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Effect of Planting Density and Nutrient Requirement on Growth and Development of Banana cv. Quintal Nendran (AAB)

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A B S T R A C T

A field experiment was conducted at University Orchard, Horticultural College and Research Institute, Coimbatore to standardize the cropping density and nutrient requirement on growth and development of banana cv. Quintal Nendran (AAB) during 2015-17. The studies were carried out by planting banana suckers at three spacing levels *viz.*, S_1–1.8x1.8 m (3086 plants ha^{-1}), S_2 - 2.1 x 2.1 m (2267 plants ha^{-1}), $S_{3\ -}$ 2.1 x 2.4 m (1984 plants ha^{-1}) with four fertigation levels *viz.*, F_1 - 75 per cent, F_2 - 100 per cent, F_3 - 125 per cent and F_4 - 150 per cent RDF. The results revealed that plant density and fertigation influenced growth and development of banana cv. Quintal Nendran. The lowest pseudostem height (294.44 and 300.86 cm) at shooting stage was recorded in spacing (S_3), fertigation (F_1) compared to other treatments. The lowest absolute growth rate (AGR) for pseudostem height (0.843 cm day^{-1}and 0.870 cm day^{-1}) during 9 month after planting (MAP) to shooting stage was recorded in S_3 spacing and F_1 fertigation. The highest pseudostem girth (68.48and 71.15 cm) at shooting stage was recorded in spacing (S_2), fertigation (F_3) and their interaction (S_3F_3) treatment (73.10 cm). The highest absolute growth rate for pseudostem girth was recorded in wider spacing (S_2 and S_3). The wider spacing (S_3) and higher level of fertigation (F_4) registered more number of suckers (7.09 and 6.90).

Introduction

Banana belongs to the genus *Musa* of the family *Musaceae*. Its cultivation is distributed throughout the warmer countries and is confined to regions between 30°N and 30°S of equator. Together, bananas and plantain, are the fourth most important food crop in the world after rice, wheat and maize (Salvador *et al.*, 2007). Banana and plantain are fruit crops of great socio-economic significance as they serve as staple food for many millions of people across the tropics and sub tropics. Globally, bananas are grown in more than 135 countries across the world with an annual production of over 144 million tonnes (NHB, 2017). Quintal Nendran banana, considered as Giant Plantain, recorded higher plant height, pseudostem girth, days from shooting to harvest, crop duration and bunch weight.

Quintal Nendran (AAB) is a popular variety in Kerala where it is relished as a fruit as well as used for processing. Commercial cultivation of Quintal Nendran has picked up rapidly in Tamil Nadu in the recent past. On an average, it produces a bunch weighing 15 -17 kg and the weight goes even up to 18–30 kg in a crop duration of 13–15 months. The number of hands per bunch varies from 7-10.

The planting distance adopted for banana varies throughout the world (Nankinga *et al.*, 2005). High density planting is gaining importance due to shrinkage of cultivated land. It provides economic use of land, efficient utilization of solar energy, water, fertilizer, pesticides and ultimately leads to increased yield.HDP has been successfully adopted in many fruit crops. HDP as one of the technologies of hi- tech banana cultivation, gives high yield and profit. HDP can significantly increase the yield per unit area as the plants are planted closer compared to traditional planting methods (Mahalakshmi, 2000).

Water and nutrients are the key important factors in banana cultivation and research experiments have clearly demonstrated that for higher productivity of banana, application of recommended doses of essential nutrients at appropriate crop growth stage is necessary. Therefore, it is essential to apply the recommended doses of nutrients at appropriate growth stages by efficient method of application in order to increase the productivity and profitability. Hence, the present study was undertaken to standardize crop density and fertigation for banana cv. Quintal Nendran for maximizing the quality and yield under tropical field conditions.

