

Original Research Article

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Effect of Planting Density and Fertilizers on Growth and Development of Tissue Culture Banana cv. Ney Poovan (AB) under Hill Zone of Karnataka

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ABSTRACT

The field experiment was conducted at College of Horticulture, Mudigere, to study on influence of planting density and fertilizers on growth and development of tissue culture banana cv. Ney poovan (AB) under hill zone of Karnataka during 2017-2018 with Factorial Randomized Block Design. The treatments were replicated twice with three factors and three levels. First spacing S₁- 2.0 x 2.0 m, S₂- 3.0 x 2.0 m and S₃-2.0 x 4.0 m, second plant density D₁- single plant per pit, D₂- double and D₃-triple plants per pit and third factor fertilizers F₁-100% RDF, F₂-125% RDF and F₃-150% RDF. The results revealed that, as influenced by different levels of spacing, plant density and fertilizers on plant and ratoon crop of banana. The maximum pseudostem height of plant and ratoon crop was recorded in S₁ (310.26 and 304.47 cm) at shooting stage and plant density in D₃ (310.44 and 309 cm). The pseudostem girth and number of leaves was recorded maximum in S₃ at 5th MAP (30.78 and 27.41 cm), (11.52 and 10.49) and in plant density was D₁ at 5th MAP (31.85 and 28.24 cm)(11.88 and 11.04) and shooting stage (62.61 and 60.18cm) and 18.39 and 17.32) of plant and ratoon crop. Whereas in fertilizer (F₃) was recorded maximum number of leaves at 5th MAP (11.54 and 10.57). The absolute growth rate for pseudostem height was maximum in D₂ during 3rd to 5th MAP (1.04 cm day⁻¹). The maximum number of suckers production per pit of plant and ratoon crop was obtained in S₃ at 7th MAP (6.52 and 7.24) and shooting (9.04 and 8.32). with respect to plant density highest suckers production was registered in D₁ at shooting (8.33). Whereas in fertilizer levels, the maximum number of suckers (6.75 and 8.04) was found in F₃. While interactions the treatment S₃D₁ recorded the maximum suckers per pit at shooting (10.07 and 8.88) in plant and ratoon crop.

Keywords

Spacing, Plant density, Fertilizers, Ney poovan, Suckers, AGR

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Introduction

Banana (*Musa* spp) is one of the most important herbaceous fruit crops in world, belongs to the family Musaceae. By virtue of its multiple uses banana is popularly known

as “Kalpataru”. It is an important crop of sustenance and farmers can ensure year-round production and income. Banana accounts 33.4 % total fruit production in India with an area of 0.89 million hectare with a total production of 33.89 million MT and productivity of

37.10 metric tonnes per hectare (Anon., 2018).

The cultivar 'Ney Poovan' also known as Elakkibale (Puttabale) is a backyard cultivar of choice, now assumes commercial cultivation. Now a day's tissue culture banana *cv.* Ney Poovan is acquiring lot of importance in hill zone of Karnataka Higher production is a prime objective hence, by adopting good yielding varieties, selection of tissue culture plants, choosing the right plant density, right inter cultural practices, water and fertilizer management are important to gain commercial yield per unit area.

Modified planting system to increase the plant density by planting one or more plants per pit at wider space is a recent and novel concept. It provides economic use of land, efficient utilization of solar energy, water, fertilizer, pesticides and ultimately leads to increased growth and productivity. Water and nutrients are the key important factors in banana production and research study has clearly demonstrated that for higher productivity of banana, application of recommended doses of essential nutrients at appropriate crop growth stage is necessary. Nutritional requirement has not been optimized in tissue culture banana especially *cv.* Ney Poovan (AB) for adopting the high density planting system with two or more plants per pit and effectively utilization of land and solar energy. This clearly emphasizes the need for research on these aspects which is expected to provide vital information to the growers.

