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Influence of planting density and fertilizers on growth, phyllochron and sucker production 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, development and sucker production of tissue culture banana *cv*. Ney poovan during 2017-2018. It was laid out Factorial Randomized Block Design and replicated twice with three factors and three levels. First spacing S_1- 2.0 x 2.0 m, S_2- 3.0 x 2.0 m and S_3-2.0 x 4.0 m, second plant density D_1- single plant per pit, D_2- double and D_3-triple plants per pit and third factor fertilizers F_1-100% RDF, F_2-125% RDF and F_3-150% 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 S_1 (310.26 and 304.47 cm) at shooting stage and plant density in D_3 (310.44 and 309 cm). The pseudostem girth and number of green leaves was recorded maximum in S_3 at 5th MAP (30.78 and 27.41 cm), (5.38 and 5.23) and in plant density was D_1 at 5th MAP (31.85 and 28.24 cm) and (5.47 and 5.34) and shooting stage (62.61 and 60.18cm) and (11.92 and 11.13) of plant and ratoon crop. The absolute growth rate for pseudostem height was maximum in D_2 during 3rd to 5th MAP (1.04 cm day-1). The minimum days recorded for successive leaf production (phyllochron) by plant and ratoon crop at shooting (9.14 and 8.74) (9.10 and 8.76) and 9.42 and 8.72 days) in $S_3D_1F_3$ respctively. The early emergence of of suckers in plant and ratoon crop (103.49 and 107.83 DAP) was recorded in spacing S_2.The maximum number of suckers production per pit of was obtained in S_3 at 7th MAP (6.52 and 7.24) and shooting (9.04 and 8.32). In plant density highest suckers production was registered in D_1 and F_3 shooting (8.33) and (6.75 and 8.04). While interactions the treatment S_3D_1 recorded the maximum suckers at shooting (10.07 and 8.88) in plant and ratoon crop.

Keywords: Spacing, Plant density, Fertilizers, Ney pooovan, Suckkers, phyllochron

Introduction
Banana (*Musa* spp) is one of the most important herbaceous fruit crop 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) [1].

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 cultre plants, choosing the right plant denity, 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 enerrgy. This clearly emphasizes the need for research on these aspects which is expected to provide vital information to the growers.

Material 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*., S_1- 2.0 x 2.0m, S_2-3.0 x 2.0m and S_3-2.0 x 4.0m. The second factor comprised of plant density at three levels *viz.*, D_1- one plant per pit, D_2- two plants per pit and D_3-three plants per pit. However, third factor consist of fertilizer dosages *viz.*, F_1-100% RDF, F_2-125% RDF and F_3-150% 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 fesibility of the spacing, plant density and nutrients. The date of emergence of two successive leaves was recorded at shooting from which the rate of emergence by counting the days taken for two successive leaf productions and expressed in days. 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}): $\{G2–G_1/ t_2 – t_1\}$ Where, H_1 G_1 and H_2 G_2 are plant heights and girth at times t_1 and t_2 respectively. The number of suckers per pit was recorded at seven months, and shooting.

Results & Discussion

Pseudostem height girth and 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 had slowed down

The data on pseudostem height and girth 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.

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

Treatment	Pseudostem height (cm)				Pseudostem girth (cm)				Number of founctional leaves per plant			
	5th MAP		Shooting		5th MAP		Shooting		5th 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	0.98	1.06	1.51	1.42	0.18	0.16	0.14	0.17	4.67	4.74	10.83	10.17
S_2	1.02	1.01	1.46	1.36	0.17	0.14	0.14	0.14	5.19	5.30	11.28	10.44
S_3	0.97	0.95	1.42	1.40	0.19	0.14	0.13	0.16	5.38	5.23	11.45	10.77
S.Em ±	0.05	0.06	0.08	0.09	0.01	0.01	0.01	0.01	0.20	0.16	0.10	0.11
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	0.57	0.46	0.30	0.31
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	5.47	5.34	11.92	11.13
D_2	1.04	1.01	1.46	1.44	0.19	0.15	0.14	0.16	5.12	5.19	10.89	10.42
D_3	1.03	1.12	1.58	1.52	0.16	0.14	0.15	0.14	4.65	4.75	10.75	9.84
S.Em ±	0.05	0.06	0.08	0.09	0.01	0.01	0.01	0.01	0.20	0.16	0.10	0.11
C.D. at 5%	0.16	0.19	NS	NS	NS	NS	NS	NS	0.57	0.46	0.30	0.31
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	4.91	4.85	10.92	10.07
F_2	1.00	1.01	1.47	1.40	0.18	0.15	0.14	0.15	5.10	5.16	11.25	10.51
F_3	1.02	1.00	1.48	1.38	0.18	0.15	0.14	0.15	5.22	5.27	11.39	10.81
S.Em ±	0.05	0.06	0.08	0.09	0.01	0.01	0.01	0.01	0.20	0.16	0.10	0.11
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.30	0.31

