Influence of different plant densities and fertilizer levels on growth and yield parameters in Banana *cv.* Grand Naine

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Abstract

An experiment was carried out in banana *cv.* Grand Naine to evaluate the effect of three different plant densities with three levels of fertilizer which was laid out in factorial RCBD design with three replications. During all the stages of growth, except plant height, all the vegetative growth parameters were higher in lowest plant density (2.0 x 2.0 m) and lower in higher plant density (1.5 x 1.5 m). The highest plant height (207.67 and 205.61 cm) and yield (108.33 and 101.95 tons/ha) was registered in higher plant density in both the plant and ratoon crop respectively. While, the lowest plant height (197.25 cm and 194.19 cm) and yield (74.26 and 69.38 tons/ha) was observed in lower plant density in both the seasons respectively. In case of fertilizer application, the significant result was obtained for growth and yield of banana. The highest growth and yield parameters was found in F_2 (125 % RDF) whereas the lowest was registered in F_3 (75 % RDF). For combined effect of plant density and fertilizer on growth and yield parameters, the treatment S_3 x F_2 (2 x 2 with 125 % RDF) recorded higher values except plant height and yield than other combinations.

Keywords: Plant density, fertilizer, *cv.* Grand Naine, growth parameters, yield, plant and ratoon crop.

Introduction

In the world of fruits, banana (*Musa spp*) is a complete food fruit packed with all the necessary energy and health giving elements (Anon, 1969). It is an important crop of sustenance and farmers can ensure year-round production and income. In recent years more emphasis is being given to higher production per unit area by adopting various means. High density planting (HDP) as an intensive system of cultivation in banana not only provides high production and net returns but also facilitates efficient utilization of solar energy, nutrients and water (Apshara and Sathiamoorthy, 2003). Recent studies on increased plant density in banana plantations either by reduced spacing or by increasing the number of plants per hill have revealed that high plant density can be beneficial in many ways. In case of fertilizer, it has been commonly observed that banana growers emphasize more on nitrogen application followed by phosphorus and almost ignore potassium. In this way, imbalance or deficiencies of these major nutrients cause considerable damage to the plant in terms of quality, stress response and yield. Moreover, application of nutrients in readily available form rapidly enhance the availability of that nutrient in the soil but all is neither taken up by plants nor remain permanently in available form (Lodhi *et al*. 2009). So, it is necessary for the growers to know the nutrient status of the banana plants and soils for better plant nutrition management and achieving better production.

Keeping this in view,this experiment was undertaken to identify an optimum plant density and fertilizer levels in relation to better vegetative growth and yield parameters in banana *cv.* Grand Naine.

Material and Methods

The experiment was laid out with tissue cultured banana *cv*. Grand Naine as a test crop in Factorial Randomized Block Design (FRBD) at three varied plant densities and three fertilizer levels which is consisted of 9 treatments and 3 replications. The treatments were imposed in the month of September 2018. Pits of size 45 x 45 x 45 cm were dug two months before the planting at a spacing of 1.5 x 1.5 m – 1.8 x 1.8 m and 2.0 x 2.0 m and the pits were applied with 10 kg of FYM before planting. Fertilizer application schedule followed with a dose of 200:100:300 g NPK (Urea, P_2O_5 and K_2O) per plant as per the package of practices of UAS, Bengaluru recommended for tissue cultured banana (Anon, 2017). Fertilizer doses calculated for banana at different growth stages according to

treatments *i.e.* 100%, 125% and 150% recommended. A drip irrigation system was installed at the experimental site with placement of emitters at 40 cm distance. The emitters' water discharge rate was 4 lit/h. Protective irrigation was given as per the need of the crop and followed the recommended production practices. The treatment details are furnished as below.