Materials and Methods

The study was carried out in fruit science experimental field, College of Horticulture, Mudigere, Karnataka during 2017 and 2018 of both plant and ratoon crop. The experiment was laid out in a Factorial Randomized Block Design. The treatments were replicated twice

with three factors consisted of spacing, plant density and different levels of fertilizers. The first factor consists of three spacings *viz.*, S₁- 2.0 x 2.0m, S₂- 3.0 x 2.0m and S₃-2.0 x 4.0m. The second factor comprised of plant density at three levels *viz.*, D₁- single plant per pit, D₂- double plants per pit and D₃-triple plants per pit. However, third factor consisted of fertilizer dosages *viz.*, F₁-100% RDF, F₂-125% RDF and F₃-150% RDF along with their interaction effect *viz.*, spacing and plant density (S x D), spacing and fertilizer (S x F), plant density fertilizer (D x F) as well as combined effect of spacing, density and fertilizers (S x D x F) consisting of total 09, 09, 09 and 27 treatments respectively. There were nine treatment combinations in each block; each treatment had a net area of 64 M² having 16, 10 and 08 pits and allotted randomly.

The tissue culture planting has been taken up according to the experiment and irrigation was scheduled through drip irrigation as per water requirement of the crop. Fertilizer dose was calculated for banana at different growth stages according to treatment *i.e.* 100%, 125% and 150%. It was calculated and applied in four split doses *i.e.*, at 60, 120, 180 and 240 days after planting in plant crop and in two splits doses *i.e.*, half quantity at 90 days or 10-15 days after harvesting of first crop and rest after 60 days of first application in ratoon crop. The following biometrical observations was made at different stages of crop growth *viz.*, 3rd MAP, 5th MAP, 7th MAP and at shooting stage to find out feasibility of the spacing, plant density and nutrients. Absolute growth rate was expected for height and plant girth by using the following formula.

Absolute growth rate of plant height (cm day⁻¹): $\{H_2 - H_1 / t_2 - t_1\}$

Absolute growth rate of plant girth (cm day⁻¹): $\{G_2 - G_1 / t_2 - t_1\}$ Where, H₁ G₁ and H₂ G₂ are

plant heights and girth at times t_1 and t_2 respectively. The number of suckers per pit was recorded at five months, six months, seven months, shooting and harvesting stage.

Results and Discussion

Pseudostem height, girth and number of leaves are important morphological parameter related to growth and development. Growth is a cellular process consisting of cell division, cell enlargement and cell differentiation. In the present study it can be observed that under different plant density and fertilizer levels, the vegetative growth in terms of pseudostem height and girth increased with age of the crop up to shooting. Further, rapid rate of increase in pseudostem height and girth was observed between 5th MAP to shooting. Thereafter, the height and girth had slowed down.

The data on pseudostem height, girth number of leaves recorded 5 MAP and shooting stage as influenced by different levels of spacing, plant density per pit, fertilizers and their interaction on plant and ratoon crop of banana is given in Table 1.

Significantly, the maximum pseudostem height of plant and ratoon crop was recorded in S_1 (2.0×2.0 m) at shooting (310.26 and 304.47cm). But non significant differences exhibited at 5th MAP. However, the minimum pseudostem height was registered in S_3 in plant crop (292.56 cm) and ratoon crop (288.44 cm) at shooting.

The maximum pseudostem height in closer planting might be due to less spacing, low canopy led to higher interplant competition for light within a plot with the advancement of growth stages and more availability of nutrients compared to other treatments resulting tall and lanky growth as a result of pseudostem height was more. Similar to the

present investigation Patel *et al* (2018) also reported that 2.0×2.0 m spacing increased plant population per unit area, which provides less space for individual plant and in search of sunlight perhaps makes the plant upright resulting in tall growth. Similar results were also reported by Sindhupriya *et al.*, (2018) in different banana cultivars.

With respect to plant density, the maximum pseudostem height was recorded in D_3 (triple plants per pit) in plant and ratoon crop at 5th MAP (153.48 and 154 cm) and shooting (310.44 and 309.42 cm) which was on par with D_2 (double plant per pit) at the 5 MAP (147.58 and 147.42cm) and shooting (302.53 and 298.54cm). However, the minimum pseudostem height was registered in D_1 (single plant per pit) in 5th and shooting in plant (138.09 and 292.00cm) ratoon crop (137.72and 283.73cm).

