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Standardization of precision farming practices for productivity enhancement in Banana

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ABSTRACT

An experiment was undertaken during March, 2015 to January, 2016 at farmer's field, Thiruvananthapuram, Kerala, India, to assess the influence of land management practices and lime application on the growth and yield of banana (var. Nendran) and to standardize its fertigation schedule for yield improvement. The difference between land management practices for precision farming and conventional cultivation and time of lime application did not impart any significant influence in banana yield. The different fertigation levels positively influenced the bunch weight plant^{-1} and yield ha^{-1} over soil application. The fertigation levels of 100 per cent and 60 per cent RD (recommended dose) of N and K (at weekly interval) along with soil application of P were observed to be on par and superior to 140 per cent RD.

Keywords : Fertigation, LAI, lime application, land management, precision farming, yield

Precision farming is considered as a novel approach to enhance productivity in a sustainable manner with better exploitation of available resources, without any adverse impact on the environment. Among the various requirements for precision agriculture, the need for expensive management practices has to be evaluated for specific crops to enhance its acceptability. The land management practice in precision farming of banana envisages deep ploughing to a depth of 50 cm, preparing raised beds and taking pits for planting. However, it was reported that the lateral root spread of banana is restricted to 20 cm and vertical or downward growth is limited to 30 cm (Sobhana e*t al.*, 1989). Hence the need for deep ploughing and raised bed preparation are to be evaluated.

Fertigation *i.e*., application of fertilizers along with irrigation water directly to the crop root zone has become one of the indispensible component of modern agriculture. Knowledge on correct dose of fertilizers and interval of fertigation is very important for saving fertilizers and to enhance productivity. Despite being a feasible method for application of fertilizers in banana, not much information is available on the correct quantity and interval of fertigation for yield improvement in banana.

Crop production in acidic soil is mostly limited by the unavailability of the nutrients due to low pH. Suresh (2009) reported addition of lime to adjust pH to the desired level as the common practice to enhance nutrient uptake and yield of wetland banana. Standardization of lime application in terms of time and rate, to get anticipated production has to be taken under consideration.

In view of the foresaid, the present investigation was carried out to assess the influence of land management practices and lime application on growth and yield of banana var. *Nendran* and to standardize a fertigation schedule for yield improvement in banana.

MATERIALS AND METHODS

The field experiment was carried out during the period from March 2015 to January 2016 in farmer's field at Pirappancode, Venjaramoodu, Thiruvananthapuram, Kerala. The experiment was laid out in split plot design with three replications. The main plot treatments included combination of land management (conventional land management (L_1) and land management for precision farming (L_2)) and time of lime application (C_1 – full dose as basal at the time of pit preparation and C_2 – applied in 2 equal splits (1/2 basal+1/2 4MAP)). The subplot treatments consisted of three levels of fertigation *viz*., 60 per cent RD of N and K (N_1), 100 per cent RD of N and K (N_2) and 140 per cent RD of N & K (N_3). Two controls were maintained, KAU *adhoc* recommendation for precision farming (control 1) and KAU POP (300:115:450 g NPK plant^{-1}, soil application of nutrients with conventional land management) (control 2), the details of control 1 and 2 are provided in table 1a and 1b.

The land management practices for precision farming comprised of deep ploughing up to 50 cm depth, raised beds of 30 cm height and taking pits of 50 x 50 x 50 cm size at 2 x 2 m spacing. Conventional land management practices included tilling the land and taking pits of 50 x 50 x 50 cm size at 2 x 2 m spacing.

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The soil type of experimental field was sandy clay loam with high organic carbon. pH was 3.2 coming under ultra-acidic range. Based on initial pH, the lime requirement was worked out as 340 g plant^{-1}. In C_1, the entire quantity was applied as single dose as basal at the time of pit preparation. In C_2, half of the quantity was applied as basal and the remaining amount was applied at 4 MAP.