Significantly 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

invstigation Patel *et al.* (2018) [15] also reported that 2.0 x 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 Sarrwy *et al.* (2012) [18], Behera *et al.* (2016) [6] and Sindhupriya *et al.* (2018) [19] 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 (137.72 and 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 prsent study line with Murugan, 2003 [10] in Ney Poovan found that with increasing planting density triple plants per pit with clolser spacing pseudostem is increased invariably. Bherar (2014) 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 by Grand Naine (Gaonkar, 2019) [9]

The pseudostem girth and number of founctional leaves significantly maximum in plant and ratoon crop was recorded in S_3 (4.0 × 2.0 m) at 5th MAP (30.78 and 27.41 cm), (5.38 and 5.23) and shooting (61.91 and 59.50 cm) (11.45 and 10.77) and it was on par with S_2 (3.0 x 2.0 m) at 5th MAP (30.69 and 26.88 cm) (5.19 and 5.30) and shooting (60.73 and 57.56 cm) (11.28 and 10.44). However, the minimum pseudostem girth and leaves was registered in S_1 (2.0 x 2.0 m) in both plant (28.22 and 59.19 cm) (4.67 and 10.83) and ratoon crop (25.63 and 56.48 cm) and (4.74 and 10.17) at 5th MAP and shooting respectively.

With respect to plant density, the maximum pseudostem girth and founctional leaves of plant and ratoon crop was recorded in D_1 at 5th MAP (31.85 and 28.24 cm) (5.47 and 5.34) and shooting stage (62.61 and 60.18cm) (11.92 and 11.13), it was on par with D_2. However, the minimum pseudostem girth and leaves was registered in D_3 (triple plant per pit) in plant (28.00 and 58.60 cm) (4.65 and 10.75) and ratoon crop (25.30 and 54.81 cm) (4.75 and 9.84).

The highest pseudostem girth was recorded in wider spacing might be due to good canopy architexure which was benefited for maximum photosynthetic assimilation, considerably redused 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) [7] in Jahaji. The highest number of founctional leaves i.e. average photosynthetically active leaves per pit was registered in wider plants could be due to less competition in soil moisture nutrient and active imbibitions light intensity led to more green leaves. In the present study, at low density levels, there was a marginal incrase in number of founctional leaves produced till shooting. A higher reduction was noted during the observation after shooting. Gogoi *et al.* (2015) [8] reported that, higher number of functional leaves was found in 3.0 x 2.0 m with single sucker per pit in banana cv. Jahaji. Slower rate of leaf emergence might have resulted due to low temperature experienced inside the canopy as reported by Robinson and Nel (1988) [16]. These findings are in confirmity with Sarrwy *et al.* (2012) [18], Naik (2016) [12] in banana cv. Grand Naine,

The maximum number of new leaves in plant and ratoon crop registered in F_3 (150 % RDF) at shooting stage (11.39 and 10.81) and it was on *par* with F_2 (125 % RDF) at 5th MAP (5.12) and it was on par with F_2 (125 % RDF) at shooting (10.51). The least number of green or founctional leaves was registered in F_1 (100 % RDF) in plant crop (10.92) and ratoon (10.07) at shooting stage respectively.

This might be due to higher amount of nutrient application resulted in more number of leaves. The duration of efficient and functional leaves has more relevance in influencing productivity than the total number of leaves. Higher nutritional dose (F_3) and lower plant density (D_1) had resulted in higher leaf duration in the present study. Decline in leaf duration with reduction in fertilizer dose and increase in plant density was reported. These findings are in confirmity with Athani *et al.* (2009) [3], Gaonkar (2019) [9] in banana *cv.* Grand Naine and Sindhupriya *et al.* (2018) [19] in Quintal Nendran.

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

Table 2: Absulute growth rate, phyllochron and days to emergence of suckers and Suckers production per pit 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				Phyllochron (days)		Days to emergence of sucker (days)		Suckers production per pit			
	Pseudostem height 3th-5th MAP		Pseudostem girth 3th-5th MAP		at shooting		Early		7th 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	0.18	0.16	11.11	9.93	114.45	119.37	5.53	5.74	6.63	6.63
S_2	1.02	1.01	0.17	0.14	9.518	8.88	103.49	107.83	6.18	6.50	7.81	7.59
S_3	0.97	0.95	0.19	0.14	9.14	8.74	107.84	112.06	6.52	7.24	9.04	8.32
S.Em ±	0.05	0.06	0.01	0.01	0.21	0.19	2.15	2.34	0.23	0.11	0.10	0.12
C.D. at 5%	NS	NS	NS	NS	0.61	0.57	6.23	6.79	0.64	0.33	0.29	0.34
Factor-02	**Factor-02- Plant density at 3 levels**											
D_1	0.90	0.87	0.19	0.15	9.10	8.76	110.02	114.96	5.93	6.78	8.33	7.82