In plant and ratoon crops, the maximum height due to more plant population per unit area led to natural shading of plants resulting competition for space and light might have made the plants tall and lanky growth as a result of which the pseudostem height was maximum. Similarly in the present study line with Murugan, 2003 in Ney Poovan found that with increasing planting density triple plants per pit with closer spacing pseudostem is increased invariably. Behera *et al.*, (2016) reported triple plants per pit the competition for space and light might have made the plants tall and lanky as a result of which the plant height recorded was more and girth was the least under the spacing accommodating highest number of plants/ha.

There was a progressive increase in pseudostem height from 5th MAP onwards with increase in planting density. Thereafter, the pseudostem height had slowed down at shooting. This could be due to increased plant population per unit area, which provides less

space for individual plant and in search of sunlight perhaps makes the plant upright. Similar results were also recorded by Grand Naine (Gaonkar, 2019) and Quintal Nendran (Sindhupriya *et al.*, 2018).

The pseudostem girth significantly maximum in plant and ratoon crop was recorded in S₃ (4.0 × 2.0 m) at 5th MAP (30.78 and 27.41 cm) and shooting (61.91 and 59.50 cm) and it was on par with S₂ (3.0 × 2.0 m) at 5th MAP (30.69 and 26.88 cm) and shooting (60.73 and 57.56 cm). However, the minimum pseudostem girth was registered in S₁ (2.0 × 2.0 m) in both plant (28.22 and 59.19 cm) and ratoon crop (25.63 and 56.48 cm) at 5th MAP and shooting respectively.

With respect to plant density, the maximum pseudostem girth of plant and ratoon crop was recorded in D₁ (single plant per pit) at 5th MAP (31.85 and 28.24 cm) and shooting stage (62.61 and 60.18cm), it was on par with D₂. However, the minimum pseudostem girth was registered in D₃ (triple plant per pit) in plant (28.00 and 58.60 cm) and ratoon crop (25.30 and 54.81 cm).

The highest pseudostem girth was recorded in wider spacing might be due to good canopy architecture which was benefited for maximum photosynthetic assimilation, considerably reduced the height which led to increased in girth. Further, lower density led to less competition for soil moisture with more nutrients and sunshine led to better metabolic activities of cell. Increased pseudostem height and reduced pseudostem girth at higher density was reported by Chaudhuri and Baruah (2010) in Jahaji. Pseudostem girth increased at low plant density indicating that pseudostem girth and height of banana are inversely proportional to each other. Similar results were also noticed in Grand Naine, (Naik, 2016; Gaonkar, 2019).

In both plant and ratoon crop, the highest pseudostem girth was recorded in single plant and double plants per pit with wider spacing might be due to less plant population per unit area, better nutrient uptake and correct water balancing helped in getting good girth. Similarly, the present findings are line with (Gaonkar, 2019) and Quintal Nendran (Sindhupriya *et al.*, 2018).

In the present study, it can be noted that under different spacings and plant density levels, the vegetative growth in terms of height and girth increased with age of the crop up to shooting. Further, rapid rate of increase in girth was recorded between 7th to shooting. Thereafter, the pseudostem girth had slowed down from shooting. The good girth in lower density might be due to less competition for soil moisture, nutrient and sunshine. The pseudostem height and girth did not differ significantly with the different levels of fertilizers and interaction effects.

The number of leaves influenced significantly by different levels of spacing. The highest number of leaves per plant crop was registered in S₃ at 5th MAP (11.52) and at shooting (18.16), which was significantly higher over S₂ and S₁. Similar trend recorded in ratoon crop also. The lowest number of leaves was registered in S₁ (2.0 × 2.0 m) in plant and ratoon crop at 5th MAP (10.61 and 9.70) and at shooting (16.47 and 15.54).

The highest number of leaves was registered in wider spacing might be due to sufficient space, more light interception and good congenial weather conditions. Hence, it indicates that sufficient reserve assimilation is a pre-requisite for higher leaf production in wider plants. Similar results were also noticed in Ney Poovan (Panjavarnam *et al.*, 2018), Martaman (Naidu *et al.*, 2015), Bantala (Behera *et al.*, 2016), and Quintal Nendran (Sindhupriya *et al.*, 2018).

