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Influence of Different Planting Methods and High-Density Planting on Yield and Economic Parameters in Banana *cv*. Williams

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

High density planting is one of novel concepts and it's effectively increase productivity of per unit area without affecting the fruit quality. Gross yield of banana per hectare mainly depends on yield of per plant and number of plants per hectare. The study was carried out at ICAR- All India Coordinated Research Project on Fruits, Kittur Rani Channamma College of Horticulture, Arabhavi in Belgavi district, Karnataka to study influence of different planting density on both yield and economic parameters 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 highest values for bunch parameters like bunch length (97.77 cm), bunch width (93.57 cm), number of hands per bunch (11.93), number of fingers in third hand (21.53) and weight of third hand (2.97 kg) was recorded in wider spacing treatment T_4 (Single row - 2.4×1.8 m). Regarding to yield parameters like highest bunch weight per hill (36.09 kg) was recorded in T_6 (3 plants per hill- 2.7×1.8×0.3 m). While, highest yield per hectare (108.75 t/ha) was found in treatment T_8 (Paired row with zig-zag - 2.1×1.2×1.2 m). With respect to the highest gross returns (10,33, 125.00 Rs/ha), net returns (5, 53,725.00 Rs/ha) and highest benefit cost ratio (2.15) was observed in T_8 (paired row system of with zig-zag planting).

Keywords: Banana; Williams; planting methods; bunch; economic attributes.

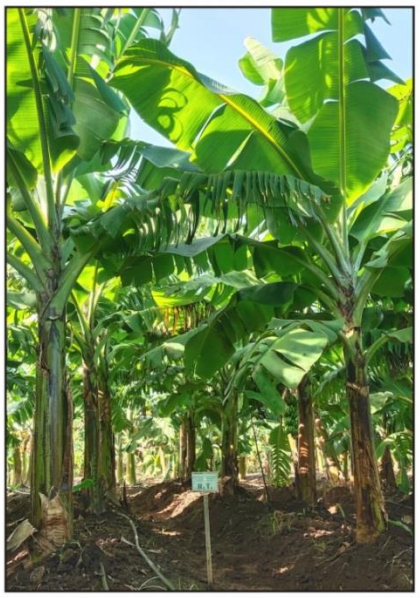
1. INTRODUCTION

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 and provides ample scope for production per unit area. Williams (*AAA*) is a cultivar of Giant Cavendish type in the Cavendish subgroup of banana. It is medium to tall plant (2.4-3.7 m). The pseudostem of Williams has dark brown with black or red streaks. It has a very larger, cylindrical bunch with 300 evenly sized fruits [1]. The high density planting system is one of the improved technology for increasing the productivity without affecting the quality of fruits. The main aim is to achieve the productivity by maintaining a balance between vegetative and reproductive stage without impairing the plant health. Principle of high density planting is effective use of both vertical and horizontal space of crop per unit area. Hence it can significantly increase the yield per unit area as compared to traditional planting methods. In India, the success of this technology has been reported in different fruit crops *viz.,* pineapple, banana, papaya, mango, apple and citrus (Pareek, 2016). There are several advantages like early production, high returns per hectare, efficient use of fertilizers and irrigation water [2].

The necessity of high density planting is increased as there is decline in cultivated land. It is an intensive system of cultivation in banana not only provide high production and net returns but also to facilitate efficient utilization of solar radiation and increase the photosynthetic efficiency of the plant. It also depends on the variety grown, method of cultivation, the height and spread of banana. It is amenable to modern input application techniques such as drip irrigation, fertigation and mechanization *etc.* This leads to a larger yield per unit area which in turn boosts productivity and profitability [3]. 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. This optimum plant density varies with the location, cultivar, soil fertility, management level and economic considerations. The plant density with proper management of nutrients is considered to be novel concept to solve the problem very effectively. There is a immense scope to study the influence of planting density on both yield and economic attributes of banana *cv.* Williams.

2. MATERIALS 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).



T_1- 1.5×1.5 m (High density planting)

T_2-1.8×1.8 m (Single row)

T_3-2.1×1.8 m – (Single row)

T_4-2.4×1.8 m – (Single row)

Plate 1 a.

