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Studies on effect of spacing and fertigation on leaf characters of banana (*Musa* sp.) cv. quintal nendran (AAB)

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Abstract
A field experiment was conducted at University Orchard, Horticultural College and Research Institute, Coimbatore to study the effect of plant density and nutrient requirement on leaf parameters of banana cv. Quintal Nendran (AAB) during 2015-17. The investigation was 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}) and 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 result revealed that plant density and fertigation influenced leaf parameters of banana cv. Quintal Nendran. The Maximum number of leaves (14.17 and 13.96), the highest leaf area (11.12 m^2 $plant^{-1}$ and 11.34 m^2 $plant^{-1}$) at shooting stage were recorded in 1.8 x1.8 m spacing (S_1) and 125 % RDF fertigation (F_3) respectively. The Leaf Area Index (LAI) (3.27 and 2.71) at shooting stage was the highest in spacing (S_1) and fertigation (F_3) levels. The minimum Phyllochron days (days taken for successive leaf emergence) during 3rd, 5th, 7th and 9 MAP were recorded in wider spacing (S_3 (10.57 days) and 125 per cent RDF (F_3 (10.69 days). The maximum number of leaves (14.47) and leaf area (11.52 m^2 $plant^{-1}$) were recorded in S_3F_3 treatment combination, while the maximum LAI (3.34) was recorded in S_1F_3 due to closer spacing. The minimum phyllochron days (10.45 days) was recorded in treatment S_3F_3.

Keywords: banana, spacing, fertigation, quintal nendran

Introduction
The major hurdle in quality banana production is the lack of professional outlook towards its production and the mismanagement of the available natural resources. An advanced technology for increasing production in the crops like banana, which has higher productivity, is the major concern of today's scientific research to feed increasing population. High density planting is assuming 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 (Chaudhuri and Baruah, 2010) [3].

Fertigation gives advantages such as higher use efficiency of water and fertilizer, minimum losses of N due to leaching, supplying nutrients directly to root zone in available forms, control of nutrient concentration in soil solution and saving in application cost. Thus, fertigation becomes prerogative for increasing the yield of most of the crops under drip irrigation (Solaimalai *et al.,* 2005) [11].

In banana, the role of leaf characters such as total number of leaves produced and number of functional leaves retained at shooting is crucial in determining the yield potential. Leaf production in banana is related to increased rate of plant growth (Sathyanarayana, 1985). The leaf area has the greater influence on photosynthetic efficiency through higher light interception as well as higher light assimilation. Leaf area index (LAI) is one of the principal factors influencing canopy net photosynthesis of the crop plants (Hansen and Hitz, 1982). Phyllochron or the rate of leaf production is an important factor to be considered as a vegetative growth which decides the production of total number of leaves. The productivity depends on the management of optimum leaf area index (LAI), leaf number and LAI on penetration of photosynthetically active radiation (PAR) which have direct effect on growth and yield parameters and productivity (Nalina *et al.*,2000) [6].

Materials and Methods
The study was conducted at University Orchard, Horticultural College and Research Institute,

Tamil Nadu Agricultural University, Coimbatore. The main plot consists of three different spacing levels viz.,1.8 m X 1.8 m (S_1), accommodating a plant population of 3086 plants ha^{-1} and 2.1 X 2.4 m (S_2), accommodating a plant population of 1984 plants ha^{-1} as compared to the normal plant populationof 1736 plants ha^{-1} (2.4 x 2.4 m)in S_3.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. The amount of fertilizer to be applied is calculated based on the recommend dose of fertilizer and split dose details given by Tamil Nadu Agricultural University. Recommended dose of fertilizer for Nendran (AAB) 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 total number of leaves at 3 MAP, 5MAP, 7MAP and 9 MAP, at shooting and at harvesting stage were recorded and expressed in number. The length of the 3rd youngest leaf from the top was measured from leaf base to the tip and expressed in cm. The breadth of the 3rd youngest leaf was measured at the broadest point and expressed in cm. The date of emergence of each leaf was recorded from which the phyllochron *i.e.*, the time interval (days) between the production of two successive leaves were calculated (Summerville, 1944) and expressed in days. The leaf area was calculated by multiplying the product of length and breadth of lamina by the factor 0.83 (Murray, 1960) and expressed in square meters. The length of leaf lamina was measured from the base to apex along the midrib and width at the broadest portion of the lamina. Leaf area was calculated using the following model developed by Robinson and Nel (1989) [9].

$$LA\ (m^2\ plant^{-1}) = \{0.83(L \times B)\} \times \text{no. of leaves.}$$

The leaf area index was calculated using the formula recommended by Watson (1952).

$$LAI = \frac{\text{Leaf area per plant}}{\text{Area occupied per plant}}$$

Result

Among different spacing levels (S) and fertigation levels (F), the leaf characters such as number of leaves, leaf area, Leaf Area Index and Phyllochron at 3rd MAP, 5th MAP, 7th MAP, 9th MAP and at shooting stage different significantly among treatments, while the interaction effect of spacing and fertigation levels did not differ significantly among treatments at all the growth stages.