Number of leaves differed significantly among the density levels highest number of leaves of plant and ratoon crop registered in D₁ (single plant per pit) at 5th MAP (11.88 and 11.04) and at shooting (18.39 and 17.32), which was, significantly superior over D₂ and D₃. However, the lowest number of leaves was registered in D₃ (triple plants per pit) in plant (10.50 and 16.26) and ratoon crop (9.31 and 15.54).

Both in plant and ratoon crop, the highest number of leaves was registered in single plant per pit with optimum spacing might be due to congenial weather condition, higher amount of nutrients, correct availability of water results more number of leaves. In the present study, leaf emergence reduced under high density planting owing to lower temperature inside the canopy since temperature had played an important role and influenced on leaf emergence. Number of leaves showed decreasing trend with increasing plant population. Murugan (2003) reported number of leaves in high density planting were lower than the number of leaves in normal planting density. These findings are in conformity with banana cv. Grand Naine, Gogoi *et al.*, (2015) Patel *et al* (2018) in banana cv. Grand Naine.

The significantly, the maximum number of leaves in plant and ratoon crop registered in F₃ (150 % RDF) at 5th MAP (11.53 and 10.57). However, the minimum number of leaves was registered in F₁ (100 % RDF) in both plant and ratoon crop (16.53 and 14.37). At shooting stage, non significant results were recorded.

In both plant and ratoon crop, the highest number of leaves was registered in plants provided with 150% recommended dose of fertilizers and it was on par with 125 % RDF might be due to higher amount of nutrient application resulted in more number of leaves.

The different workers on banana have reported that higher levels of nitrogen, phosphorus and potash promote production of more leaves. These findings are in conformity with banana cv. Ney Poovan (Panjavarnam *et al.*, 2018), Grand Naine (Naik, 2016; Patel *et al.*, 2018) and Quintal Nendran (Sindhupriya *et al.*, 2018) in different banana varieties.

The data on the absolute growth rate (AGR) for pseudostem height, girth and sucker production as influenced by different levels of spacing, density fertilizers and their interaction effect of plant and ratoon crop are depicted in Table 2.

The absolute growth rate for pseudostem height exhibited a steady increase with the advancement of age and was peak during 7th to 9th MAP. The AGR of pseudostem height in plant density was different significantly at 3rd MAP to 5th in plant crop was recorded maximum in D₂ (1.04 cm day⁻¹), which was on par with D₃ (1.03 cm day⁻¹). But in ratoon crop, it was highest in D₃ (1.12 cm day⁻¹), which was on par with D₂ (1.01 cm day⁻¹). However, the minimum in D₁ (0.90 cm day⁻¹) and ratoon (0.87 cm day⁻¹). Remaining all the stages of banana crop growth was differed non-significantly. The absolute growth rate for pseudostem height was highest in closer planting S₁ (2.0 × 2.0 m), it was highest in plant density with D₃ and F₃ compared to other levels. Compacted light intensity at ground level with increase in size of the plant canopy and age and solar energy conversion efficiency was maximum in closer spacing and minimum in wider spacing. The results of the present investigation also point out that there was a variation in growth rate in terms of pseudostem height with the age recording more growth rate during initial stages and less during later stages. These results are in corroborated with Martaman (Sailaja, 2014), Grand Naine, (Naik *et al.*, (2016).

Table.1 Pseudostem height, girth (cm) and number of leaves per pit at different growth stages as influenced by spacing, density and fertilizer in tissue culture banana cv. Ney Poovan