T_1 (S_1F_1) 100% RDF at 1.5 x 1.5 m^2 + 40cm Emitters Placement

T_2 (S_1F_2) 125% RDF at 1.5 x 1.5 m^2 + 40cm Emitters Placement

T_3 (S_1F_3) 75% RDF at 1.5 x 1.5 m^2 + 40cm Emitters Placement

T_4 (S_2F_1) 100% RDF at 1.8 x 1.8 m^2 + 40cm Emitters Placement

T_5 (S_2F_2) 125% RDF at 1.8 x 1.8 m^2 + 40cm Emitters Placement

T_6 (S_2F_3) 75% RDF at 1.8 x 1.8 m^2 + 40cm Emitters Placement

T_7 (S_3F_1) 100% RDF at 2 x 2 m^2 + 40cm Emitters Placement

T_8 (S_3F_2) 125% RDF at 2 x 2 m^2 + 40cm Emitters Placement

T_9 (S_3F_3) 75% RDF at 2 x 2 m^2 + 40cm Emitters Placement

Result and Discussion

Significant difference was registered among the treatments with different plant densities and fertilizer levels on growth parameters like pseudostem height and girth, number of leaves and leaf area per plant, number of functional leaves at flowering and number of functional leaves at harvest in both the plant and ratoon crop (Table 1).

During all the stages, the highest plant height was noticed in high plant density S_1 (1.5 x 1.5 m), while, it was lowest in lower plant density S_3 (2 x 2 m). Similarly, plant height with regard to different fertilizer levels was found significantly highest with F_2 (125 % RDF) and lowest in F_3 (75 % RDF). The highest growth parameters *viz.*, pseudostem girth, number of leaves and leaf area per plant, number of functional leaves at flowering and number of functional leaves at harvesting were registered in lower plant density S_3 (2 x 2 m) and higher fertilizer percentage (125 % RDF), while the lowest were found in higher plant densities S_1 (1.5 x 1.5 m) and lower fertilizer level F_3 (75 % RDF). However, significant differences except plant height were found in interaction effect between varied

plant densities and fertilizer levels (S x F) on growth parameters. The highest was registered in treatment S_3F_2 (2 x 2 with 125 % RDF) and the lowest was noticed in S_1F_3 (1.5 x 1.5 with 75 % RDF).

The yield parameters like bunch weight, number of hands per bunch and number of fingers per bunch were found significant and were registered highest in both plant and ratoon crop with lower plant density S_3 (2 x 2 m) and higher fertilizer percentage F_2 (125 % RDF) respectively and it was found lowest in S_1 (1.5 x 1.5) and F_3 (75 % RDF) (Table 2). But yield (tons/ha) was found significantly highest in S_1 (1.5 x 1.5 m) and F_2 (125 % RDF). However the yield (tons/ha) was found lowest with lower plant density S_3 (2 x 2) and lower fertilizer percentage (75 % RDF) (Table 3).

The highest pseudostem height in higher plant density and higher fertilizer percentage is due to high interplant competition for light within the plot with the advancement of growth stages and more competition for nutrients compared to other treatments resulting in tall and lanky growth as a result pseudostem height was more. Similar results were also reported by Naik, (2016) and Patel *et al.* (2018). The highest pseudostem girth was registered in low plant density might be due to good canopy architecture which was benefited for highest photosynthetic assimilation, considerably reduced the height which led to increase in girth. The higher levels of nutrient application had a significant influence on psedudostem girth especially nitrogen and potash which help in formation of complex nitrogenous substances such as proteins and amino acids which are the building blocks of tissues. Similar results were also noticed in Ney Poovan (Murugan, 2003 and Panjavarnam *et al.* 2018), Srinivas *et al*. (2001) and Ashok *et al*. (2009). The highest numbers of leaves was registered in low plant density which is due to sufficient space for more light interception and good congenial weather conditions favor. Hence, it indicates that sufficient reserve assimilation is a pre-requisite for higher leaf production in widely placed. In case of fertilizer 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 Grand Naine (Naik, 2016; Gaonkar, 2018) and Quintal Nendran (Sindhupriya *et al.* 2018). The highest leaf area was observed in low plant density might be due to increase in leaf size by cell division, cell enlargement, cell expansion and metabolic processes involving synthesize of macromolecules during the growth stage. The different workers on banana have reported that higher levels of nitrogen and potash promote production of more leaves resulting in increased leaf area which has positive correlation with bunch weight. These findings are in conformity in Red Banana (Suganthi, 2002) and Ney Poovan (Murugan, 2003). Pandey *et al*. (2001) and Srinivas *et al*. (2001). The highest number of functional leaves at

flowering and functional leaves at harvest per plant was registered in low plant density and higher fertilizer percentage *i.e.* S_3 and F_2 (2 x 2 m, 125 % RDF) could be due to less competition in soil moisture nutrient and active imbibitions light intensity leads to more green leaves. With respect to fertilizer, higher number of leaf production at flowering and at harvest per plant at high levels of fertilizer indicates that enough reserve resources or assimilation of resources is a pre-requisite for higher leaf production Srinivas, (2001).

