Fertigation-Driven Optimization of Growth Characters in Banana (*Musa acuminate* AAA) cv. Red banana

ABSTRACT

The main aim of the study was to standardize the fertigation schedule and nutrient levels for growth enhancement in red banana**.** The study was conducted at the Department of Fruit Science College of Agriculture, Vellayani, Thiruvananthapuram during 2021-2023. The statistical design used was factorial Randomized Block Design replicated thrice with 12 plants per plot at a spacing of 2.1m x 2.1 m laid out with 12 treatment combinations of 4 different nutrient levels (60%, 80%, 100%and 120% RD of N and K) and 3 fertigation schedule (equal splits at weekly interval, at fortnightly interval, and according to the growth stage of the crop) and a control (KAU POP recommendation). Soil test based on fertilizer recommendation was derived based on KAU POP (200:200:400 g plant^{-1} year^{-1}). Farm yard manure was applied as organic source at 10 kg plant^{-1}) and P (200 g plant^{-1}) to all treatments as basal. Water soluble fertilizers used included Urea as nitrogen source and Muriate of Potash as potassium source;. Data was collected from pseudo stem height, girth, number of leaves, leaf index, leaf area, days to shooting, time taken from shooting to harvest and crop duration. Data was analyzed using analysis of variance. The highest pseudostem height (310.53 cm) and girth (89.30 cm) was observed with the interactive effect of 120% of the recommended dose of N and K applied according to the crop growth stage) which was on par with F_2S_3(80% of the recommended dose of N and K applied according to the crop growth stage) at flowering stage. The total functional leaf area was maximum on F_3S_3 at the flowering (23.86 m^2) and harvest stage (21.50 m^2). Data on days to shooting (363 days), shoot to harvest (89 days) and total crop duration (452 days) in red banana showed that the interaction effect F_2S_3 has taken the least number of days. In conclusion the growth characters were observed to be better at 80% recommended dose of N and K with split application according to the growth stage of the crop .

Keywords: Red banana, fertigation, growth characters, urea, muriate of potash, rajphos,

1. INTRODUCTION

Banana is one of the most important fruit crops grown in India. India is the largest producer of banana in the world with a production of 30.81 million tonnes from an area of 8.84 million hectares [1]. Among the banana varieties, Red banana or Chenkadali (fruit locally known as Kappa pazham) is one of the most relished and highly priced varieties of Kerala rich in antioxidants, beta carotene, vitamin C and vitamin B_6. This finicky-to-grow cultivar is extensively cultivated in southern parts of the state and bordering regions of Kanyakumari district in Tamil Nadu for its sweet flavour and creamy and distinctive purplish red peel colour.

Banana being a gross feeder requires high amount of nutrients for proper growth, development and optimum production. The unscientific crop management practices followed

by farmers have led to poor utilization of nutrients resulting in low productivity. Fertigation has vast potential to improve nutrient use efficiency, saving labour towards weeding and reducing the cost of production thereby maintaining soil health and meeting the specific nutritional requirements of the crop [2]. Fertilizer use efficiency in fertigation increases up to 67 per cent over conventional fertilizer application. Forty per cent saving in fertilizer usage can be achieved without any reduction in banana yield. Banana plants can effectively utilize the accurately-placed fertilizer in solution form in the active root zone area, resulting in vigorous growth, early flowering and early bunch development.

Knowledge about the precise dosage of fertilizers for application through fertigation is crucial for optimizing crop productivity. The success of any fertigation program predominantly hinges on the strategic scheduling of fertilization, as the frequency of application significantly influences the fulfilment of crop growth and development requirements. An accurate fertilizer recommendation for Red banana cultivation in Kerala is lacking. Despite this, numerous farmers are increasingly embracing its commercial cultivation. Growers face challenges such as extended crop duration, substantial fertilizer needs, and the elevated cost of production. Therefore, it is imperative to establish standardized nutrient requirements and a fertigation schedule for red banana. Addressing these considerations, the current study aims to standardize nutrient levels and a fertigation schedule to enhance the growth of red bananas under a fertigation system.

2. MATERIALS AND METHODS

The present study was carried out at the Department of Fruit Science, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala during the period 2020-2023. The main objective was to standardize nutrient levels and fertigation schedule for growth improvement in red banana.