Treatment	Pseudostem height (cm)				Pseudostem girth (cm)				Number of leaves per plant			
	5 th MAP		Shooting		5 th MAP		Shooting		5 th MAP		Shooting	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
Factor-01	Factor-01- Spacing levels at 3 levels											
S ₁	149.90	149.47	310.26	304.47	28.22	25.63	59.19	56.48	10.61	9.70	16.47	15.54
S ₂	146.81	145.55	302.15	298.77	30.69	26.88	60.74	57.56	11.43	10.58	17.29	16.30
S ₃	142.45	144.62	292.56	288.44	30.78	27.41	61.91	59.50	11.52	10.49	18.16	16.97
S.Em ±	2.99	3.75	4.70	4.89	0.69	0.49	0.57	0.46	0.17	0.14	0.30	0.30
C.D. at 5%	NS	NS	13.65	NS	2.00	1.43	1.67	1.35	0.50	0.42	0.87	0.87
Factor-02	Factor-02- Plant density at 3 levels											
D ₁	138.09	137.72	292.00	283.73	31.85	28.24	62.61	60.18	11.88	11.04	18.39	17.32
D ₂	147.58	147.42	302.53	298.54	29.84	26.38	60.64	58.55	11.17	10.42	17.27	16.05
D ₃	153.48	154.51	310.44	309.42	28.00	25.30	58.60	54.81	10.50	9.31	16.26	15.44
S.Em ±	2.99	3.75	4.70	4.89	0.69	0.49	0.57	0.46	0.17	0.14	0.30	0.30
C.D. at 5%	8.69	10.90	13.65	14.20	2.00	1.43	1.67	1.35	0.50	0.42	0.87	0.87
Factor-03	Factor-03- Fertilizer at 3 levels											
F ₁	142.82	144.54	299.17	293.67	29.51	26.18	60.11	57.29	10.78	9.91	16.95	15.87
F ₂	146.45	146.88	301.61	296.91	29.91	26.64	60.46	57.71	11.23	10.28	17.32	16.29
F ₃	149.89	148.22	304.20	301.11	30.27	27.10	61.28	58.54	11.54	10.57	17.66	16.66
S.Em ±	2.99	3.75	4.70	4.89	0.69	0.49	0.57	0.46	0.17	0.14	0.30	0.30
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	0.50	0.42	NS	NS

Table.2 Absolute growth rate, suckers production per pit and days to emergence of suckers at different stages of crop growth as Influenced by different levels of spacing, plant density and fertilizer in tissue culture banana cv. Ney Poovan

Treatment	Absolute growth rate (cm day ⁻¹) for pseudostem height				Absolute growth rate (cm day ⁻¹) for pseudostem girth				Suckers production per pit			
	3 th -5 th MAP		7 th -9 th MAP		3 th -5 th MAP		7 th -9 th MAP		7 th MAP		At shooting	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
Factor-01	Factor-01- Spacing levels at 3 levels											
S ₁	0.98	1.06	1.51	1.42	0.18	0.16	0.14	0.17	5.53	5.74	6.63	6.63
S ₂	1.02	1.01	1.46	1.36	0.17	0.14	0.14	0.14	6.18	6.50	7.81	7.59
S ₃	0.97	0.95	1.42	1.40	0.19	0.14	0.13	0.16	6.52	7.24	9.04	8.32
S.Em ±	0.05	0.06	0.08	0.09	0.01	0.01	0.01	0.01	0.23	0.11	0.10	0.12
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	0.64	0.33	0.29	0.34
Factor-02	Factor-02- Plant density at 3 levels											
D ₁	0.90	0.87	1.35	1.23	0.19	0.15	0.13	0.16	5.93	6.78	8.33	7.82
D ₂	1.04	1.01	1.46	1.44	0.19	0.15	0.14	0.16	6.60	6.67	8.04	7.84
D ₃	1.03	1.12	1.58	1.52	0.16	0.14	0.15	0.14	5.71	6.03	7.11	6.88
S.Em ±	0.05	0.06	0.08	0.09	0.01	0.01	0.01	0.01	0.23	0.11	0.11	0.12
C.D. at 5%	0.16	0.19	NS	NS	NS	NS	NS	NS	0.64	0.33	0.29	0.34
Factor-03	Factor-03- Fertilizer at 3 levels											
F ₁	0.95	1.00	1.45	1.41	0.18	0.15	0.14	0.15	5.71	6.27	7.66	7.25
F ₂	1.00	1.01	1.47	1.40	0.18	0.15	0.14	0.15	5.96	6.44	7.78	7.59
F ₃	1.02	1.00	1.48	1.38	0.18	0.15	0.14	0.15	6.57	6.78	8.04	7.69
S.Em ±	0.05	0.06	0.08	0.09	0.01	0.01	0.01	0.01	0.23	0.11	0.10	0.12
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	0.64	0.33	0.29	0.34
	Interaction effect (S X D)											
S ₁ D ₁	0.83	0.96	1.26	1.25	0.20	0.16	0.134	0.191	5.06	5.44	6.65	6.58
S ₁ D ₂	0.99	1.04	1.50	1.40	0.19	0.7	0.154	0.172	5.94	6.09	6.87	6.92
S ₁ D ₃	1.13	1.17	1.76	1.63	0.16	0.16	0.158	0.147	5.59	5.70	6.37	6.42