The data pertaining to total number of leaves per plant as influenced by spacing levels and fertigation are presented in Fig.1 to Fig. 5. During shooting stage, among spacing levels, the highest number of leaves (14.17) was recorded in S_3, which was significantly superior over S_2 (13.86) and S_1 (13.09). The lowest number of leaves recorded in treatment S_1. There were significant differences among different treatments of fertigation and the highest number of leaves (13.96) was recorded in F_3, which was on par with F_4 (13.79) and lowest number of leaves (13.45) was recorded in F_1, which was on par with F_2 (13.62).The interaction between spacing and fertigation did not differ significantly.

The effect of spacing and fertigation on leaf area at different stages of plant growth was presented in Fig.1 to Fig. 5.There were significant differences in leaf area due to spacing and fertigation levels at shooting stage. Among spacing levels, S_3 recorded highest leaf area (11.34 m^2 $plant^{-1}$) and followed by S_2 (11.15 m^2 $plant^{-1}$) and S_1 (10.60 m^2 $plant^{-1}$). The highest leaf area (11.12 m^2 $plant^{-1}$) was noticed in F_3, which was on par with F_4 (11.08 m^2 $plant^{-1}$). The lowest leaf area was registered in F_1 (10.94 m^2 $plant^{-1}$), which was on par with F_2 (10.99 m^2 $plant^{-1}$). The interactions between spacing and fertigation levels were found non-significant.

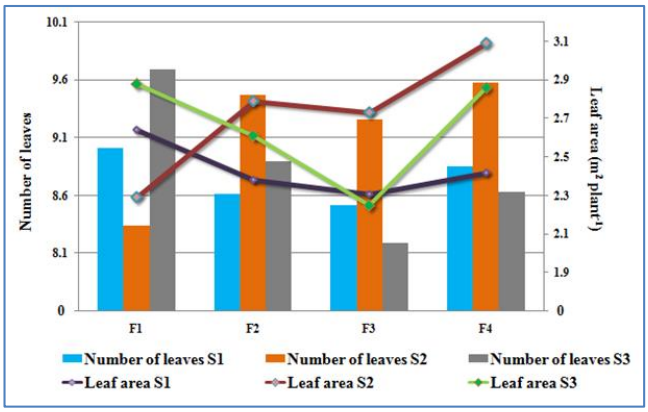

Fig 1: Effect of spacing and fertigation on Number of leaves and leaf area (m^2 $plant^{-1}$) at 3 MAP of banana cv. Quintal Nendran (AAB)

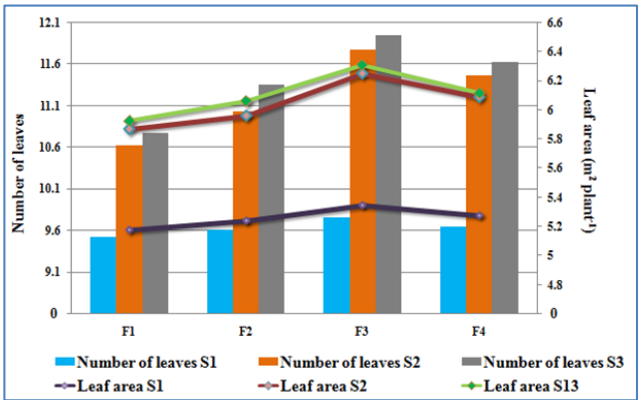

Fig 2: Effect of spacing and fertigation on Number of leaves and Leaf area (m^2 $plant^{-1}$) at 5 MAP of banana cv. Quintal Nendran (AAB)

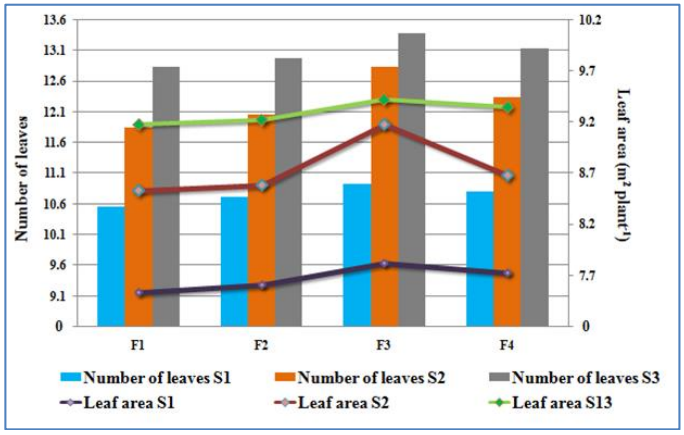

Fig 3: Effect of spacing and fertigation on Number of leaves and leaf area (m^2 $plant^{-1}$) at 7 MAP of banana cv. Quintal Nendran (AAB)