Soil analysis revealed that major nutrients except P, were in medium range. P was in high range and Mg and B were found deficient. Uniform application of FYM @ 15 kg plant^{-1} was done as basal for all treatments. For supplying Mg and B, $MgSO_4$ and borax were added uniformly @ 32g plant^{-1} and 20 g plant^{-1}, respectively. Since P was analyzed to be high, only 75 per cent of recommendation was applied as rock phosphate (20% P_2O_5) uniformly for all treatments. Fertigation was carried out at weekly interval from the first month onwards for all treatments except control 1 and control 2. Sources of N and K for fertigation in n_1, n_2 and n_3 treatments were urea (46 % N) and MOP (60 % K). In control 1, fertigation was carried out once in four days using urea, MAP (11% N and 52% P) and SOP (50 % K). Fertigation was carried out using as injector unit.

Tissue culture plants of uniform age were planted in the centre of the pits. Except nutrient management, all other management practices were adopted as per POP recommendation (KAU, 2011).

Observations were taken at bimonthly intervals on plant height and plant girth up to 6 MAP and on leaf area index (LAI) up to 6 MAP and at harvest. The observations on yield attributes like number of hands bunch^{-1}, number of fingers bunch^{-1} and number of fingers D hand^{-1} were made at the time of harvest. Bunch weight plant^{-1} was recorded in kg and total bunch yield was worked out in t ha^{-1}.

RESULTS AND DISCUSSION

Land management practices (L) showed significant influence on plant height, plant girth and LAI at different stages of plant growth [Table 2]. Land management for precision farming (L_2) showed higher plant height at 2 and 4 MAP (80.36 cm and 203.18 cm, respectively), higher plant girth at 4 MAP (38.56 cm) and higher LAI at 2 and 4 MAP (0.09 and 0.71, respectively). The variation in LAI was not significant at 6 MAP and was higher in conventional land management practices (L_1) at harvest (0.90).

Varying the time of lime application (C) had no significant influence on the vegetative growth parameters. Different levels of fertigation (N) significantly influenced the plant height, plant girth and LAI at different stages of plant growth. Among the levels, fertigation with 100 per cent RD of N and K (N_2) recorded higher plant height, which was on par with 60 per cent RD of N and K (N_1) at 2 MAP. At 6 MAP, 100 per cent RD of N and K (N_2) registered higher plant height. Regarding the plant girth, 100% of RD of N and K (N_2) registered more girth and found to be on par with 60 per cent RD of N and K (N_1) at 2 and 6 MAP. The same level (100%) also recorded higher LAI at 2 and 6 MAP and harvest. In general, increasing N and K levels up to 100 per cent improved the vegetative growth characters. The results are in agreement with the findings of Sailaja (2013), who reported higher values of growth parameters in banana cv. *Martaman* under fertigation with 100 per cent RDF. She also observed that the variation between 100 per cent RDF and 75 per cent RDF was not significant.

Among interactions, cn interactions were found significant on LAI. At 4 MAP, basal application of lime in combination with 60 per cent RD of N and K (c_1n_1) registered significantly higher LAI, which was on par with split application of lime with fertigation of 60%, 100 per cent and 140 per cent RD of N and K (c_2n_1, c_2n_2 and c_2n_3). At harvest, c_2n_2 registered a higher value of 1.09 which was on par with c_1n_3.

Land management-fertigation interactions significantly influenced the plant height at 6 MAP and LAI at 2 MAP. Land management for precision farming in combination with 100 per cent RD of N and K (l_2n_2) improved the plant height and LAI over other treatments. Ideal soil conditions due to the pulverization of compacted soil in combination with intermittent but continuous supply of sufficient quantities of nutrients might have led to better uptake of nutrients thereby resulting in increased LAI.

Considering lcn interactions, significance was observed only on LAI at harvest, where precision farming land management practices in combination with split application of lime and fertigation with100 per cent RD of N and K ($l_2c_2n_2$), exhibited higher LAI which was on par with $l_1c_1n_3$, $l_1c_2n_2$, $l_1c_1n_2$ and $l_1c_2n_1$. In general, the variation between controls was not significant on the growth attributes. On comparing the controls and treatments, treatment mean recorded significantly higher values for plant height at 4 MAP, plant girth at 6 MAP and LAI at 6 MAP and harvest, over control 1. All the growth attributes registered lower values in control 2, where 100 per cent RD of nutrients was given as soil application.