S₂ D₁	0.92	0.91	1.43	1.12	0.19	0.16	0.146	0.145	6.25	6.78	8.27	8.03
S₂ D₂	1.097	0.98	1.45	1.45	0.18	0.13	0.136	0.154	6.85	6.93	8.53	8.08
S₂ D₃	1.06	1.14	1.51	1.51	0.15	0.14	0.140	0.126	5.45	5.81	6.63	6.65
S₃ D₁	0.96	0.76	1.36	1.33	0.20	0.15	0.111	0.164	6.48	8.16	10.07	8.88
S₃ D₂	1.05	1.02	1.44	1.48	0.20	0.15	0.145	0.176	6.10	6.70	8.73	8.52
S₃ D₃	0.90	1.06	1.48	1.41	0.18	0.14	0.152	0.146	6.01	6.57	8.32	7.58
S.Em ±	0.10	0.11	0.15	0.16	0.023	0.018	0.032	0.025	0.38	0.20	0.17	0.21
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.58	0.52	0.59
Interaction effect (S X F)												
S.Em ±	0.10	0.11	0.15	0.16	0.023	0.018	0.032	0.025	0.38	0.20	0.17	0.21
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction effect (D X F)												
S.Em ±	0.10	0.11	0.15	0.16	0.023	0.018	0.032	0.025	0.38	0.20	0.17	0.21
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction effect (S X D X F)												
S.Em ±	0.17	0.19	0.26	0.27	0.040	0.030	0.055	0.025	0.67	0.35	0.31	0.35
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Footnote

Spacing	S₁- 2.0 × 2.0 m	S₂ -3.0 × 2.0 m	S₃- 4.0 × 2.0 m
Plant density	D ₁ - Single plant per pit	D ₂ – Double plants per pit	D ₃ – Triple plants per pit
Fertilizer	F ₁ - 100 % RDF (200-100-300 g NPK per pit) 100100- NS-Non Significant	F ₂ - 100 % RDF (250-125-375g NPK per pit) RDF-Recommended Dose of Fertilizer	F ₁ - 100 % RDF (300-150-450 g NPK per pit) MAP- Months After Planting

The absolute growth rate for pseudostem girth exhibited a steady decrease with the advancement of age and was peak during earlier and middle stage of growth. Later decreased growth rate was noticed. Non-significant differences were obtained for with respect spacing, density fertilizers and their interaction effect of plant and ratoon crop during 3rd-5th and 7th – 9th period.

It was highest in medium planting S₂ D₁ and F₃ compared to other levels might be due to reduced pseudostem height, which led to more increase in stem girth due to more availability of nutrients compared to other treatments. The decrease in girth in closer spacing was due to increase in pseudostem height of the plant as a resulted in diversion of assimilates to increase in height at the expense of girth. Sindhupriya *et al.*, (2018) reported that, optimum AGR for pseudostem height and girth was recorded in wider spacing (2.4 m x 2.1 m) compared to closer spacing. The minimum AGR for height and stem girth in wider spacing might be due to less competition for soil moisture, nutrient and sunshine.

The maximum AGR for pseudostem height and girth was recorded in (125 per cent RDF). The results of the present study pointed out that there was a variation in growth rate in terms of plant height with the age registering more growth rate during initial stages and less during later stages. The present results are in accordance with Jahaji (Gogoi, 2015) and Grand Naine, (Naik, 2016)

The significantly maximum number of suckers production per pit of plant and ratoon crop was obtained in S₃ (4.0 × 2.0 m) at 7th MAP (6.52 and 7.24) and shooting (9.04 and 8.32), which was found to be *on par* with S₂ (3.0 x 2.0 m) at 7 MAP (6.12). However, the lowest number of suckers was registered in S₁ in plant 5.53 and 6.63 and ratoon crop (5.74 and 6.63).

