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Comparative Performance of Water Soluble and Routinely used Fertilizer with Respective to Different Fertigation Levels and Frequencies on Growth Parameters and Crop Duration of Banana cv. Grand Naine under Drip Irrigation

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Abstract

Field experiment with banana crop was conducted on moderately drained clayey soil which was classified earlier as "deep black soil" in Southern Gujarat. The study indicated that the fertilizer sources influenced significantly on growth parameters. Maximum plant height (3rd and 7th MAP), stem girth (3rd, 5th and 7th MAP), total leaf area (3rd and 5th MAP) was recorded with water soluble fertilizer (S_2). Moreover, fertilizer sources and fertigation frequencies failed to exert any significant effect on crop duration. Considering the effect of fertigation levels, *viz.*, 80 % RDF (L_3) and fertigation frequencies, *viz.,* fertigation applied at twice in a week (F_2) induced early and vigorous vegetative growth was observed in terms of plant height, stem girth, number of leaves and total leaf area at various stages of growth of banana i.e. at 3rd, 5th and 7th MAP, and after harvest in banana cv. Grand Naine. The treatment L_3 (80% RDF) was also found better with respect to crop duration parameters viz., early initiation of inflorescence, maturity of the fruit as well as total crop duration. In drip control vs. rest, all the rest of the treatments except 40% RDF (L_1) were recorded higher values in plant height. However, stem girth and total leaf area were recorded maximum in treatment S_2 (WSF), L_3 (80% RDF) and F_2 (twice in a week) as compared to drip control.

Keywords: Banana, Fertigation Levels and Frequencies, Morphological Characters and Crop Duration, Water Soluble and Routinely used Fertilizer

1. Introduction

Banana (*Musa paradisiaca* L.), which belongs to the family Musaceae in the order Scitamineae, have been associated with man for centuries and now one of the most important fruit crop of the world. Indeed many consider the banana to be one of man's first foods. In term of area and production of banana in India are 7.76 lakh hectares and 265.09 lakh tonnes, respectively. The highest productivity of 66.0 MT/ha in Madhya Pradesh followed by Gujarat (64.1 MT/ha). In Gujarat, banana covers an area of 0.70 lakh hectares with production of 45.23 lakh tonnes[1].

Adaption of new system for an easy, efficient and cost effective cultivation of banana with considerably minimum labor involvement for increasing productivity at lesser cost is essential. The use of soluble fertilizers through drip irrigation is one of the major advantages of the drip irrigation system. Along with drip irrigation, farmers are practicing fertigation using costly water soluble fertilizers. Because of this, the production cost of

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banana has increased considerably. On the other hand, the conventional fertilizers viz., urea and MoP available in market which can be prudently used through drip system. This will reduce the production cost of banana. Under South Gujarat situation, information related to conventional vs. water soluble fertilizer particularly in banana is not available. Hence, present investigation was carried out during 2011 to 2013.

2. Materials and Methods

The investigation was conducted at Soil and Water Management Research Farm, N.A.U., Navsari during 2011–12 and 2012–13. A field experiment with 12 treatment combinations comprising of two fertilizer sources (S_1: Routine fertilizers- Urea + orthophosphoric acid + MoP, S_2: Water soluble fertilizers -Urea, 12:61:00, 13:00:45), three fertigation levels in different percent of RDF (L_1: 80 %, L_2: 60 % and L_3: 40 %) and two fertigation frequencies (F_1: once in week and F_2: twice in week) along with one control i.e., drip control were tested in FRBD with three replications.