During the present investigation, in plant and ratoon crop, the bunch weight, number of hands and number of fingers per bunch were registered highest in S_3, F_2 (2 x 2, 125 % RDF). It might be due to high light intensity and plants were more exposed to sun light and indirectly got greater amount of assimilates accumulated in the various organ and led to good bunch size and its parameters. Similar results were also obtained in Robusta (Kulapathi *et al*. 2000) and Jahaji (Gogi, 2015). The highest yield (tons/ha) was registered in S_1 (1.5 x 1.5 m) and F_2 (125 % RDF). It can be attributed to increase in plant population per unit urea (Ahmad and Manan, 1970). But in case of low plant density S_3 (2 x 2 m) was registered the highest morphological and physiological characters, therefore it was recorded the highest yield in individual levels of plant, but number of plants occupied per hectare area was low. With respect to different doses of fertilizer the higher fertilizer percentage led to highest yield per hectare, it provides the highest amount of nutrients to fulfill the requirement of N, P and K which is essential to physiological and morphological growth of plant, which could lead to increase the yield per unit area.

Conclusion

Adoption of three different plant densities and three levels of fertilizer greatly influenced on vegetative growth and yield parameters. The highest growth parameters except plant height in S_1 (1.5 x 1.5 m), was registered in treatment S_3, F_2 (2 x 2, 125 % RDF). With respect to reproductive characteristics, the highest bunch weight, number of hands and number of fingers per bunch was registered in S_3, F_2 (2 x 2 m, 125 % RDF). Whereas the yield (tons/ha) was found highest in S_1, F_2 (1.5 x 1.5, 125 % RDF) which is due to more plant population per unit area. But yield in case of S_3 (2 x 2 m) was registered the highest morphological and physiological characters, therefore, the highest yield was observed in individual levels of plant, but number of plants occupied per hectare area was low. However, long-term studies are needed to determine the effect of different plant densities and residual effects of fertilizer application on soil and plants as well as its interaction with other factors such as irrigation, desuckering and management practices.

Table 1. Influence of different plant densities and fertilizer levels on growth parameters in Banana *cv.* Grand Naine

Treatments	Plant height at shooting (cm)		Pseudostem girth at shooting (cm)		Total Number of leaves per plant		Number of functional leaves at flowering		Number of functional leaves at harvest		Leaf area at shooting (m^2)	
	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	**Spacing**											
S_1	207.67	205.61	45.42	43.16	28.65	27.17	8.63	8.40	7.06	6.93	8.90	8.25
S_2	203.48	202.07	52.01	49.38	31.11	29.03	10.35	10.09	8.65	8.46	11.88	10.49
S_3	197.23	194.19	55.30	51.35	31.59	29.98	11.23	10.97	9.16	8.83	12.86	11.43
S.Em ±	1.02	0.79	0.74	0.88	0.33	0.28	0.161	0.07	0.08	0.12	0.12	0.10
C.D. at 5%	3.10	2.38	2.24	2.67	1.02	0.86	0.48	0.21	0.26	0.36	0.37	0.30
Factor-02	**Fertilizers**											
F_1	202.57	200.74	50.84	48.32	29.62	28.34	9.93	9.63	8.27	7.99	10.93	10.05
F_2	211.89	209.72	55.34	52.96	33.16	30.98	10.94	10.70	8.79	8.53	13.18	11.50
F_3	193.92	191.41	46.55	42.61	28.57	26.85	9.34	9.13	7.81	7.70	9.52	8.61
S.Em ±	1.02	0.79	0.74	0.88	0.33	0.28	0.16	0.07	0.08	0.12	0.12	0.10
C.D. at 5%	3.10	2.38	2.24	2.67	1.02	0.86	0.48	0.21	0.26	0.36	0.37	0.30
Interaction effect (S X F)												
S_1F_1	207.94	205.41	45.36	42.74	27.70	27.01	8.41	8.13	7.05	6.9	8.84	8.13
S_1F_2	216.71	215.65	47.17	45.22	30.41	28.53	9.20	9.03	7.21	7.06	9.77	8.62
S_1F_3	198.35	195.79	43.73	41.53	27.83	25.96	8.30	8.05	6.93	6.77	8.17	8.01
S_2F_1	202.98	203.09	51.91	49.45	30.75	28.53	10.21	10.01	8.55	8.20	11.67	10.53
S_2F_2	214.12	211.98	57.59	55.43	34.20	31.88	11.50	11.18	9.25	9.03	14.23	12.41
S_2F_3	193.35	191.14	46.53	43.26	28.40	26.68	9.35	9.08	8.16	8.16	9.73	8.52
S_3F_1	196.80	193.73	55.25	52.77	30.41	29.48	11.18	10.75	9.23	8.83	12.29	11.50
S_3F_2	204.85	201.55	61.28	58.22	34.86	32.55	12.13	11.88	9.91	9.51	15.55	13.47
S_3F_3	190.05	187.29	49.39	43.06	29.50	27.91	10.38	10.27	8.35	8.16	10.73	9.31
S.Em ±	1.77	1.36	1.28	1.53	0.58	0.49	0.278	0.124	0.154	0.20	0.213	0.175
C.D. at 5%	NS	NS	3.89	4.64	NS	NS	NS	0.376	0.466	NS	0.64	0.53