In plant and ratoon crop, the highest number of suckers produced per pit in wider spacing could be due to availability of plenty of space between plants, good light intervention, nutrient and soil moisture uptake led to more suckers production and also due to genetic makeup (diploids are vigorous in growth behavior). Similar results were also reported by Naik (2016) in Grand naine.

With respect to plant density significantly highest suckers production per pit of plant and ratoon was registered in D₁ at shooting (8.33 and 7.84) and it was on par with D₂(8.04 and 7.84). During 7th MAP significantly registered in D₂ (6.60) and it was on par with D₁ (5.93). In ratoon crop also highest was registered in D₁ at 7th MAP (6.78) and it was on par with D₂ (6.67). The lowest number of suckers production per pit in D₃ in plant (5.71 and 7.11) and ratoon crop (6.03 and 6.88).

In the present investigation, both plant and ratoon crop, the highest number of suckers produced per pit in low and medium density (single and double plants per pit) with wider spacing could be due to good light involvement, soil moisture uptake and good farming unit leads to more suckers production and also genetic ploidy level i.e., diploids are vigorous in growth behavior. Gaonkar (2019) reported the sucker production was minimal at high density levels compared to normal density at all the stages of growth. The results of the present study are in accordance with the findings of Patel *et al.*, (2018) in banana cv. Grand Naine, and Sindhupriya *et al.*, (2018) in banana cv. Quintal Nendran.

The different levels of fertilizer significantly influenced on number of suckers production per pit in plant and ratoon crop. The maximum number of suckers (6.57 and 8.04) was found in F₃ (150 % RDF) and it was on par with F₂ (125 % RDF) (5.96 and 7.78). In ratoon crop also significantly, the maximum number suckers production per pit 6.78 and

7.69 was recorded in F₃ and it was on par with F₂ (6.44 and 7.59). The minimum number of suckers was recorded in F₁ (100 % RDF) in both main and ratoon crop from 7th MAP (5.71 and 6.27) to shooting (7.66 and 7.25).

In plant and ratoon crop, the highest suckers production per pit was registered in plants supplied with 150% recommended dose of fertilizers and it was *on par* with 125 % RDF might be due to higher amount of nutrient supply and ample moisture led to more number of suckers. The different workers on banana have reported NPK levels promote production of more suckers. These findings are in conformity with Sindhupriya *et al.*, (2018) in banana cv. Quintal Nendran. In present research, the maximum number of suckers was found in wider spacing, low plant density and high fertilizer dose. So sucker production was minimal at high density levels compared to normal density of growth.

The interaction effects between spacing and density levels on suckers per pit was found significant in plant and ratoon crop. The treatments S₃D₁ (4.0 x 2.0 m with single plant per pit) and S₂D₁ recorded maximum suckers per pit at shooting (10.07 and 8.88) (8.53 and 8.08). It was *on par* with S₃D₂ (4.0 x 2.0 m with 2 plants per pit)(8.73 and 8.52). The minimum number of suckers was recorded in S₁D₁ (2.0 x 2.0 m with single plant per pit) at shooting (6.65 and 6.58).

In main and ratoon crop, the highest suckers production per pit significantly registered in (S₃D₁) and (S₂D₁) wider spacing with single plant per pit and medium spacing with single plant per pit may be due to more spacing between plants, ample light intensity, better moisture with nutrient uptake led to more suckers. Gaonkar (2019) reported that, the maximum number of suckers was found in lower plant density with maximum level of fertilizer dose. At shooting stage, the

interaction effect of S₂P₁ (2.5 x 2.0m with 2plants per hill) recorded maximum (15.52) suckers per hill, followed by S₃P₂ (2.5 x 2.5m with 3plants per hill). These findings are in accordance with Sindhupriya *et al.*, (2018) in Quintal Nendran.

The interaction effect of different levels of spacing and fertilizers (S x F), density and fertilizers (D x F) as well as combined effect of spacing, density and fertilizers (S x D x F) showed non-significant.

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