The different treatments did not influence the number of hands bunch^{-1} and number of fingers bunch^{-1} (Table 3). However, number of fingers D hand^{-1} (9.89) was significantly influenced by land management practices for precision farming compared to conventional land management practices (9.42). The different levels of

Table 1a: Details of the fertigation schedule in control 1

Sources	Application			No. of fertigations
	Time	Amount (g plant^{-1})	Method	
Rock phosphate	**Basal**	**57.5**	**Soil**	**0**
Urea	from planting-60 DAP	8	fertigation	15
	61-120 DAP	14.2		15
	121-180 DAP	13.0		15
	181-280 DAP	3.6		25
MAP	from planting-60 DAP	4.4	fertigation	15
	61-120 DAP	6.6		15
SOP	from planting-60 DAP	10	fertigation	15
	61-120 DAP	17.5		15
	121-180 DAP	15.0		15
	181-280 DAP	4.7		25

Table 1b : Details of the fertigation schedule in control 2

Sources	Soil application	
	Time	Amount (g plant^{-1})
Rock phosphate	1 MAP	65
	3 MAP	50
Urea	1 MAP	50
	2 MAP	50
	3 MAP	50
	4 MAP	50
	5 MAP	50
	7 MAP (after bunch emergence)	50
MOP	1 MAP	65
	2 MAP	65
	3 MAP	65
	4 MAP	65
	5 MAP	65
	7 MAP (after bunch emergence)	125

fertigation significantly influenced the bunch weight and yield ha^{-1} (Table 3). The higher bunch weight (12.34 kg) and total yield (30.84 t ha^{-1}) were observed with 100 per cent RD of N and K (N_2), which was *on par* with 60 per cent RD of N and K (N_1). Improvement in growth attributes like plant height, plant girth and LAI under fertigation with 100 per cent RD of N and K might have contributed to enhanced photosynthetic rate leading to higher bunch weight and yield ha^{-1}. Similar results of increased bunch weight and yield ha^{-1} with 100 per cent RD of fertilizer by drip fertigation was reported by Kumar *et al*. (2009) in *Basrai* (AAA) variety of banana and Pawar and Dingre (2013) in banana cv. Grand Naine, respectively.

No significant difference was observed between two controls and control 1 and treatments on number of hands bunch^{-1}, number of fingers bunch^{-1} and number of fingers D hand^{-1}. However, the variation between control 2 and treatments on number of hands bunch^{-1} was significant, where treatments registered a higher value over control 2 (4.94 and 4.5, respectively). Similar increase in number of hands bunch^{-1} in fertigation treatments over soil application of fertilizers was reported by Kumar *et al*. (2009) in *Basrai* (AAA) variety of banana.

The difference between control 1 and control 2 on bunch weight and total yield ha^{-1} was significant and control 1 registered higher values over control 2 (10.86 kg, 27.16 t ha^{-1} and 8.68 kg, 21.71 t ha^{-1} respectively). Comparing treatments and control 2, treatments significantly improved the bunch weight and total yield ha^{-1} over control 2 (11.69 kg, 29.22 t ha^{-1} and 8.68 kg, 21.71 t ha^{-1}). All the treatments and control 1 were found superior to control 2. Improvement in yield in KAU *adhoc* recommendation for precision farming over conventional practices was to the tune of 25.12 per cent, while the improvement in treatments over control 2 was 34.68 per cent. This increase in yield could be attributed to the beneficial effect of drip fertigation, where the availability of sufficient quantity of nutrients throughout the crop growth stage might have improved the crop growth and nutrient uptake resulting in higher yield. The results are in accordance with the findings of Bhalerao *et al* (2010) who also reported higher yield in banana cv. *Grand Naina* with fertigation compared to soil application of nutrients. The variation between drip fertigation treatments and KAU *adhoc* recommendation for precision farming was found not significant.