Materials and Methods

The study was conducted at University Orchard, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The amount of fertilizer to be applied is calculated based on the fertilizer dose and split dose details recommended by TNAU. The suckers are planted at three different spacings viz., 1.8 m X 1.8 m (S1) accommodating 3086 plants $ha^{-1,}$ 2.1 X 2.4 m (S2) accommodating 1984 plants $ha^{-1}$and 2.4 x 2.4 m (S3) accommodating 1736 plants $ha^{-1.}$ The sub plot treatments include four fertigation levels *viz.*, F_1 - 75 per cent, F_2 - 100 per cent, F_3 - 125 per cent and F_4 - 150 per cent RDF. Recommended dose of fertilizer for Nendran is 150:90:300 g $plant^{-1}$ $year^{-1}$. The treatments were arranged in a split plot design with twelve treatment combinations in three replications. The height of the pseudostem was measured from the base of the trunk to the axil of the youngest leaf at third month, fifth month, seventh month, ninth month and at shooting stage. The girth of the pseudostem was measured at 30 cm height from the ground level at third month, fifth month and at shooting stage. Sucker production was recorded from 5 MAP to harvesting stages. Absolute growth rate was estimated for pseudostem height and pseudostem girth by using the following formula,

Absolute growth rate of pseudostem height (cm day^{-1}) = $[H_2 – H_1 / t_2 – t_1]$

Where, H_1 and H_2 are pseudostem heights at times t_1 and t_2 respectively.

Absolute growth rate of pseudostem girth ($cmday^{-1}$) = $[G_2 – G_1 / t_2 – t_1]$

Where, G_1 and G_2 are pseudostem girths at times t_1 and t_2 respectively.

Results and Discussion

Pseudostem height is an important morphological parameter related to growth and development of the crop. Growth involves both cell growth and development. Cell growth and development is a process consisting of cell division, cell enlargement and cell differentiation. In the present study it can be observed that under different plant density and fertigation 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 5^{th} to 9^{th} MAP. Thereafter, the pseudostem height and girth had slowed down from 9^{th} MAP to shooting.

There were significant differences in pseudostem height due to spacing and fertigation levels at shooting stage (Table 1). In spacing levels S_3 recorded lowest pseudostem height (294.44 cm), which was on par with S_2 (302.46 cm) and highest pseudostem height was recorded in S_1 (321.75cm). The lowest pseudostem height was registered in F_1 (307.41cm). The highest height of the pseudostem (312.19 cm) was noticed in $F_{3,}$ which was on par with F_4 (307.98 cm) and significantly superior over F_1 and F_2 (303.82 cm). The interactions between spacing and fertigation levels were found non-significant. The highest pseudostem height in closer planting might be due to natural shading of plants resulting in competitive growth rate to intercept the light and also due to more availability of fertilizers, compared to other treatments. Similar results were also recorded by Athani *et al.*, (2009), Sarrwy *et al.*, (2012) and Naik (2016).

Increase in girth is a desirable factor as far as banana is concerned which has a close bearing on yield, anchorage as well as production of more roots as against the pseudostem height, which beyond certain limit is associated with more of negative influence such as susceptibility to wind and requirement of high propping cost etc., The variations in pseudosterm girth due to different levels of planting density and fertigation are tabulated in the table 2. The pseudostem girth at shooting stage due to spacing and fertigation differed significantly. The pseudostem girth at shooting stage due to spacing and fertigation differed significantly. The highest pseudostem girth (69.86 cm) was recorded in $S_{3,}$ which was on par with S_2 (68.98 cm). The lowest pseudostem girth is registered in treatment S_1 (67.17 cm). The fertigation treatments differed significantly in pseudostem girth. In fertigation levels the highest pseudostem girth (72.15 cm) was recorded in F_3, which was on par with F_4 (70.84 cm), followed by F_2 (68.59 cm), while F_1 (63.10 cm) registered lowest pseudostem girth. The interaction effects not differed significantly. The highest pseudostem girth in wider spacing (S_2 and S_3) at highest level of fertigation (F_3 and F_4) 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 (S_1) was due to increase in pseudostem height of the plant as a resulted of diversion of assimilates to increase in heights at the expense of girth.

Pseudostem girth increased at wider plant density indicating that pseudostem girth and height of banana are inversely proportional to each other. Increase in pseudostem girth and number of suckers per plant due to decrease in plant density may be due to the fact that, plants faced less competition for moisture and sunlight in wider spacing. The results of the present study are in accordance with the findings of Robinson Athani *et al.*, (2009) in banana. Highest pseudostem girth was noted in F_3. This might be due to the higher dose of nitrogen is responsible for the formation, growth and development of the cells and accelerated the synthesis of chlorophyll and amino acid which are associated with major photosynthesis process of plants, it causes an increase in the formation of meristematic tissues (Pralhad., 2014).