The height of plant was measured from soil level to the upper most points of contact of petioles of two youngest leaves as suggested by Lahav[2]. The circumference of pseudostem was measured with help of measuring tape at 20 cm above ground level. The leaf area was worked out as the multiplication of the product of length and breadth of the leaf with leaf area factor (0.8) suggested by Obiefuna and Ndubizu[3]. The total leaf area per plant was worked out as the multiplication of the leaf area and total number of leaves per plant. The number of days taken from planting to flowering was recorded and average days taken for flowering were calculated. The physiological maturity of the fruit was judged by observing the change in color of the skin from green to light green and disappearance of the triangular ridges of the fruits and counted days taken to harvest from initiation of inflorescence and mean was calculated. Total number of days required form planting to harvesting were calculated and their average mean was considered as total duration of crop.

P application was started after 21 days after planting and completed within 4.5 month (F_1 = 16 equal splits and F_2 = 32 equal splits). Application of N and K were started 35 DAP in which N was completed within 6.5 month. Application of K was completed within 7.5 month of planting (F_1 = 22 equal splits and F_2 = 44 equal splits).

2.1 Scheduling of NPK (Days)

21---**P**---35---**NPK**---50---**NP**---65---**NPK**---80---**NP**---95---**NPK**----110----**NPK**---140---**NK**----200---**K**----230.

2.2 Fertilizer Schedule for Drip Recommended Practices (Drip Control)

- P (SSP) in two equal splits i.e. 30 and 60 DAP (100% RD).
- 40% of N (Urea) and K (MoP) in two equal splits i.e. 30 and 60 DAP. While, remaining 60% N and K will applied in 6 equal splits at 15 days interval starting after three month of planting through drip (N and K 60% of RD).

3. Results and Discussion

3.1 Effect of Fertilizer Sources (S)

The results on fertilizer sources (s) in pooled analysis indicated that near to the all the results also found to be a non-significant except 3rd and 7th MAP in plant height and 3rd, 5th and 7th MAP in stem girth (Table 1). Fertilizers source failed to exert any significant influence on number of leaves per plant. While, in the case of total leaf area the pooled data shows that, fertilizer sources (s) were recorded significant results at 3rd MAP and 5th MAP and it was recorded maximum in water soluble fertilizers (S_2). However, during 7th MAP and at the time of harvest, non-significant results were recorded for total leaf area during individual year as well as in pooled analysis (Table 2).

During growth stages of banana, though the maximum values for plant height, stem girth, number of leaves and total leaf area were recorded with water soluble fertilizer treatment (S_2), yet in general it failed to manitest into any significant difference when compared with routinely used fertilizers (S_1-Urea; orthophophoric acid; MoP). The non significant differences in growth parameters observed between WSF (S_2) and RF (S_1) could be attribute to the:

- Similar availability at N, P and K to plant with both the sources *i.e.* S_1 and S_2 as in RF, orthophophoric acid (commercial grade) was used as source of P.
- Application of both the sources at higher frequency (more number of spilt) which might have synchronized with the demand of nutrient by plant.

Table 1. Effect of fertilizer sources, fertigation levels and fertigation frequencies on plant height (cm) and stem girth (cm) of banana cv. Grand Naine (pooled over two year)