The study employed a randomized block design, encompassing 12 treatment combinations and a control, each replicated three times.The combinations of fertigation levels (F) and split application of fertilizers (S) and fertigation treatments were fixed according to the soil test based N and K recommendation. The requirement of lime was calculated based on the initial soil status and the same was applied uniformly for all treatments. Soil test based fertilizer recommendation was derived based on 200:200:400 g plant^{-1} year^{-1} as per KAU POP [3] (KAU, 2016). The fertigation levels included four levels of recommended dose of fertilizers (RDF) with respect to N and K *viz*., F_1 – 60 per cent RDF, F_2 – 80 per cent RDF, F_3 – 100 per cent RDF and F_4 – 120 per cent RDF. The split application include S_1 – Equal splits of N and K at weekly intervals up to 12 months, S_2 – Equal splits of N and K at fortnightly intervals up to 12 months, S_3 – split application of N and K in the proportion given in table 1 and the control was 100% RDF with manual application of nutrients with conventional land management and drip irrigation system.

Table 1 Split application of N and K according to stages of growth

Stages of growth	N (%)	N (g)	K (%)	K (g)
5th to 12th week	30	60	10	40
13th to 25th week	35	70	10	40
26th to 37th week	20	40	30	120
38th to 49th week	15	30	25	100
50th to 52nd week	-	-	25	100
Total	**100**	**200**	**100**	**400**

Farm yard manure @ 10 kg plant^{-1} and P (200 g plant^{-1}) as rock phosphate was given uniformly to all treatments as basal. Water soluble fertilizers used for the work included urea as nitrogen source and muriate of Potash as potassium source.

Assessment of vegetative characters was conducted at five months after planting (MAP), nine MAP and at flowering. Pseudo stem height was measured from soil level to the base of the unopened leaf and expressed in centimeters, while girth of the pseudo stem was measured at 10 cm height of the pseudo stem from the ground level. The total number of fully opened functional leaves that appeared healthy on the plants were counted and recorded. The third fully opened leaf from the top (index leaf) was considered for measuring the leaf area (leaf area of index leaf = length of lamina x width of lamina x constant (0.8)) and was expressed in meter square. Days to shooting was calculated from planting to shooting.Time taken from shooting to harvest and crop duration was observed and expressed in days.

3. RESULTS AND DISCUSSION

Pseudostem height (cm): The effect of fertigation level and split application of fertilizers have shown significant effect on pseudostem height at 5 months after planting (MAP), 9 MAP, flowering stage and at the time of harvest (Table 2). Among the fertigation levels F_4 (120% of the recommended dose) recorded significantly higher values for plant height throughout the growth period and the lowest was recorded by F_1 (60% of the recommended dose) and in the split application level S_3 (split application according to growth stage) recorded the highest value. The interactive effect has shown that F_4S_3 recorded the highest value at 5 MAP (178.73 cm) which was on par with F_2S_3 (174 cm) and the lowest data was recorded for F_1S_1 during all stages of growth. From the contrast analysis data it was found that the control was significantly different from the treatment combinations. This might be due to the fact that nutrients applied through soil application may not be available to the plants at different stages which might have resulted in lower pseudostem height [4]. The steady increase in pseudostem height through fertigation could be best explained with the regular supply of plant nutrients and water which increased the availability of N, P and K in crop root zone ultimately leading to the enhanced uptake of these nutrients [5]. The results were similar to the findings of [6] and [7].

Pseudostem girth (cm): Perusal of the data on table 3, at 5 MAP revealed that pseudo stem girth (63.03 cm) was the highest for 75 % of the recommended dose of N and K through fertigation (F_3) along with split application according to the growth stage (S_3) which was on par with F_4S_3 (62.00 cm). Pseudostem girth at 9 MAP (77.27 cm) and flowering stage (89.30 cm) was the highest for F_4S_3 which was on par with F_3S_3. This may be due to increased amount of nitrogen and potash in the soil due to fertigation which help in the formation of complex nitrogenous substances such as proteins and amino acids which are the building blocks of tissues. Similar findings have also been reported [8].The lowest value for pseudostem girth among the treatment combinations was recorded for F_1S_1 at 9MAP and flowering stage. The control significantly varied from the treatment combinations; this may be due to low uptake of nutrients by the plants through conventional method.