Based on the results of the study, it could be inferred that land management practices and time of application of lime did not have any influence on yield of banana var. *nendran*. The long term effect of land management practices needs further investigation. Fertigation treatments showed positive effect on banana yield over non fertigation treatments. Higher bunch weight and yield ha^{-1} were observed in fertigation with 100 per cent RD of N and K, which was *on par* with 60 per cent RD of N and K. Based on this study, it could be inferred that the conventional land management practices, application of entire quantity of lime as basal along with fertigation of 60 per cent RD of N ad K and soil application of P is sufficient for yield improvement in banana under precision farming.

Table 2: Effect of different management practices, on plant height, plant girth and LAI

Treatments	Plant height			Plant girth			LAI			HARVEST
	2MAP	4 MAP	6 MAP	2 MAP	4 MAP	6 MAP	2 MAP	4 MAP	6 MAP	
Land management										
l_1	62.10	165.59	244.01	10.17	32.89	61.47	0.04	0.55	0.30	0.90
l_2	80.36	203.18	247.65	11.54	38.56	63.78	0.09	0.71	0.33	0.78
SEm(±)	**3.388**	**9.596**	**2.999**	**0.509**	**0.937**	**0.508**	**0.007**	**0.042**	**0.007**	**0.025**
LSD(0.05)	**11.723**	**33.207**	**NS**	**NS**	**3.242**	**NS**	**0.02**	**0.146**	**NS**	**0.09**
Lime application										
c_1	73.83	183.26	245.75	11.04	34.67	63.60	0.07	0.61	0.32	0.81
c_2	68.62	185.52	245.92	10.67	36.78	61.65	0.06	0.64	0.31	0.88
SEm(±)	**3.388**	**9.596**	**2.999**	**0.509**	**0.937**	**0.508**	**0.007**	**0.042**	**0.007**	**0.025**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Fertigation										
n_1	77.94	181.63	234.75	11.00	35.62	62.98	0.06	0.69	0.29	0.70
n_2	80.08	196.90	267.00	12.10	37.79	65.55	0.09	067	0.35	0.97
n_3	55.67	174.64	235.75	9.46	33.75	59.35	0.04	0.52	030	0.85
SEm(±)	**4.190**	**10.430**	**4.313**	**0.539**	**1.848**	**1.020**	**0.009**	**0.060**	**0.016**	**0.042**
LSD(0.05)	**12.562**	**NS**	**12.932**	**1.616**	**NS**	**3.058**	**0.030**	**NS**	**0.047**	**0.125**
Interaction										
l_1c_1	62.83	172.52	245.64	10.06	33.33	63.14	0.04	0.55	0.32	0.87
l_1c_2	61.36	158.67	242.39	10.28	32.44	59.80	0.04	0.55	0.28	0.93
l_2c_1	84.83	194.00	245.86	12.03	36.00	64.06	0.11	0.68	0.32	0.74
l_2c_2	75.89	212.37	249.44	11.06	41.12	63.50	0.07	0.74	0.33	0.82
SEm(±)	**4.791**	**13.570**	**4.241**	**0.720**	**1.325**	**0.718**	**0.011**	**0.060**	**0.011**	**0.035**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 2 Contd.... 5

