.07	8.71	11.68	12.93	16.01
T_4 (2.4×1.8 m)	0.89	2.25	4.41	7.23	9.90	12.82	13.86	18.71
T_5 (2.4×1.8×0.3 m)	0.58	1.22	2.44	4.04	5.05	7.38	7.79	8.84
T_6 (2.7×1.8×0.3 m)	0.46	1.09	1.93	2.87	3.42	4.96	5.25	6.41
T_7 (2.4×1.2×1.0 m)	0.75	1.51	3.15	4.73	6.61	9.55	9.51	11.59
T_8 (2.1×1.2×1.2 m)	0.62	1.45	3.10	4.25	6.59	8.89	9.55	11.21
S. Em. ±	**0.05**	**0.05**	**0.14**	**0.20**	**0.17**	**0.33**	**0.25**	**0.40**
CD @ 5 %	**0.14**	**0.17**	**0.43**	**0.61**	**0.52**	**1.01**	**0.75**	**1.22**
CV %	**11.84**	**5.85**	**7.63**	**7.06**	**4.36**	**6.15**	**4.24**	**5.53**

T_1– High density planting; T_2 - Single row system; T_3 - Single row system; T_4 - Single row system; T_5 - Two plants per hill; T_6 - Three plants per hill; T_7 - Paired row system; T_8 - Paired row with zig-zag system; **DAP – Days after planting**

cv. Ney Poovan and Sanjay (2011) in cv. Poovan. Less competition for soil moisture, nutrients and more light intensity leads to production of more functional green leaves in wider spacing. This increased leaves production helped to synthesize more amounts of photosynthates. Meanwhile, it highly influences the overall the growth and development of plants. The parallel observations were reported by Athani and Hulamani (2000) in banana cv. Rajapuri, Sanjay (2011) in cv. Poovan, Sarrwy *et al.*, (2012) in cv. Williams, Gaonkar (2019) in cv. Grand Naine and Panjavarnam *et al.*, (2018) in cv. Ney Poovan.

The higher leaf area was obtained in low density planting during all the stages of growth. This might be due to high number of functionally active leaves in wider area which gives more light interception and also obtain sufficient amount of photosynthates for assimilation. It increases size of leaves by cell division, cell enlargement, cell expansion and other metabolic processes which are involved in synthesis of macromolecules. These results are in line with previous research reports by Sarrwy *et al*. (2012) in cv. Williams, Behera *et al.*, (2016) in cv. Bantala, Patel *et al.*, (2018) cv. Grand Naine, Sindhupriya *et al.*, (2018) in cv. Nendran, Kumar *et al*., (2020) in cv. Ney Poovan and Naika *et al.*, (2022) in cv. Williams (1st Ratoon)

The number of suckers in banana cv. Williams was influenced by different planting density and was statistically significant. At 30 and 60 days after planning, there was no sucker emergence was observed for all the treatments under study. After 90, 120, 150, 180, 210 DAP and during shooting stage, the maximum number of suckers per plant (4.13, 5.60, 6.97, 7.23, 7.40 and 7.97 respectively) was noticed in Treatment T_4 (Single row - 2.4×1.8 m). Whereas, the least number of suckers (2.50, 3.10, 3.27, 3.48, 3.54 and 4.17 respectively) were obtained in the treatment of closer spacing T_6 (3 plants per hill - 2.7×1.8×0.3 m). During early growth stages, suckers were not produced up to 2 months in all treatments. Later, a greater number of suckers were observed in wider spacing due to more ample space between plants. These findings are in conformity with previous reports by Athani *et al*., (2009) in banana cv. Rajapuri, Sarrwy *et al*., (2012) in cv. Williams, Behera *et al.*, (2016) in cv. Bantala and Naik (2016a) in cv. Grand Naine. The production of sucker was less in close planting system when compared to normal plant spacing due to more competition for moisture and sunlight among the plant population in all stage of development. These results are reported by Basavaraj (2014) and Naik *et al.*, (2016a) in cv. Grand Naine, Kumar *et al*., (2020) in cv. Ney Poovan and Naika *et al.*, (2022) in cv. Williams (1st Ratoon).

Table 5: Effect of different planting methods and high density planting on number of sucker (days) in banana cv. Williams.

Treatments	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	At shooting
T_1 (1.5×1.5 m)	2.87	4.40	5.77	6.03	6.13	6.63
T_2 (1.8×1.8 m)	3.30	4.93	6.10	6.30	6.63	7.17
T_3 (2.1×1.8 m)	3.73	5.13	6.43	6.40	6.87	7.37
T_4 (2.4×1.8 m)	4.13	5.60	6.97	7.23	7.40	7.97
T_5 (2.4×1.8×0.3 m)	2.60	3.40	3.60	4.03	4.33	4.47
T_6 (2.7×1.8×0.3 m)	2.50	3.10	3.27	3.27	3.54	4.17
T_7 (2.4×1.2×1.0 m)	3.10	4.33	5.40	5.70	5.83	6.10
T_8 (2.1×1.2×1.2 m)	2.93	4.20	5.10	5.37	5.53	5.80
S. Em. ±	**0.08**	**0.13**	**0.12**	**0.11**	**0.13**	**0.19**
CD @ 5 %	**0.23**	**0.41**	**0.35**	**0.32**	**0.41**	**0.57**
CV %	**4.19**	**5.28**	**3.76**	**3.33**	**4.04**	**5.27**

T_1– High density planting; T_2 - Single row system; T_3 - Single row system; T_4 - Single row system; T_5 - Two plants per hill; T_6 - Three plants per hill; T_7 - Paired row system; T_8 - Paired row with zig-zag system; **DAP – Days after planting**

Conclusion

Among various treatments influence of planting geometry on growth parameters T_4 (Single row - 2.4×1.8 m) recorded maximum pseudostem girth (71.83 cm), the number of functional leaves (16.27), leaf area (18.71 m^2) and the number of suckers (7.97). With respect to highest pseudostem height (1.93 m) was achieved in the treatment T_1 (Single row – 1.5×1.5 m). On the other hand, the lowest pseudostem height (1.59 m), pseudostem girth (47.13 cm), the number of functional leaves (11.53), leaf area (6.41 m^2) and the number of suckers (4.17) was observed in treatment T_6 (3 plants per hill - 2.7×1.8×0.3 m).

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