Treatments		Plant height (cm)				Stem girth (cm)			
		3rd MAP	5th MAP	7th MAP	At harvest	3rd MAP	5th MAP	7th MAP	At harvest
Fertilizer sources (S)									
S_1 (RF)		56.00	142.28	188.67	226.97	31.87	42.17	55.44	61.07
S_2 (WSF)		58.58	146.31	194.81	230.42	33.41	43.52	57.64	63.31
SEm±		0.730	1.498	1.810	2.213	0.377	0.462	0.597	0.820
CD at 5%		2.08	NS	5.16	NS	1.07	1.32	1.70	NS
Fertigation levels (L)									
L_1 (40 % RDF)		49.79	133.46	173.46	219.25	29.27	38.55	52.10	58.02
L_2 (60 % RDF)		57.67	144.71	193.13	228.63	32.60	42.33	56.47	62.03
L_3 (80 % RDF)		64.42	154.71	208.63	238.21	36.04	47.65	61.06	66.53
SEm±		1.032	2.118	2.560	3.130	0.533	0.654	0.844	1.159
CD at 5%		2.94	6.04	7.30	8.92	1.52	1.86	2.41	3.30
Fertigation frequencies (F)									
F_1 (Once in a week)		55.47	140.92	187.94	224.44	31.61	41.79	55.20	60.78
F_2 (Twice in a week)		59.11	147.67	195.53	232.94	33.66	43.90	57.88	63.60
SEm±		0.730	1.498	1.812	2.213	0.377	0.462	0.597	0.820
CD at 5%		2.08	4.27	5.16	6.31	1.07	1.32	1.70	2.34
Treatment mean		**57.29**	**144.29**	**191.74**	**228.69**	**32.64**	**42.84**	**56.54**	**62.19**
Control vs. rest									
Drip control		**49.33**	**136.50**	**179.67**	**224.50**	**28.89**	**40.85**	**53.64**	**60.73**
Control vs. rest	SEm±	1.330	2.756	3.309	4.071	0.698	0.828	1.077	1.424
	CD at 5%	3.78	7.84	9.41	NS	1.99	2.35	3.06	4.05
Control vs. mean	SEm±	1.807	3.744	4.496	5.532	0.949	1.124	1.463	1.934
	CD at 5%	5.09	NS	NS	NS	2.67	NS	NS	NS
C. V. %		**7.65**	**6.23**	**5.66**	**5.81**	**6.93**	**6.47**	**6.34**	**7.91**

Table 2. Effect of fertilizer sources, fertigation levels and fertigation frequencies on number of leaves per plant and total leaf area (m^2) of banana cv. Grand Naine (pooled over two year)

Treatments	Number of leaves/plant				Total leaf area (m^2)			
	3rd MAP	5th MAP	7th MAP	At harvest	3rd MAP	5th MAP	7th MAP	At harvest
Fertilizer sources (S)								
S_1 (RF)	13.36	14.40	15.28	15.55	3.51	9.92	18.46	19.75
S_2 (WSF)	13.54	14.76	15.61	15.91	3.75	10.54	19.19	20.28
SEm±	0.127	0.132	0.156	0.140	0.065	0.14	0.262	0.193
CD at 5%	NS	NS	NS	NS	0.19	0.39	NS	NS
Fertigation levels (L)								
L_1 (40 % RDF)	12.60	13.71	14.46	14.75	3.05	9.16	17.20	18.24
L_2 (60 % RDF)	13.45	14.44	15.49	15.79	3.58	10.12	18.81	20.15
L_3 (80 % RDF)	14.30	15.58	16.37	16.65	4.27	11.41	20.46	21.67
SEm±	0.180	0.186	0.221	0.198	0.092	0.19	0.370	0.274
CD at 5%	0.51	0.53	0.63	0.56	0.26	0.55	1.06	0.78

(*Continued*)

Table 2. Continued

Treatments		Number of leaves/plant				Total leaf area (m^2)			
		3rd MAP	5th MAP	7th MAP	At harvest	3rd MAP	5th MAP	7th MAP	At harvest
Fertigation frequencies (F)									
F_1 (Once in a week)		13.25	14.29	15.25	15.49	3.46	9.84	18.48	19.60
F_2 (Twice in a week)		13.65	14.86	15.63	15.97	3.81	10.62	19.17	20.44
SEm±		0.127	0.132	0.156	0.140	0.065	0.14	0.262	0.193
CD at 5%		0.36	0.38	NS	0.40	0.19	0.39	NS	0.55
Treatment mean		**13.45**	**14.58**	**15.44**	**15.73**	**3.63**	**10.23**	**18.83**	**20.02**
Control vs. rest									
Drip control		**13.34**	**13.82**	**14.94**	**15.81**	**3.33**	**9.42**	**17.81**	**19.63**
Control vs. rest	SEm±	0.223	0.241	0.281	0.249	0.114	0.251	0.467	0.349
	CD at 5%	NS	0.68	NS	NS	0.33	0.71	1.33	0.99
Control vs. mean	SEm±	0.302	0.327	0.382	0.338	0.155	0.340	0.634	0.475
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
C. V. %		**5.69**	**5.42**	**6.06**	**5.33**	**10.80**	**8.06**	**8.35**	**5.80**

- Application of both the sources through drip system directly into the root zone which also enhance nutrient availability.