Table.1 Effect of plant density and fertigation on pseudostem height (cm) at different stages of growth of banana cv. Quintal Nendran (AAB)

Stages	3 MAP				5 MAP				7 MAP			
Spacing/ Fertigation	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	89.43	87.46	89.56	**88.82**	137.49	133.04	130.15	**133.56**	191.79	181.94	178.39	**184.04**
F_2	87.44	87.32	88.22	**87.66**	139.36	133.34	131.59	**134.76**	194.14	183.20	180.85	**186.06**
F_3	88.16	86.11	85.79	**86.69**	144.45	136.42	132.86	**137.91**	200.01	188.44	182.84	**190.43**
F_4	86.89	89.07	90.54	**88.83**	140.82	135.03	132.50	**136.12**	195.84	185.55	182.06	**187.82**
Mean	**87.98**	**87.49**	**88.53**		**140.53**	**134.46**	**131.78**		**195.45**	**184.78**	**181.04**	
	S	**F**	**S at F**	**F at S**	**S**	**F**	**S at F**	**F at S**	**S**	**F**	**S at F**	**F at S**
SEd	1.50	1.21	2.36	2.09	1.19	1.50	2.54	2.59	2.60	2.12	4.11	3.67
CD = p (0.05)	NS	NS	NS	NS	3.30**	3.15*	NS	NS	7.22**	4.45*	NS	NS

*Significant at ($P \leq 0.05$) NS: Not Significant

Stages	9 MAP				At shooting			
Spacing/ Fertigation	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	259.59	246.74	239.59	**248.64**	315.81	297.26	289.51	**300.86**
F_2	261.94	248.60	242.65	**251.06**	319.00	299.48	292.99	**303.82**
F_3	269.61	255.64	247.64	**257.63**	328.95	308.80	298.82	**312.19**
F_4	264.84	252.15	245.66	**254.22**	323.22	304.29	296.42	**307.98**
Mean	**264.00**	**250.78**	**243.89**		**321.75**	**302.46**	**294.44**	
	S	**F**	**S at F**	**F at S**	**S**	**F**	**S at F**	**F at S**
SEd	1.16	3.11	4.81	5.38	2.56	3.22	5.48	5.58
CD = p (0.05)	3.24*	6.53*	NS	NS	7.12*	6.78*	NS	NS

Spacing	S_1 – 1.8 x 1.8 m (3,086 plants ha $^{-1}$); S_2 – 2.1 x 2.1 m(2,267 plants ha $^{-1}$); S_3 – 2.4 x 2.1 m (1,984 plants ha $^{-1}$)
Fertigation	F_1 – 75 % RDF; F_2 – 100 % RDF; F_3 – 125 % RDF; F_4 – 150 % RDF (RDF – 150:90:300 g NPK)

Table.2 Effect of plant density and fertigation on pseudostem girth (cm) at different stages of growth of banana cv.

Quintal Nendran (AAB)

Stages	3 MAP				5 MAP				7 MAP			
Spacing/ Fertigation	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	23.84	24.67	23.78	**24.10**	36.93	38.28	38.67	**37.96**	46.29	47.76	48.38	**47.48**
F_2	23.58	23.16	22.47	**23.07**	38.76	38.57	38.86	**38.73**	50.22	50.21	51.16	**50.53**
F_3	24.39	25.22	23.33	**24.31**	39.78	40.71	40.90	**40.46**	52.00	53.19	53.45	**52.88**
F_4	23.79	24.97	23.56	**24.11**	39.05	40.33	40.69	**40.02**	51.23	52.18	52.57	**51.99**
Mean	**23.90**	**24.51**	**23.29**		**38.63**	**39.47**	**39.78**		**49.94**	**50.84**	**51.39**	
	S	F	S at F	F at S	S	F	S at F	F at S	S	F	S at F	F at S
SEd	0.37	1.26	0.97	0.95	0.30	0.43	0.71	0.73	0.45	0.72	1.09	1.16
CD = p (0.05)	NS	NS	NS	NS	0.58*	0.92*	NS	NS	0.87*	1.53*	NS	NS

Stages	9 MAP				At shooting			
Spacing/ Fertigation	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	54.03	55.74	56.54	**55.44**	61.59	63.42	64.28	**63.10**
F_2	59.46	60.63	61.84	**60.64**	67.38	68.55	69.84	**68.59**
F_3	62.72	64.49	64.82	**64.01**	70.82	72.53	73.10	**72.15**
F_4	60.83	63.05	63.67	**62.52**	68.87	71.43	72.23	**70.84**
Mean	**59.26**	**60.98**	**61.72**		**67.17**	**68.98**	**69.86**	
	S	F	S at F	F at S	S	F	S at F	F at S
SEd	0.56	0.69	1.19	1.18	0.61	0.73	1.26	1.25
CD = p (0.05)	1.60*	1.46*	NS	NS	1.75*	1.55*	NS	NS