Table 2 From page 4

Treatments	**Plant height**			**Plant girth**			**LAI**			**HARVEST**
	2MAP	**4 MAP**	**6 MAP**	**2 MAP**	**4 MAP**	**6 MAP**	**2 MAP**	**4 MAP**	**6 MAP**	
c_1n_1	83.25	190.67	238.71	11.92	36.83	64.45	0.07	0.81	0.30	0.63
c_1n_2	77.50	185.75	268.21	11.12	34.00	65.93	0.10	0.55	0.35	0.85
c_1n_3	60.75	173.37	230.33	10.08	33.17	60.42	0.05	0.48	0.31	0.93
c_2n_1	72.62	172.58	230.79	10.08	34.42	61.50	0.06	0.58	0.28	0.77
c_2n_2	82.67	208.00	265.79	13.08	41.58	65.17	0.08	0.79	0.36	1.09
c_2n_3	50.58	175.92	241.17	8.83	34.34	58.28	0.04	0.56	0.29	0.77
SEm(±)	**5.926**	**14.750**	**6.099**	**0.762**	**2.613**	**1.442**	**0.013**	**0.084**	**0.022**	**0.060**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.251**	**NS**	**0.177**
l_1n_1	73.38	172.42	238.21	11.25	34.42	61.95	0.05	0.63	0.29	0.76
l_1n_2	63.50	164.25	254.42	10.50	33.25	63.52	0.04	0.52	0.31	1.00
l_1n_3	49.42	160.12	239.42	8.75	31.00	58.95	0.03	0.51	0.30	0.95
l_2n_1	82.50	190.83	231.29	10.75	36.83	64.00	0.08	0.76	0.28	0.65
l_2n_2	96.67	229.55	279.58	13.71	42.33	67.58	0.14	0.82	0.40	0.94
l_2n_3	61.92	189.17	232.08	10.17	36.51	59.75	0.05	0.54	0.30	0.76
SEm(±)	**5.926**	**14.750**	**6.099**	**0.762**	**2.613**	**1.442**	**0.013**	**0.084**	**0.022**	**0.060**
LSD(0.05)	**NS**	**NS**	**18.286**	**NS**	**NS**	**NS**	**0.039**	**NS**	**NS**	**NS**
$l_1c_1n_1$	83.67	183.17	242.08	12.17	37.83	63.73	0.07	0.80	0.32	0.58
$l_1c_1n_2$	55.83	165.83	259.00	9.00	30.67	65.03	0.03	0.42	0.33	0.95
$l_1c_1n_3$	49.00	168.57	235.83	9.00	31.50	60.67	0.02	0.43	0.31	1.08
$l_1c_2n_1$	63.08	161.67	234.33	10.33	31.00	60.17	0.03	0.45	0.27	0.93
$l_1c_2n_2$	71.17	162.67	249.83	12.00	35.83	62.00	0.06	0.61	0.29	1.05
$l_1c_2n_3$	49.83	151.67	243.00	8.50	30.50	57.23	0.04	0.58	0.29	0.81
$l_2c_1n_1$	82.83	198.17	235.33	11.67	35.83	65.17	0.08	0.82	0.27	0.68
$l_2c_1n_2$	99.17	205.67	277.42	13.25	37.33	66.83	0.17	0.67	0.37	0.75
$l_2c_1n_3$	72.50	178.17	224.83	11.17	34.83	60.17	0.07	0.53	0.31	0.78
$l_2c_2n_1$	82.17	183.50	227.25	9.83	37.83	62.83	0.08	0.70	0.29	0.61
$l_2c_2n_2$	94.17	253.43	281.75	14.17	47.33	68.33	0.11	0.96	0.42	1.13
$l_2c_2n_3$	51.33	200.17	239.33	9.17	38.18	59.33	0.03	0.55	0.30	0.73
SEm(±)	**8.380**	**20.860**	**8.627**	**1.077**	**3.696**	**2.039**	**0.018**	**0.118**	**0.032**	**0.084**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.251**
Treatment mean	71.23	184.39	245.83	10.85	35.72	62.63	0.07	0.63	0.31	0.84
Control 1 mean	53.50	131.50	241.00	10.33	29.17	56.00	0.05	0.48	0.17	0.62
Control 2 mean	40.33	118.50	209.00	7.83	25.33	50.33	0.02	0.27	0.16	0.55
Control 1 vs. Control 2	NS	NS	S	NS	NS	NS	NS	NS	NS	NS
Control 1 vs. Treatment	NS	S	NS	NS	NS	S	NS	NS	S	S
Control 2 vs. Treatment	S	S	S	S	S	S	S	S	S	S

Table 3: Effect of different management practices, on yield attributing characters and yield.