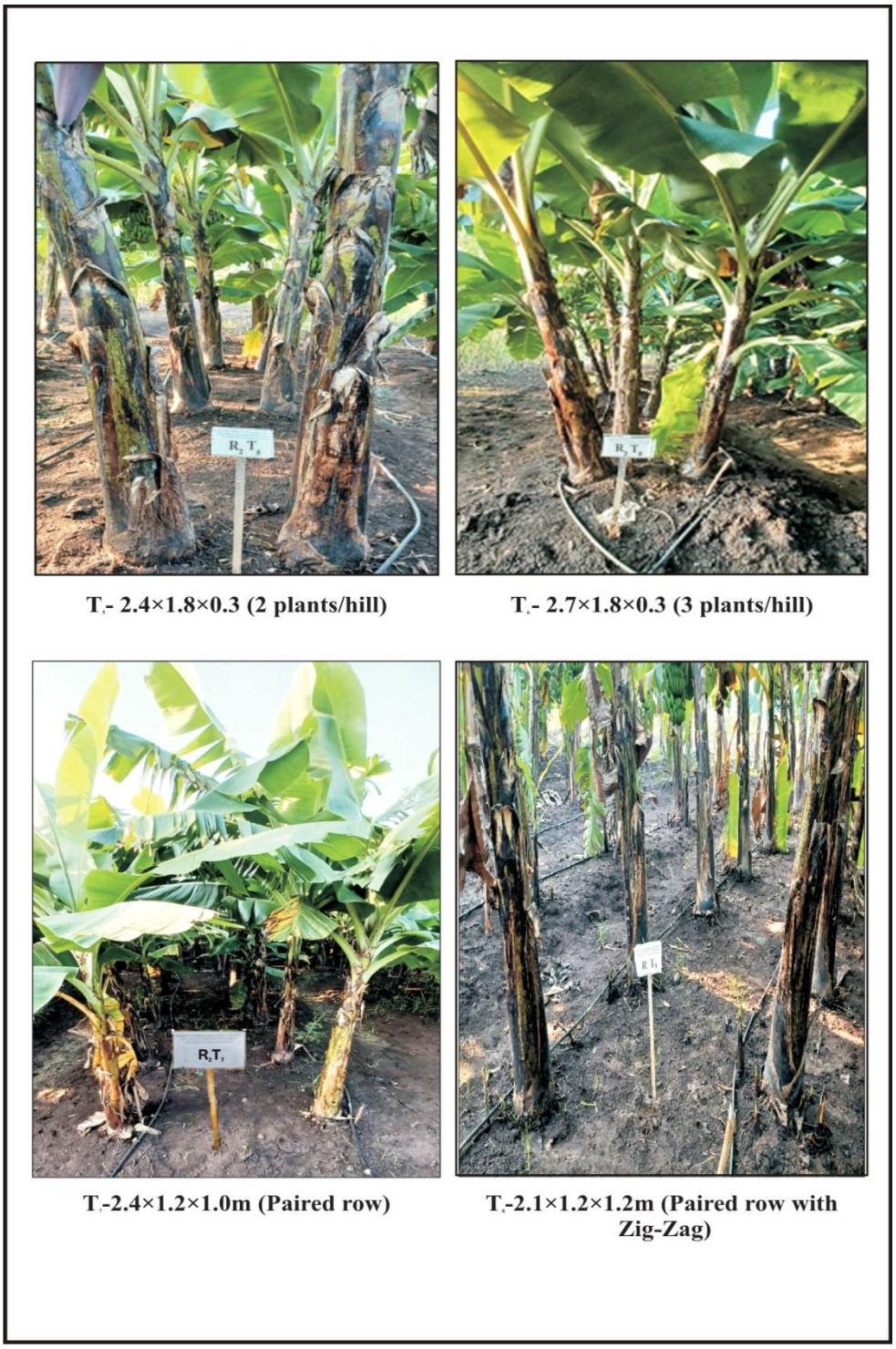


Plate 1 b.

Plate 1(A-b). Treatments details of the experimental plot

Measurements were taken for various yield parameters like bunch length, bunch width, bunch weight, number of hands per bunch, finger length, finger width and number of fingers per bunch and economic attributes such as gross return, net return and benefit cost ratio. The obtained data which are related to yield and economic parameters were organized into tables

and statistically analyzed in a randomized complete block design (RCBD) by using analysis of variance by Fisher and Yates [4]. When the F-test showed significance in comparing treatment means, critical differences (C.D. at 5%) were calculated.