*Significant at ($P \leq 0.05$) NS: Not Significant

Spacing	**S_1 – 1.8 x 1.8 m (3,086 plants ha^{-1}); S_2 – 2.1 x 2.1 m(2,267 plants ha^{-1}); S_3 – 2.4 x 2.1 m (1,984 plants ha^{-1})**
Fertigation	F_1 – 75 % RDF; F_2 – 100 % RDF; F_3 – 125 % RDF; F_4 – 150 % RDF (RDF – 150:90:300 g NPK)

Table.3 Effect of plant density and fertigation on sucker production at different stages of growth of banana cv. Quintal Nendran (AAB)

Stages	5 MAP				7 MAP				9 MAP			
Spacing/ Fertigation	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**
F_1	1.97	2.33	2.64	**2.31**	3.18	3.92	4.42	**3.84**	4.42	5.29	5.78	**5.16**
F_2	2.07	2.48	2.67	**2.41**	3.52	4.18	4.94	**4.21**	4.69	5.32	5.81	**5.27**
F_3	2.13	2.49	2.73	**2.45**	3.73	4.23	4.97	**4.31**	4.75	5.63	6.19	**5.52**
F_4	2.26	2.51	2.84	**2.54**	3.87	4.36	5.03	**4.42**	5.18	5.71	6.33	**5.74**
Mean	**2.11**	**2.45**	**2.72**		**3.58**	**4.17**	**4.84**		**4.76**	**5.49**	**6.03**	
	S	**F**	**S at F**	**F at S**	**S**	**F**	**S at F**	**F at S**	**S**	**F**	**S at F**	**F at S**
SEd	0.03	0.03	0.05	0.05	0.04	0.06	0.09	0.10	0.06	0.07	0.11	0.12
CD = p (0.05)	0.07*	0.06*	NS	NS	0.10*	0.12*	NS	NS	0.15*	0.14*	NS	NS

Stages	At shooting				At harvesting			
Spacing/ Fertigation	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**
F_1	5.82	6.56	6.84	**6.41**	6.02	6.73	6.98	**6.58**
F_2	6.23	6.68	6.86	**6.59**	6.27	6.86	7.01	**6.71**
F_3	6.33	6.73	7.22	**6.76**	6.34	6.89	7.34	**6.86**
F_4	6.45	6.81	7.45	**6.90**	6.41	6.91	7.63	**6.98**
Mean	**6.21**	**6.70**	**7.09**		**6.26**	**6.85**	**7.24**	
	S	**F**	**S at F**	**F at S**	**S**	**F**	**S at F**	**F at S**
SEd	0.05	0.08	0.13	0.14	0.02	0.09	0.14	0.16
CD = p (0.05)	0.14*	0.17*	NS	NS	0.07*	0.19*	NS	NS

*****Significant at ($P \leq 0.05$) NS: Not Significant

Spacing	**S_1 – 1.8 x 1.8 m (3,086 plants ha $^{-1}$); S_2 – 2.1 x 2.1 m(2,267 plants ha $^{-1}$); S_3 – 2.4 x 2.1 m (1,984 plants ha $^{-1}$)**
Fertigation	F_1 – 75 % RDF; F_2 – 100 % RDF; F_3 – 125 % RDF; F_4 – 150 % RDF (RDF – 150:90:300 g NPK)

Fig.1. Effect of plant density and fertigation on Absolute Growth Rate (AGR) (cm day^{-1}) for pseudostem height and pseudostem girth at 3-5 MAP of banana cv. Quintal Nendran (AAB)