Treatments	Number of hands bunch^{-1}	Number of fingers bunch^{-1}	Number of fingers in D hand	Bunch weight (kg plant^{-1})	Yield (t ha^{-1})
Land management					
l_1	4.92	42.53	9.42	11.45	28.62
l_2	4.97	43.11	9.89	11.93	29.83
SEm(±)	**0.044**	**0.851**	**0.037**	**0.115**	**0.287**
LSD (0.05)	**NS**	**NS**	**0.316**	**NS**	**NS**
Lime application					
c_1	5.06	42.40	9.72	11.90	29.75
c_2	4.83	43.25	9.58	11.48	28.70
SEm(±)	**0.044**	**0.851**	**0.037**	**0.115**	**0.287**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
Fertigation					
n_1	4.92	40.79	9.50	11.49	28.72
n_2	4.88	44.96	9.92	12.34	30.84
n_3	5.04	42.71	9.54	11.25	28.12
SEm(±)	**0.082**	**1.402**	**0.138**	**0.295**	**0.739**
LSD (0.05)	**NS**	**NS**	**NS**	**0.886**	**2.215**
Interaction					
l_1c_1	5.06	42.33	9.44	11.60	29.00
l_1c_2	4.78	42.72	9.39	11.30	28.24
l_2c_1	5.06	42.44	10.00	12.20	30.49
l_2c_2	4.89	43.78	9.78	11.67	29.16
SEm(±)	**0.062**	**1.203**	**0.053**	**0.162**	**0.406**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
c_1n_1	5.17	42.50	9.75	12.25	30.62
c_1n_2	4.83	41.83	9.75	12.02	30.04
c_1n_3	5.17	42.83	9.67	11.43	28.57
c_2n_1	4.67	39.08	9.25	10.73	26.81
c_2n_2	4.92	48.08	10.08	12.66	31.64
c_2n_3	4.92	42.58	9.42	11.07	27.66
SEm(±)	**0.115**	**1.983**	**0.195**	**0.418**	**1.045**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
l_1n_1	4.92	41.75	9.17	11.42	28.54
l_1n_2	4.83	43.25	9.58	11.91	29.78
l_1n_3	5.00	42.58	9.50	11.02	27.54
l_2n_1	4.92	39.83	9.83	11.56	28.90
l_2n_2	4.92	46.67	10.25	12.76	31.90
l_2n_3	5.08	42.83	9.58	11.48	28.70
SEm(±)	**0.115**	**1.983**	**0.195**	**0.418**	**1.045**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**

Table 3 Contd. ... 7

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Treatments	Number of hands bunch^{-1}	Number of fingers bunch^{-1}	Number of fingers in D hand	Bunch weight (kg plant^{-1})	Yield (t ha^{-1})
$l_1c_1n_1$	5.17	42.83	9.50	12.08	30.20
$l_1c_1n_2$	4.83	41.00	9.33	11.58	28.96
$l_1c_1n_3$	5.17	43.17	9.50	11.13	27.83
$l_1c_2n_1$	4.67	40.67	8.83	10.75	26.87
$l_1c_2n_2$	4.83	45.50	9.83	12.24	30.61
$l_1c_2n_3$	4.83	42.00	9.50	10.90	27.25
$l_2c_1n_1$	5.17	42.17	10.00	12.41	31.04
$l_2c_1n_2$	4.83	42.67	10.17	12.45	31.12
$l_2c_1n_3$	5.17	42.50	9.83	11.72	29.32
$l_2c_2n_1$	4.67	37.50	9.67	10.70	26.75
$l_2c_2n_2$	5.00	50.67	10.33	13.07	32.67
$l_2c_2n_3$	5.00	43.17	9.33	11.23	28.08
SEm(±)	**0.163**	**2.804**	**0.276**	**0.591**	**1.477**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
Treatment total	4.94	42.82	9.65	11.69	29.22
Control 1 mean	4.83	41.67	9.67	10.86	27.16
Control 2 mean	4.5	40.5	9.17	8.68	21.71
Control 1 vs. Control 2	NS	NS	NS	S	S
Control 1 vs. Treatment	NS	NS	NS	NS	NS
Control 2 vs. Treatment	S	NS	NS	S	S

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