NS: Non Significant

Table 2. Effect of different plant densities and fertilizer levels on bunch parameters in Banana *cv.* Grand Naine

Treatments	Bunch weight (kg)		Number of hands per bunch		Number of fingers per bunch	
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop
Factor-01	**Spacing**					
S_1	24.37	22.94	8.77	7.44	200.08	156.44
S_2	29.70	27.75	9.44	8.00	244.05	188.92
S_3	30.35	28.89	9.44	8.33	255.34	206.56
S.Em ±	0.52	0.74	0.27	0.19	9.28	6.69
C.D.at 5%	1.59	2.25	NS	0.59	28.07	20.24
Factor-02	**Fertilizers**					
F_1	29.44	27.83	9.11	7.77	232.55	174.46
F_2	31.60	30.24	9.83	8.66	273.47	219.79
F_3	23.39	21.50	8.72	7.33	193.45	146.55
S.Em ±	0.52	0.74	0.27	0.19	9.28	7.13
C.D.at 5%	1.59	2.25	0.84	0.59	28.07	21.58
Interaction effect (S X F)						
S_1F_1	25.77	24.96	8.83	7.33	189.16	153.94
S_1F_2	27.11	25.30	9.00	7.66	244.58	178.83
S_1F_3	20.23	18.56	8.50	7.33	166.50	136.56
S_2F_1	30.91	28.57	9.33	7.66	249.75	186.44
S_2F_2	34.16	33.61	10.00	9.00	274.16	228.62
S_2F_3	25.97	24.50	9.00	7.33	208.25	151.69
S_3F_1	31.63	29.98	9.16	8.33	258.75	216.34
S_3F_2	33.51	31.83	10.50	9.33	301.66	251.93
S_3F_3	23.97	21.44	8.66		205.62	151.41
S.Em ±	0.91	1.29	0.48	0.33	16.08	11.59
C.D.at 5%	NS	NS	NS	NS	NS	NS

NS: Non Significant

Table 3. Effect of different plant densities and fertilizer levels on yield (tons/ha) in Banana *cv.* Grand Naine

Treatments	Yield (tons/ha)	
	Plant crop	**Ratoon crop**
Factor-01	**Spacing**	
S_1	108.33	101.95
S_2	93.62	91.41
S_3	74.26	69.38
S.Em ±	1.69	2.03
C.D.at 5%	5.11	6.16
Factor-02	**Fertilizers**	
F_1	96.35	93.58
F_2	103.21	98.58
F_3	76.67	70.58
S.Em ±	1.69	2.03
C.D.at 5%	5.11	6.16
Interaction effect (S X F)		
S_1F_1	114.55	110.92
S_1F_2	120.513	112.44
S_1F_3	89.93	82.50
S_2F_1	95.40	94.87
S_2F_2	105.33	103.73
S_2F_3	80.15	75.63
S_3F_1	79.09	74.94
S_3F_2	83.78	79.58
S_3F_3	59.93	53.61
S.Em ±	2.93	3.53
C.D.at 5%	NS	NS

NS: Non Significant

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