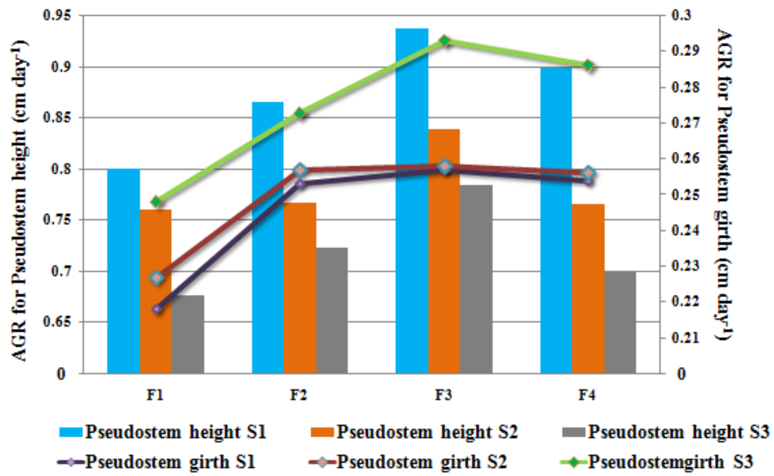


Fig.2. Effect of plant density and fertigation on Absolute Growth Rate (AGR) (cm day^{-1}) for pseudostem height and pseudostem girth at 5 -7 MAP of banana cv. Quintal Nendran (AAB)

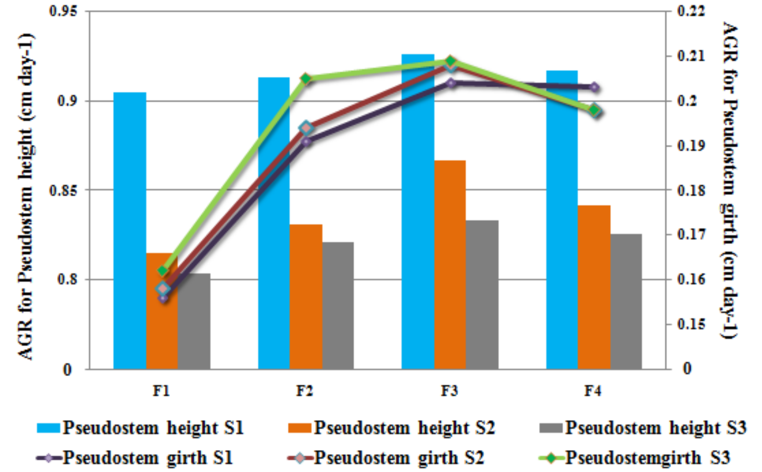


Fig.3. Effect of plant density and fertigation on Absolute Growth Rate (AGR) (cm day^{-1}) for pseudostem height and pseudostem girth at 7-9 MAP of banana cv. Quintal Nendran (AAB)

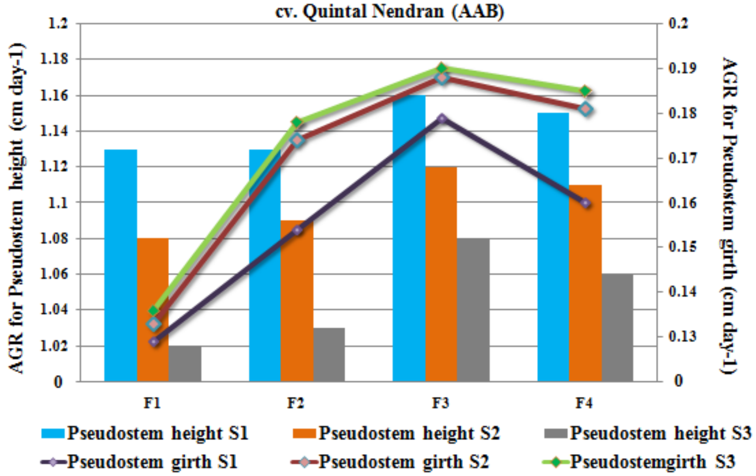
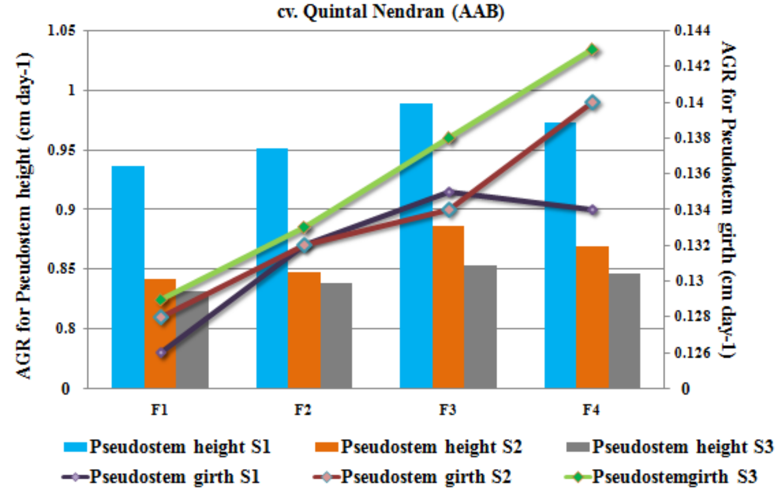