3. RESULTS AND DISCUSSION

In the present study, data on bunch characteristics of banana cv. Williams were influenced by effect of different planting density among the all treatments. The wider spacing treatment T_4 (Single row - 2.4×1.8 m) recorded the higher values for bunch length (97.77 cm), bunch width (93.57 cm), number of hands per bunch (11.93), number of fingers in third hand (21.53) and weight of third hand (2.97 kg). In contrast, lower values for bunch length (72.47 cm), bunch width (74.83 cm), number of hands per bunch (7.13), number of fingers in third hand (15.47) and weight of third hand (1.74 kg) was observed in T_6 (3 plants per hill - 2.7×1.8×0.3 m).

The wider spacing treatments was achieved the maximum value for bunch length, bunch width, number of hands per bunch, number of fingers in third hand and weight of third hand than compare to closer spacing [5]. Due to low population, there is reduction in competition for sunlight and nutrients and also more leaf area will be exposed to light which in turn increased photosynthetic activity led to more accumulation of biomass that caused positive effect on bunch characteristic in wider spacing. The parallel observations were recorded in different varieties of banana by Pawar *et al.* [6] in *cv*. Grand Naine, Patel *et al*. [3] in *cv*. Grand Naine, Kumar *et al*. [7] in *cv*. Ney Poovan.

Regarding the finger parameters, the maximum finger length (16.03 cm), finger width (13.97 cm), finger weight (147.12 g) and number of fingers per bunch (186.07) was observed in treatment T_4 (Single row - 2.4×1.8 m). Whereas, the minimum values for maximum finger length (17.01 cm), finger width (14.23 cm), finger weight (147.12 g) and number of fingers per bunch (186.07) was recorded in T_6 (3 plants per hill - 2.7×1.8×0.3 m).

The maximum finger length, width and weight were observed in low density planting. During early stage of growth, there was more number of functional leaves and maximum leaf area was recorded in wider spacing. So more amount of biomass accumulation caused the positive effect on finger parameters. This contribution of all the increased vegetative parameters appears to have strong impact on the finger characteristics of banana cv. Williams. Similar findings of banana was reported by Pujari and Marbhal [8] in *cv.* Basrai, Sarrwy *et al*. [1] in *cv.* Williams, Gogoi *et al*. [9] in *cv.* Jahaji, Naidu *et al*. [10] *in cv.* Martaman, and Gaonkar [11] in cv. Grand Naine.

Table 1. Effect of different planting methods and high density planting on bunch characteristics in banana *cv.* Williams

Treatments	Bunch length (cm)	Bunch width (cm)	Hands per bunch	No. of fingers in 3rd hand	Weight of 3rd hand (kg)
T_1 (1.5×1.5 m)	83.40	84.07	9.93	18.20	2.16
T_2 (1.8×1.8 m)	91.67	87.27	10.20	19.03	2.63
T_3 (2.1×1.8 m)	93.33	91.60	10.50	19.37	2.73
T_4 (2.4×1.8 m)	97.77	98.57	11.93	21.53	2.97
T_5 (2.4×1.8×0.3 m)	80.80	83.20	8.27	17.20	1.94
T_6 (2.7×1.8×0.3 m)	72.47	74.83	7.13	15.47	1.74
T_7 (2.4×1.2×1.0 m)	84.47	85.10	8.93	17.60	2.15
T_8 (2.1×1.2×1.2 m)	84.20	85.27	9.27	18.27	2.20
S. Em. ±	1.75	2.69	0.44	0.67	0.08
CD @ 5 %	5.31	8.15	1.35	2.04	0.23
CV %	3.53	5.40	8.07	6.35	5.75

T1– High density planting *T5 - Two plants per hill*
T2 - Single row system *T6 - Three plants per hill*
T3 - Single row system *T7 - Paired row system*
T4 - Single row system *T8 - Paired row with zig-zag system*

Table 2. Effect of different planting methods and high density planting on finger and yield characteristics in banana *cv.* Williams

Treatments	Finger length (cm)	Finger girth (cm)	Finger weight (g)	Finger per bunch	Bunch weight (kg/hill)	Yield (t/ha)
T_1 (1.5×1.5 m)	15.31	12.57	123.62	162.27	20.51	90.24
T_2 (1.8×1.8 m)	15.67	12.71	135.63	172.73	25.32	75.96
T_3 (2.1×1.8 m)	15.77	13.20	139.07	174.87	27.28	70.98
T_4 (2.4×1.8 m)	17.01	14.23	147.12	186.07	33.59	77.25
T_5 (2.4×1.8×0.3 m)	14.11	12.27	116.18	126.60	34.53	67.33
T_6 (2.7×1.8×0.3 m)	13.23	11.58	114.40	102.47	36.09	72.80
T_7 (2.4×1.2×1.0 m)	14.11	12.11	120.64	152.13	21.06	103.19
T_8 (2.1×1.2×1.2 m)	14.90	12.20	121.21	153.20	21.75	108.75
S. Em. ±	0.37	0.62	2.11	3.54	0.94	3.92
CD @ 5 %	1.12	1.90	6.41	10.74	2.85	11.90
CV %	4.30	8.58	2.88	3.99	5.92	8.18