D_2	1.04	1.01	0.19	0.15	9.90	9.09	107.90	111.99	6.60	6.67	8.04	7.84
D_3	1.03	1.12	0.16	0.14	10.75	9.69	107.85	112.30	5.71	6.03	7.11	6.88
S.Em ±	0.05	0.06	0.01	0.01	0.21	0.19	2.15	2.34	0.23	0.11	0.11	0.12
C.D. at 5%	0.16	0.19	NS	NS	0.61	0.57	NS	NS	0.64	0.33	0.29	0.34
Factor-03	**Factor-03- Fertilizer at 3 levels**											
F_1	0.95	1.00	0.18	0.15	10.29	9.65	109.43	114.39	5.71	6.27	7.66	7.25
F_2	1.00	1.01	0.18	0.15	10.04	9.12	108.03	112.32	5.96	6.44	7.78	7.59
F_3	1.02	1.00	0.18	0.15	9.42	8.76	108.32	112.54	6.57	6.78	8.04	7.69
S.Em ±	0.05	0.06	0.01	0.01	0.21	0.19	2.15	2.34	0.23	0.11	0.10	0.12
C.D. at 5%	NS	NS	NS	NS	0.61	0.57	NS	NS	0.64	0.33	0.29	0.34
	Interaction effect (S X D)											
S_1 D_1	0.83	0.96	0.20	0.16	10.27	9.62	120.22	125.74	5.06	5.44	6.65	6.58
S_1 D_2	0.99	1.04	0.19	0.7	10.91	9.75	113.90	118.05	5.94	6.09	6.87	6.92
S_1 D_3	1.13	1.17	0.16	0.16	12.14	10.40	109.23	114.36	5.59	5.70	6.37	6.42
S_2 D_1	0.92	0.91	0.19	0.16	8.69	8.22	105.23	110.68	6.25	6.78	8.27	8.03
S_2 D_2	1.097	0.98	0.18	0.13	9.05	8.46	98.87	101.65	6.85	6.93	8.53	8.08
S_2 D_3	1.06	1.14	0.15	0.14	10.80	9.94	106.36	111.16	5.45	5.81	6.63	6.65
S_3 D_1	0.96	0.76	0.20	0.15	8.34	8.45	104.60	108.49	6.48	8.16	10.07	8.88
S_3 D_2	1.05	1.02	0.20	0.15	9.75	9.07	110.94	116.29	6.10	6.70	8.73	8.52
S_3 D_3	0.90	1.06	0.18	0.14	9.30	8.72	107.97	111.41	6.01	6.57	8.32	7.58
S.Em ±	0.10	0.11	0.023	0.018	0.37	0.34	3.73	4.05	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	0.023	0.018	0.37	0.34	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	0.023	0.018	0.37	0.34	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	0.040	0.030	0.63	0.60	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

Spacing	S_1- 2.0 × 2.0 m	S_2 -3.0 × 2.0 m	S_3- 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-	F_2- 100 % RDF (250-125-375g NPK per pit)	F_1- 100 % RDF (300-150-450 g NPK per pit)
	NS-Non Significant	RDF-Recommended Dose of Fertilizer	MAP- Months After Planting

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 diffred significantly at 3rd MAP to 5th in plant crop was recorded maximum in D_2 (1.04 cm day-1), which was on par with D_3 (1.03 cm day-1). But in ratoon crop was highest in D_3 (1.12 cm day-1), which was on par with D_2 (1.01 cm day-1). However, the minimum in D_1 (0.90 cm day-1) and ratoon (0.87 cm day-1). The absolute growth rate for pseudostem height was highest in closer planting S_1 (2.0 × 2.0 m), it was highest in plant density with D_3 and F_3 compared to other levels. Compacted light intensity at ground level with increase in size of the plant canopy 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, 2013) [17], Grand Naine, (Naik *et al* (2016) [12].

The absolute growth rate for pseudostem girth exhibited a steady decrease with the advancement of age and was peak during earlier and middle statge of growth. Later decreased growth rate was noticed. Non-significant differences were obtained in spacing, density fertilizers and their interaction effect of plant and ratoon crop.

It was highest in medium planting S_2 D_1 and F_3 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) [19] 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) [8] and Grand Naine, (Naik *et al (*2016) [12]

The minimum days for successive leaf production (phyllochron) by plant crop was recorded in S_3 and D_1 at shooting (9.14 and 9.10), which was found to be *on par* with S_2 and D_2 at shooting (9.52 and 9.90). Similar trend was reported in ratoon crop also. However, the maximum days was registered in S_1 and D_3 in plant and ratoon crop (11.11 and 9.93) and 10.75 and 9.69).