Fig.4. Effect of plant density and fertigation on Absolute Growth Rate (AGR) (cm day^{-1}) for pseudostem height and pseudostem girth at 9 MAP-shooting of banana cv. Quintal Nendran (AAB)



The influence of plant density and fertigation on number of suckers produced per plant at different stages of crop growth in cv. Quintal Nendran is depicted in table 3. At shooting stage, the number of suckers obtained per plant differed significantly. At shooting stage, the number of suckers obtained per plant differed significantly. The spacing level S_3 registered highest number of suckers (7.09) per plant, followed by S_2 (6.70). The lowest number of suckers (6.21) was recorded in S_1.

The highest number of suckers per plant (6.90) was recorded in F_4 treatment, which was on par with F_3 (6.76) and followed by F_2 (6.59). The lowest number of suckers per plant (6.41) was recorded in F_1 treatment. The interaction effects not differed significantly. Wider spacing (S_3) and higher levels of fertigation (F_4) recorded more number of sucker per plant compared to other treatments. Maximum availability of nutrients (F_4) and ample spacing between plants (S_3) might have led to development of more number of suckers in these treatments and their interactions. Similar results were also reported by Athani and Hulamani (2000) and Husameldin *et al.,* (2013) in cv. Grand Naine.

The absolute growth rate for pseudostem height exhibited a steady increase with the advancement of age irrespective of the treatments upto 7th- 9th month after planting, later decreased growth rate was noted. The absolute growth rate for pseudostem height was peak during 7th to 9th MAP. The data pertaining to the absolute growth rate (AGR) (cm day^{-1}) for pseudostem height of cv. Quintal Nendran as influenced by planting densities and fertigation at different stages of crop growth are presented in the Figure 1 to 4. The absolute growth rate pseudostem height exhibited a steady increase with the advancement of age irrespective of the treatments. The AGR for pseudostem height at 9 MAP to shooting stage due to spacing and fertigation differed significantly. In spacing levels, the lowest pseudostem height was recorded in S_3 (0.843 cm day^{-1}), which was on par with S_2 (0.861 cm day^{-1}). The maximum absolute growth rate (0.963 cm day^{-1}) was recorded in S_1 which was superior over other two levels. The fertigation treatments differed significantly in AGR for pseudostem height, the lowest AGR for pseudostem height was registered in F_1 (0.870 cm day^{-1}), which was on par with F_2 (0.879 cm day^{-1}), while the highest AGR for pseudostem height (0.909 cm day^{-1}) was recorded in F_3 and it was on par with F_4 (0.896 cm day^{-1}). The interaction between spacing and fertigation did not differ significantly.

The absolute growth rate for pseudostem height was highest in closer planting (S_1) compared to other levels and in interaction effect, it was highest in combination with F_3 (125 per cent RDF. Reduced 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 Athani *et al.,* (2009).

The absolute growth rate for pseudostem girth exhibited a steady decrease with the advancement of age irrespective of the treatments upto shooting. The absolute growth rate for pseudostem girth was peak during earlier statge of growth. The AGR for pseudostem girth at 9 MAP to shooting stage due to spacing differed significantly. The maximum absolute growth rate (0.136 cm day^{-1}) was recorded in S_3 and the lowest pseudostem girth was recorded in S_1 (0.132 cm day^{-1}), which was on par with S_2 (0.133 cm day^{-1}). The heighest AGR for pseudostem girth was recorded in S_4 (0.139 cm day^{-1}), which was on par with S_3 (0.136 cm day^{-1}) and the lowest AGR for pesudostem girth was recored in F_1 (0.128 cm day^{-1}). The interaction between spacing and fertigation not differed significantly. The interaction between spacing and fertigation not differed significantly. The highest absolute growth rate for pseudostem girth in wider spacing (S_3) at highest level of fertigation (F_3) 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 (S_1) was due to increase in pseudostem height of the plant as a resulted of diversion of assimilates to increase in heights at the expense of girth. The present results are in accordance with those Jagirdar *et al.*, (1963) and Gogai *et al.*, (2015).

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