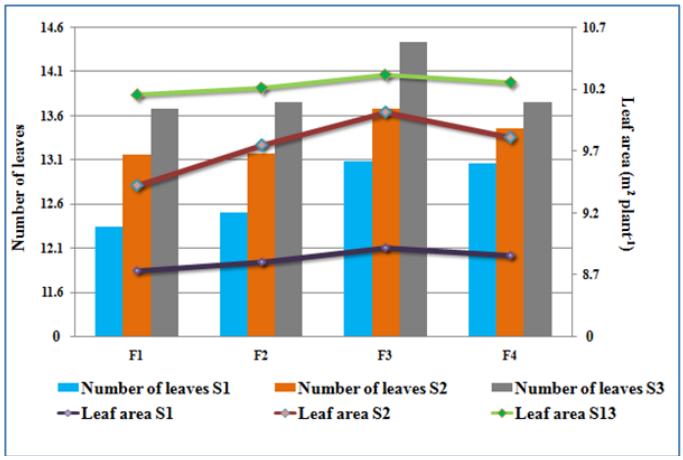

Fig 4: Effect of spacing and fertigation on Number of leaves and leaf area (m^2 $plant^{-1}$) at 9 MAP of banana cv. Quintal Nendran (AAB)

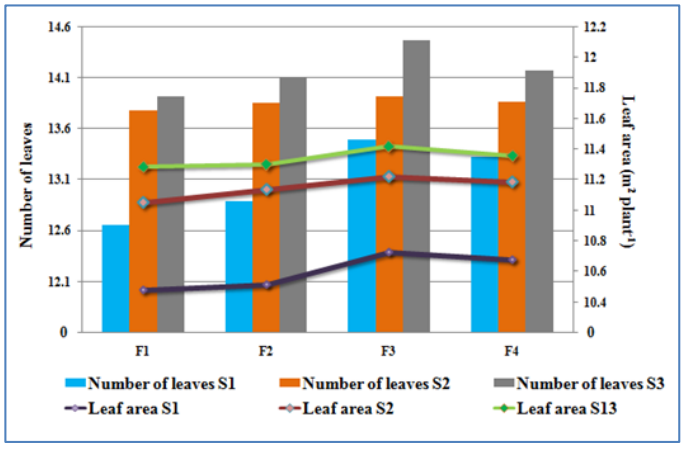

Fig 4: Effect of spacing and fertigation on Number of leaves and leaf area (m^2 $plant^{-1}$) at shooting stage of banana cv. Quintal Nendran (AAB)

At shooting stage, there were significant differences in LAI (Table 1).The highest LAI (3.27) was recorded in closer spacing *i.e.*, S_1 and was significant over S_2 (2.53) and S_3 (2.25). The plants responded significantly to fertigation levels, the highest LAI (2.71) was recorded in F_3, which were on par with F_4 (2.70) and significantly least LAI was noticed in F_1 (2.66). The interaction of spacing and fertigation levels was not significant.

Table 1: Effect of spacing and fertigation on leaf area index at different growth stages of bananacv. 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	0.815	0.519	0.571	0.635	1.60	1.33	1.18	1.37	2.33	1.93	1.82	2.03
F_2	0.735	0.633	0.518	0.628	1.62	1.35	1.20	1.39	2.35	1.95	1.83	2.04
F_3	0.713	0.619	0.446	0.593	1.65	1.42	1.25	1.44	2.41	2.08	1.87	2.12
F_4	0.747	0.701	0.567	0.672	1.63	1.38	1.21	1.41	2.39	1.97	1.86	2.07
Mean	0.752	0.618	0.526		1.62	1.37	1.21		2.37	1.98	1.84	
	S	F	F at S	S at F	S	F	F at S	S at F	S	F	F at S	S at F
SEd	0.10	0.05	0.014	0.013	0.02	0.02	0.03	0.03	0.03	0.03	0.05	0.05