T1– High density planting T5 - Two plants per hill
T2 - Single row system T6 - Three plants per hill
T3 - Single row system T7 - Paired row system
T4 - Single row system T8 - Paired row with zig-zag system

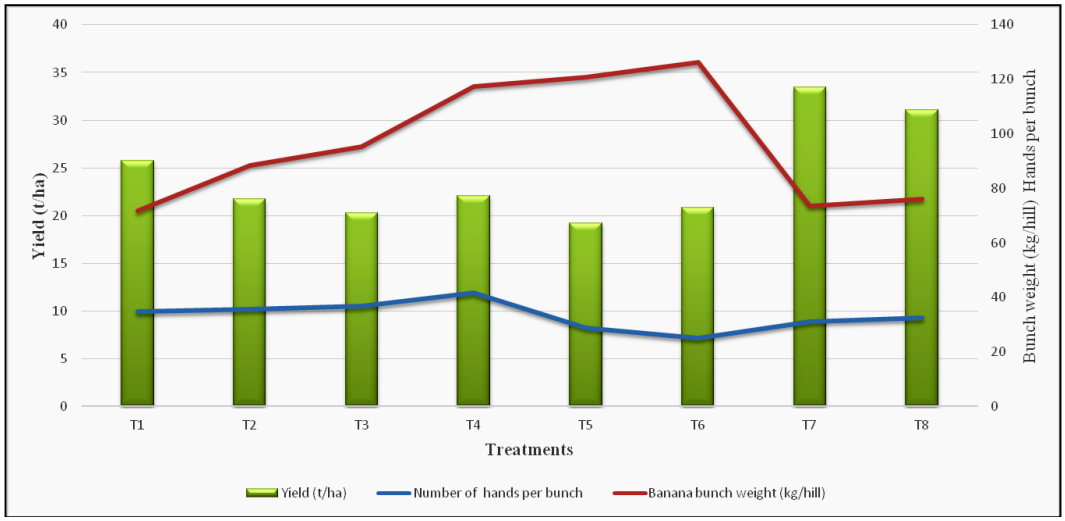


Fig. 1. Effect of different planting methods and high planting density on number of hands per bunch, bunch weight per hill and yield of banana *cv*. Williams

T1 - High density planting (1.5×1.5 m) T5 - Two plants per hill (2.4×1.8×0.3 m)
T2- Single row system (1.8×1.8 m) T6 - Three plants per hill (2.7×1.8×0.3 m)
T3 - Single row system (2.1×1.8 m) T7 - Paired row system (2.4×1.2×1.0 m)
T4 - Single row system (2.4×1.8 m) T8 - Paired row with zig-zag system (2.1×1.2×1.2 m)

In this study, the yield parameters like bunch weight per hill and yield per hectare was significantly influenced by the different methods of planting and planting density on banana cv. Williams. The Treatments T_6 (3 plants per hill- 2.7×1.8×0.3 m) had the greatest bunch weight per hill (36.09 kg) which was found on par with T_5 (34.53 kg) and T_4 (33.59 kg). Conversely, lowest bunch weight per hill (21.06 kg) was recorded in treatment T_7 (Paired row system- 2.4 x 1.2 x 1.0 m). With respect to the highest yield per hectare (108.75 t/ha) was recorded in treatment T_8 (Paired row with zig-zag - 2.1×1.2×1.2 m), which was statistically at parity with T_7 (Paired row system - 2.4×1.2×1.0 m) that produced 103.19 t/ha. On the other hand, T_5 (2 plants per hill - 2.4×1.8×0.3 m) had the lowest yield per hectare (67.33 t/ha).