Total functional leaf area: Effect of fertigation level and split application had significant effect on functional leaf area throughout the growth period of the crop (Table: 4). The leaf area consistently increased in the F_3 fertigation level and S_3 split application treatment. The interactive effect has shown that at 5 MAP the total functional leaf area was maximum for

F_2S_3 (7.59 m^2) and at flowering (23.86 m^2). The lowest leaf area was recorded for F_1S_3 at 5 MAP and 9MAP. These results are in conformity with the findings by [9] and [10] who stated maximum leaf retention was at lowest fertigation level combined with consortium of fertilizer application. Higher frequency of irrigation and increased availability of soil moisture under subsurface drip fertigation might have led to effective absorption and utilization of available nutrients and better proliferation of roots resulting in quick canopy growth and physiological parameters [11]. According to [12], frequent application of nutrients through drip system improves the uptake of nutrients through two main mechanisms: i) continuous replenishment of nutrients in the depletion zone at the vicinity of root interface and ii) enhanced transport of dissolved nutrients, by mass flow, due to the higher water content in the medium.

Data (Table 5) on days to shooting (325.33 days), shoot to harvest (89 days) and total crop duration (414.33 days) in red banana showed that the interaction effect of 80% of the recommended dose of N and K through drip irrigation (F_2) along with split application with regard to the crop growth stages (S_3) has taken the least number of days. The maximum number of days for shooting (455 days), shoot to harvest (106 days),and crop duration (561 days) were observed for F_1S_1 *i.*e. 60% of the recommended dose of N and K through drip irrigation (F_1) along with weekly application of fertilizers (S_1). The early flowering in subsurface drip fertigation with fertilizers inoculated plants may be ascribed to easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinin to the auxiliary buds resulting in breakage of apical dominance [10]. Similar results were obtained by [13] who found that the drip irrigation minimized the days to harvest (398 days) as compared to surface method of irrigation (435 days). [14] reported that the fruit setting took place 28 days earlier and the average harvesting period was less by 32 days in drip irrigation system. Compared to soil application of fertilizers, low concentrations of fertilizers are applied in more number of splits in fertigation. This enables a precise and uniform application of nutrients to the wetted area, where the active roots are focused resulting in continuous supply of nutrients according to demand, reducing the losses and enhancing the availability [15].

Table 2 Effect of nutrient level and fertigation schedule on plant height (cm)

Treatments	5 MAP	9 MAP	At flowering
Fertigation level (F)			
F_1	123.37	206.07	256.30
F_2	143.51	229.52	281.50
F_3	143.39	226.91	272.77
F_4	155.89	242.48	286.53
SE m (±)	1.727	2.32	1.81
CD (0.05)	5.066	6.804	5.316
Split application (S)			
S_1	130.04	211.87	261.55
S_2	133.12	216.03	265.36
S_3	161.47	250.84	295.91
SE m (±)	1.496	2.009	1.57
CD (0.05)	4.387	5.892	4.604

Interaction (F X S)			
F_1S_1	120.00	200.20	251.00
F_1S_2	125.00	210.00	257.87
F_1S_3	125.13	208.00	260.03
F_2S_1	126.00	207.07	265.00
F_2S_2	130.53	211.50	269.23
F_2S_3	174.00	270.00	310.27
F_3S_1	130.16	210.20	253.00
F_3S_2	132.00	214.33	260.23
F_3S_3	168.00	256.20	305.07
F_4S_1	144.00	230.00	277.20
F_4S_2	144.93	228.30	274.10
F_4S_3	178.73	269.16	308.30
SE m (±)	2.992	2.32	3.14
CD (0.05)	8.774	6.804	9.208
Treatment mean	141.54	226.20	274.27
Control mean	105.20	198.13	236.26
Control vs. treatments	S	S	S

Table 3 Effect of nutrient level and fertigation schedule on plant girth (cm)

Treatments	5 MAP	9 MAP	At flowering
Fertigation level (F)			
F_1	44.08	61.43	70.28
F_2	51.83	66.80	75.50
F_3	56.35	67.50	79.97
F_4	55.38	68.09	83.12
SE m (±)	1.488	1.444	1.285
CD (0.05)	4.364	4.236	3.769
Split application (S)			
S_1	48.87	63.85	72.52
S_2	49.34	62.31	75.87
S_3	57.52	71.70	83.26
SE m (±)	1.289	1.251	1.113
CD (0.05)	3.78	3.669	3.264