CD = p (0.05)	NS	NS	NS	NS	0.05**	0.04**	NS	NS	0.08**	0.06**	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	2.70	2.14	2.02	2.28	3.23	2.51	2.24	2.66
F_2	2.72	2.21	2.03	2.32	3.25	2.53	2.24	2.67
F_3	2.75	2.27	2.05	2.36	3.31	2.54	2.27	2.71
F_4	2.73	2.22	2.04	2.33	3.30	2.54	2.25	2.70
Mean	2.73	2.21	2.03		3.27	2.53	2.25	
	S	F	F at S	S at F	S	F	F at S	S at F
SEd	0.03	0.02	0.04	0.04	0.02	0.02	0.05	0.05
CD = p (0.05)	0.08**	0.03**	NS	NS	0.06**	0.05**	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)

At 9 MAP, spacing levels influenced the phyllochron days (Table 2). The least number of days (10.57) for successive leaf production was recorded in S_3 treatment, which was on par with S_2 (10.73 days) and the maximum days was noted in S_1 (11.05 days). Among fertigation levels, the minimum days for successive leaf emergence (10.69 days) was recorded in F_3 treatment and maximum days were noted in F_1 (10.85 days). The interaction effects did not differ significantly.

Table 2: Effect of spacing and fertigation on phyllochron at different growth stages of banana cv. Quintal Nendran (AAB)

Phyllochron (Days)																
Stages	3MAP				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	S_1	S_2	S_3	Mean
F_1	7.56	8.25	7.05	7.62	9.56	9.11	9.01	9.23	10.64	10.27	9.96	10.29	11.11	10.85	10.64	10.87
F_2	8.07	7.27	7.78	7.71	9.52	8.99	8.83	9.11	10.56	10.15	9.89	10.20	11.07	10.72	10.63	10.81
F_3	8.15	7.31	8.37	7.94	9.21	8.70	8.67	8.86	10.46	9.96	9.79	10.07	10.99	10.64	10.45	10.69
F_4	7.84	7.16	7.93	7.64	9.35	8.97	8.82	9.05	10.52	10.03	9.83	10.13	11.01	10.69	10.57	10.76
Mean	7.91	7.50	7.78		9.41	8.94	8.83		10.55	10.10	9.87		11.05	10.73	10.57	
	S	F	F at S	S at F	S	F	F at S	S at F	S	F	F at S	S at F	S	F	F at S	S at F
SEd	0.09	0.08	0.18	0.19	0.06	0.10	0.16	0.17	0.14	0.09	0.19	0.16	0.11	0.11	0.20	0.18
CD = p (0.05)	0.24*	0.21*	NS	NS	0.18**	0.21**	NS	NS	0.379*	NS	NS	NS	0.313*	NS	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)

Discussion

Leaves are the most important contributors of yield through photosynthesis and the resultant metabolites produced. Number of leaves reflects on yield and quality of fruits since they act as a source to the developing fruits (Badgujar *et al.*, 2010) [2].The greater number of leaves at wider spacing (S_3) and higher fertigation (F_3) may be due to adequate availability of nutrients to induce more leaves, provided with ample space for more light interception and air movement under tropical conditions. Similar results were reported by Nankinga *et al.* (2005) [7], Athani *et al.* (2009) [1] and Sarrwy *et al.* (2012) [10] in different cultivars of banana.

It is well known that the leaf area has the greater influence on photosynthetic efficiency through higher light interception, as well as higher light assimilation. The leaf area was the highest in wider spacing (S_3) and at higher levels of fertigation (F_4), while when the plant density increased at closer spacing (S_1) leaf area was reduced. Higher leaf area and Leaf Area Index were also recorded in wider spacing (S_3) and 125 per cent RDF (F_3).

The increased LAI in closer spacing (S_1) was due to minimum land area occupied by individual plants compare to wider spacing. In fertigation it might be attributed by the higher fertigation levels (F_3), enhanced vegetative growth in respect of number of leaves and leaf area which simultaneously enhanced LAI, as reported by Hazarika and Ansari (2010) in banana.

The rate of leaf emergence (Phyllochron) was found to be faster in wider spacing (S_3) and high fertigation level (F_3). The increased number of successive leaf production by better light utilization, higher uptake of plant nutrients and excellent maintenance of soil, water and air continuum with higher oxygen concentration in the root zone (Raina *et al.*, 2011) [8]. Shortening of time interval between the successive leaves was due to adequate supply of fertilizer and optimum spacing at appropriate growth stages.

Conclusion

The leaf parameters of banana plant with respect to number of leaves, leaf area (m^2 plant^{-1}) and phyllochron were recorded the highest in the wider spacing (S_3) and high fertigation dose (F_3) while, leaf area index was higher in closer spacing and (S_1) and high fertigation dose (F_3).

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