The lowest phyllochron was registered and incrased emergence of leaf production in wider planting systems owing

to good maintainance of soil, water and good environmental condition such as light and temperature inside the canopy. Further, better utilization of natural resources led to better nutrients uptake and ample air moment in root zsingle resulted greater leaf production. Shortening of time interval between the successive leaves was due to optimum spacing at appropriate growth stages. Reduction in leaf emergence rate at high density was associated with lower temperature induced by increased shading and decresed temperature below the canopy (Robinson, 1988) [16]. Chaudhuri and Baruah (2010) [7] reported extended phyllochron at higher density was recorded especially at 7 MAP. Nalina *et al.* (2000) [13] noticed that, phyllocron was longest under high density planting, while it was shortest under low density. Similar results were also reported in Robusta (Nalina *et al*., 2009) [14] Ney Poovan, Bantala (Behera *et al.*, 2016) [6] and (Sindhupriya *et al.*, 2018) [19]. Ferilizer and interaction effect showed statistically non-significant.

The early emergence of of suckers in main and ratoon crop (103.49 and 107.83 DAP) was recorded in spacing S_2, which was on par with S_3 (107.84 and 112.06 DAP). Comparetively late emergence of suckers (114 and 119.37 DAP) in S_1.

This may be due to physiologically active and early development of plant due to maximum interception of light led to robust growth. It is also found in early development of lateral buds of particular rhizome of a mother plants. This is because of the high nutrient availability from the mother plants to daughter suckers. Gaonkar (2019) [9] reported by early emergence of suckers was recorded wider spacing with high density plants. These findings are in confirmity with Gogoi *et al,* (2015) [8], (Naik *et al (*2016) [12] and Sindhupriya *et al.* (2018) [19] in banana cultivars.

The significantly maximum number of suckers production per pit of plant and ratoon crop was obtained in S_3 at 7th MAP (6.52 and 7.24) and shooting (9.04 and 8.32), which was found to be *on par* with S_2 at 7 MAP (6.12). However, the lowest number of suckers was registered in S_1 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 gentic makeup (diploids are vigorous in growth behavior). Similar results were also reported by Balakrishnana (1980) [4], Murugan (2003) [10] in Ney Poovan, Athani *et al*. (2009) [3] in Rajapuri (Naik *et al (*2016) [12] in Grand naine.

With respect to plant density significantly highest suckers production per pit of plant and ratoon was registered in D_1 at shooting (8.33 and 7.84) and it was on par with D_2(8.04 and 7.84). During 7th MAP significantly registered in D_2 (6.60) and it was on par with D_1 (5.93). In ratoon crop also highest was registered in D_1 at 7th MAP (6.78) and it was on par with D_2(6.67). The lowest number of suckers production per pit in D_3 in plant (5.71 and 7.11) and ratoon crop (6.03 and 6.88).

This could be due to good light involvement, soil moisture uptake and good farming unit leads to more suckers production and also gentic ploidy level i.e., diploids are vigorous in growth behavior. Gaonkar *(*2019) [9] 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 Balakrishnana (1980) [4], Murugan (2003) [10], in Ney poovan, Athani *et al*. (2009) [3] and Sindhupriya *et al.* (2018) [19].

The maximum number of suckers (6.57 and 8.04) and (7.8 and 7.69) was found in fertilizer F_3 (150 % RDF) and it was on par with F_2 (125 % RDF) (5.96 and 7.78) (6.44 and 7.59) in main and ratoon crop. The minimum number of suckers was recorded in F_1 in 7th MAP (5.71 and 6.27) and shooting (7.66 and 7.25) respectively.

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 confirmity with Athani *et al*. (2009) [3] and Sindhupriya *et al.* (2018) [19] 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 S_3D_1 (4.0 x 2.0 m with single plant per pit) and S_2D_1 recorded maximum suckers per pit at shooting (10.07 and 8.88) and (8.53 and 8.08). It was *on par* with S_3D_2 (8.73 and 8.52). The minimum number of suckers was recorded in S_1D_1 at shotting (6.65 and 6.58).

In main and ratoon crop might be due to more spacing between plants, ample light intensity, better moisture with nutrient uptake led to more suckers. Gaonkar (2019) [9] 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 S_2P_1 (2.5 x 2.0m with 2plants per hill) recorded maximum (15.52) suckers per hill, followed by S_3P_2 (2.5 x 2.5m with 3plants per hill). These findings are in accordance with Sailaja (2013) [17] in Martaman and Sindhupriya *et al.* (2018) [19] in Quintal Nendran. The interaction effect (S x F), (D x F) as well as combined effect of (S x D x F) showed non-significant.

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