Interaction (F X S)			
F_1S_1	43.23	58.17	67.30
F_1S_2	44.00	62.03	73.27
F_1S_3	45.00	64.10	70.27
F_2S_1	48.20	66.17	71.07
F_2S_2	47.23	59.07	68.23
F_2S_3	60.07	75.17	87.20
F_3S_1	49.03	63.07	71.47
F_3S_2	57.00	69.17	82.17
F_3S_3	63.03	70.27	86.27
F_4S_1	55.00	68.00	80.27
F_4S_2	49.13	59.00	79.80
F_4S_3	62.00	77.27	89.30
SE m (±)	2.577	2.502	2.226
CD (0.05)	4.363	7.337	6.529
Treatment mean	51.91	65.95	77.21
Control mean	41.00	58.00	63.23
Control vs. treatments	S	S	S

Table 4 Effect of nutrient level and fertigation schedule on total functional leaf area (m^2)

Treatments	5 MAP	9 MAP	AT flowering
Fertigation level (F)			
F_1	2.33	5.60	7.02
F_2	5.04	10.21	16.43
F_3	5.89	10.29	20.05
F_4	5.79	9.52	19.94
SE m (±)	0.02	0.02	0.017
CD (0.05)	0.06	0.059	0.05
Split application (S)			
S_1	4.26	8.52	14.75
S_2	4.16	7.85	14.01
S_3	5.86	10.34	18.82
SE m (±)	0.018	0.017	0.015
CD (0.05)	0.052	0.051	0.043
Interaction (F X S)			

F_1S_1	2.71	6.05	7.30
F_1S_2	2.23	4.68	6.49
F_1S_3	2.04	6.05	7.25
F_2S_1	3.80	9.60	13.13
F_2S_2	3.72	9.27	14.03
F_2S_3	7.59	11.75	22.13
F_3S_1	4.87	9.63	16.51
F_3S_2	5.73	9.83	19.77
F_3S_3	7.05	11.40	23.86
F_4S_1	5.64	8.76	22.03
F_4S_2	4.96	7.64	15.76
F_4S_3	6.77	12.14	22.03
SE m (±)	0.035	0.035	0.03
CD (0.05)	0.104	0.102	0.087
Treatment mean	4.75	8.90	15.80
Control mean	2.37	5.70	8.43
Control vs. treatments	S	S	S

Table 5 Effect of nutrient level and fertigation schedule on days to shooting, shoot to harvest duration and crop duration

Treatments	Days to shooting	Shoot to harvest duration	Crop duration
Fertigation level (F)			
F_1	434.11	104.94	539.06
F_2	384.11	96.78	480.89
F_3	386.56	97.05	483.61
F_4	389.83	97.44	487.28
SE m (±)	2.158	1.371	2.343
CD (0.05)	6.328	4.022	6.87
Split application (S)			
S_1	417.79	99.79	517.58
S_2	405.12	101.00	506.12
S_3	373.04	96.37	469.42
SE m (±)	1.868	1.187	2.029
CD (0.05)	5.48	3.483	5.95

Interaction (F X S)			
F_1S_1	455.00	106.00	561.00
F_1S_2	422.67	105.00	527.67
F_1S_3	424.67	103.83	528.50
F_2S_1	413.33	100.00	513.33
F_2S_2	413.67	101.33	515.00
F_2S_3	325.33	89.00	414.33
F_3S_1	413.17	96.17	509.33
F_3S_2	412.33	99.00	511.33
F_3S_3	334.17	96.00	430.17
F_4S_1	389.67	97.00	486.67
F_4S_2	371.83	98.67	470.50
F_4S_3	408.00	96.66	504.67
SE m (±)	3.737	2.375	4.057
CD (0.05)	10.96	5.169	11.9
Treatment mean	398.65	99.05	497.70
Control mean	409.00	105.00	514.00
Treatment vs. Control	S	S	S

4. CONCLUSION

Assessment of the vegetative characters of cv. Red banana at 5 MAP, 9MAP and flowering stage has shown that there is significant difference among the characters on application of different nutrient level and fertigation scheduling. The plant height, pseudo stem girth, total functional leaf area was observed to be the highest for 120% recommended dose of N and K with application of fertilizers according to growth stage of crop (F_4S_3) which was on par with F_2S_3 and F_3S_3. The days to shooting, shoot to harvest and total crop duration was found to be the least for 80% recommended dose of N and K with application of fertilizers according to the growth stage of the crop (F_2S_3). Thus the overall growth characteristics of cv. Red banana was proved better with interaction effect of 80% recommended dose of N and K along with split application according to the growth stage of the crop (F_2S_3).

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