According to O' Neill et al.[4] phosphorous was delivered to greater soil volume when applied as orthophosphoric acid through a drip system than triple super phosphate applied as a soil amendment beneath each emitter. The orthophosphoric acid lowered enough the pH of irrigation water and to minimize clogging problems under drip irrigation. Regarding the crop duration, the non-significant result was observed with regard of fertilizers source (Table 3).

3.2 Effect of Fertigation Levels (L)

3.2.1 Effect on Morphological Characters

The maximum plant height (64.42, 154.71, 208.63 and 238.21), stem girth (36.04, 47.65, 61.06 and 66.53 cm), number of leaves (14.30, 15.58, 16.37 and 16.65), and total leaf area (4.27, 11.41, 20.46 and 21.67 M^2) were recorded with fertigation level of 80 % RDF (L_3) treatment and increased gradually with the period of growth *i.e.,* at 3rd, 5th, 7th MAP and at harvest, respectively as compared to 60 % RDF (Table 1 and 2).

During the study it was observed that, there was highly significant response to plant height and pseudostem girth at 80% RDF (L_3). This may be due to nitrogen is responsible for the formation, growth and development of the cells and accelerated the synthesis of chlorophyll and amino

Table 3. Effect of fertilizer sources, fertigation levels and fertigation frequencies on crop duration of banana cv. Grand Naine (pooled over two year)

Treatments	Crop duration (Days)		
	Days required for flower initiation	Days required for harvesting after flower initiation	Total crop duration (Days)
Fertilizer sources (S)			
S_1 (RF)	251.40	99.00	350.40
S_2 (WSF)	249.42	97.21	346.62
SEm±	2.159	0.967	2.160
CD at 5%	NS	NS	NS
Fertigation levels (L)			
L_1 (40 % RDF)	256.72	103.78	360.50
L_2 (60 % RDF)	251.54	96.97	348.51
L_3 (80 % RDF)	242.96	93.56	336.52
SEm ±	3.053	1.367	3.055
CD at 5%	8.70	3.90	8.71
Fertigation frequencies (F)			
F_1 (Once in a week)	251.90	99.10	351.00
F_2 (Twice in a week)	248.92	97.11	346.02
SEm±	2.159	0.967	2.160
CD at 5%	NS	NS	NS
Treatment mean	**250.41**	**98.11**	**348.51**

(*Continued*)

Table 3. Continued

Treatments		Crop duration (Days)		
		Days required for flower initiation	Days required for harvesting after flower initiation	Total crop duration (Days)
Control vs. rest				
Drip control		262.55	100.83	363.37
Control vs. rest	SEm ±	3.824	1.725	3.780
	CD at 5%	10.87	NS	10.75
Control vs. mean	SEm ±	5.196	2.344	5.137
	CD at 5%	NS	NS	NS
C. V. %		5.17	5.91	3.72

acid which are associated with major photosynthesis process of plants, it causes an increase in the formation of meristematic tissues. Mustaffa[5] reported that the nitrogen application at higher level significantly increased the girth of pseudostem. Oubahou et al.[6] revealed that at higher levels of N and K in 'Grand Naine' (Giant Cavendish) variety of banana increased the circumference of the pseudostem. Similar results were also reported by Upadhyay[7]; Mahalakshmi et al.[8]; Srinivas et al.[9]; Anon[10] and Anon[11].