Table 3. Effect of different planting methods and high density planting on benefit cost ratio in banana *cv.* Williams

Treatments	Total cost of cultivation Rs/100 m^2	Total cost of cultivation (Rs/ha)	Yield (Kg/100 m^2)	Yield (t/ha)	Gross returns Rs/100 m^2	Gross returns Rs/ha	Net returns Rs/100 m^2	Net returns Rs/ha	Benefit: cost ratio
T_1 (1.5×1.5 m)	4630	463000	902.44	90.24	8573	857280	3943	394280	1.85
T_2 (1.8×1.8 m)	3886	388600	759.60	75.96	7216	721620	3330	333020	1.86
T_3 (2.1×1.8 m)	3777	377700	709.28	70.93	6738	673835	2961	296135	1.78
T_4 (2.4×1.8 m)	3695	369500	772.50	77.25	7339	733875	3644	364375	1.98
T_5 (2.4×1.8×0.3 m)	4488	448800	673.30	67.33	6396	639635	1908	190835	1.42
T_6 (2.7×1.8×0.3 m)	4492	449200	728.00	72.80	6916	691600	2424	242400	1.53
T_7 (2.4×1.2×1.0 m)	4767	476700	1031.90	103.19	9803	980305	5036	503605	2.05
T_8 (2.1×1.2×1.2 m)	4794	479400	1087.5	108.75	10331	1033125	5537	553725	2.15

T1– High density planting *T5 - Two plants per hill*
T2 - Single row system *T6 - Three plants per hill*
T3 - Single row system *T7 - Paired row system*
T4 - Single row system *T8 - Paired row with zig-zag system*
Selling price – Rs 9.5/kg

The yield per plant was a complex and highly polygenic in nature. It was influenced by both vegetative parameters like functional leaves, leaf area and reproductive parameters such as bunch weight, number of fingers per bunch and finger weight. Although these traits are achieved lower values in closer planting, but yield per unit area was significantly having higher values. This is due to accommodation of more number of plant population in per unit area is high

in closer spacing. So, lower values of bunch and finger characteristic were compensated by higher value of yield in closer spacing than wider spacing. These results were in agreement with previous findings as reported by Panjavarnam *et al*. [5] in *cv.* Ney Poovan, Gaonkar [11] in *cv.* Grand Naine and Naika *et al.* [12] in *cv.* Williams (1st Ratoon).

The highest gross returns (Rs.10,33,125/ha), net returns (Rs. 5,53,725/ha) and benefit cost ratio (2.15) was recorded in treatment T_8 (paired row system with zig-zag planting) followed by T_7 (Paired row system) had gross returns of (Rs.9,80,305/ha), net returns (Rs. 5,03,605/ha) and benefit cost ratio (2.05). While treatment T_5 (2 plants per hill - 2.4×1.8×0.3 m) was observed the lowest gross returns (Rs. 6,39,635/ ha), net returns (Rs. 1,90,835/ha) and benefit cost ratio (1.42).

In paired row system, the yield of individual plants may be reduced, while total yield of per unit area was increased due to a greater number of plants accommodated in unit area. Similar findings were reported by Behera *et al.* [13] in banana *cv.* Grand Naine and Basrai. Although cost of cultivation for unit area was high in high density planting system compared to normal planting due to higher input cost. However, overall total production of unit area contributed to increase in benefit-cost ratio of banana. These results of banana were supported with the previous findings by Puttanna [14] in *cv.* Grand Naine, Gaonkar [11] in *cv.* Grand Naine and Naika *et al.* [12] in *cv.* Williams (1st Ratoon).

4. CONCLUSION

The maximum bunch length, bunch width, number of hands per bunch, number of fingers in third hand and weight of third hand, maximum finger length, finger girth, finger weight and number of fingers per bunch was recorded in the treatment with wider spacing T_4 (Single row - 2.4×1.8 m) followed by T_3 (Single row - 2.1×1.8 m).

Among all the treatments, treatment T_6 (3 plants per hill- 2.7×1.8×0.3 m) had the highest bunch weight per hill (36.09 kg). With respect to the highest yield per hectare (108.75 t/ha) was recorded in treatment T_8 (Paired row with zig-zag - 2.1×1.2×1.2 m), which was statistically at parity with T_7 (Paired row system - 2.4×1.2×1.0 m) that produced 103.19 t/ha. In terms of the highest gross returns, net returns and benefit cost ratio was recorded in treatment T_8 (paired row system with zig-zag planting) followed by T_7 (Paired row system - 2.4×1.2×1.0 m).

Overall, from the study it can be concluded that the wider spacing treatments T_4 (Single row - 2.4×1.8 m) and T_3 (Single row - 2.1×1.8 m) seemed to be optimum spacing for enhancing the bunch and finger parameters. The treatment T_8 (paired row system with zig-zag planting) and T_7 (Paired row system - 2.4×1.2×1.0 m) are optimum spacing for improving yield and economic attributes of banana *cv.* Williams.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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