The number of functional leaves and total leaf area were highest in treatment L_3 (80% RDF). This might be due to nitrogen enhance rate of vegetative growth, which resulted in earlier and maximum leaves. Similar results were reported by Mustaffa[5]; Mahalakshmi et al.[8]; Srinivas et al.[9]; Anon[10]; Anon[11]; Teaotia and Dubey[12] and Teaotia et al.[13]; and concluded that there was an increase in number of leaves with the application of highest level of N. Increased K fertilizer per plant caused significant increase in number of leaves in banana. According to Mahadevan[14], greater leaf area aids to plant to synthesize more metabolites, exhibiting high photosynthetic rate during the period of growth and development.

3.2.2 Effect on Crop Duration

Regarding the effect of fertigation levels, the treatment L_3 (80% RDF) resulted in reduced duration of days from planting to shooting, shooting to harvesting and total crop duration (Table 3). This was perhaps due to the regular availability of the nutrients, which results in early completion of vegetative growth, induce early flowering and subsequently bunch development. Significant reduction in number of days required for flowering and minimum days required for harvesting with the higher levels of nitrogen and potash were observed in banana. Similar results were also obtained by Mustaffa[5], Upadhyay[7], Srinivas et al.[9], Teaotia and Dubey[12] and Teaotia et al[13].

3.3 Effect of Fertigation Frequencies (F)

In present investigation, maximum plant height (59.11, 147.67, 195.53 and 232.94 cm), stem girth (33.66, 43.90, 57.88 and 63.60 cm), number of leaves (13.65, 14.86, 15.63 and 15.97) and total leaf area (3.81, 10.62, 19.17 and 20.44 m^2) was recorded in the treatment of fertigation applied at twice in a week (F_2) as compared to F_1 (once in a week) during 3rd, 5th, 7th MAP and at the time of harvest, respectively. This might be due to improved photosynthetic activity of plants might have enhanced the fertilizers use efficiency as influenced by different levels of fertigation and splits application. Higher frequencies of 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 Mahendran et al[15]. Similar findings were also reported by Mahalakshmi et al.[8], Chandrakumar et al.[16] and Guerra et al[17]. Scheduling fertilizers application on basis need offers the possibility of reducing nutrient element losses associated with conventional application Solaimalai et al[18]. Regarding the crop duration, the non-significant result was observed with regard of fertigation frequencies (Table 3).

3.4 Drip Control vs. Rest

3.4.1 Effect on Morphological Characters

In drip control vs. rest, plant height was recorded minimum in drip control as compared to rest of the treatment except 40% RDF. And stem girth and total leaf area were recorded minimum in drip control as compared to S_2, L_3 and F_2 (Table 1 and 2). In drip control vs. rest, non-significant result was observed with regard to number of leaves per plant. However, drip control vs. treatment mean had non-significant effect in all the growth parameters. This fact is supported by the works of Kavino et al.[19] and Pawar and Dingre[20] that the higher plant height, stem girth and greater leaf area is achieved with fertigation. The possible reasons for the difference in growth parameters in between control vs. rest might be due to application of fertilizer at higher frequency which was started earlier in rest of the treatments as compared to drip control. Second

factor is during the growing time all the macronutrient readily available to the plant because this nutrient easily soluble in water but in drip control SSP is used as source of P which is not easily readily available in soil.

3.4.2 Effect on Crop Duration

In between the comparison of control vs. rest analysis, earliness was recorded in treatment mean for flowering, flowering to harvesting and in total crop duration as compared to drip control (Table 3). The early flowering in drip fertigatied 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. Similar findings were also reported by Mahendran et al.[15], Pawar and Dingre[20].

4. Conclusion

In banana cv. Grand Naine the results of pooled data inferred that 80% RDF was found better with twice in a week frequency with respect to growth parameters. While in the comparison of fertilizer sources, routinely used fertilizers (RF) equally performed when compared with Water Soluble Fertilizers (WSF) and it was more profitable to the banana grower to the economic point of view.

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