Nutrient and water management strategy as a tool for enhancing yield and water productivity in banana variety nendran *(Musa* Spp.*)*

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Abstract
A research study entitled "Soil nutrient dynamics under varying moisture regimes in banana" was conducted at Agronomic Research Station, Kerala Agricultural University, Chalakudy during the period of 2016-2018 with the objective of studying the optimum nutrient requirement under different irrigation levels of banana variety Nendran.The experiment was laid out in factorial RBD with two levels of irrigation and six levels of fertilizer treatments. The irrigation methods used were basin irrigation at 100 per cent pan evaporation (PE)(I_1) and drip irrigation at 75per cent PE at two days interval (I_2). The fertilizer treatments were 100 per cent recommended dose of NPK 190:115:300g/plant (KAU, 2016) (T_1), 100:100:125 per cent NPK (T_2), 100:75:100 per cent NPK (T_3), 100:75:125 per cent NPK (T_4), 100:50:100 per cent NPK (T_5), 100:50:125 per cent NPK (T_6). Observations were taken on different parameters for three years and pooled analysis of data had shown that application of P at 75 per cent and K at 125 per cent (T4) of recommended dose of fertilizer gave significantly higher yield. Between the irrigation treatments, basin irrigation (100% PE) resulted in significantly higher yield than drip irrigation. Drip irrigation at 75 per cent PE could save irrigation water and recorded significantly higher water productivity. Considering the economics of cultivation and B:C ratio, the treatment with P at 75 per cent and K at 125 per cent NPK recorded significantly higher value than all other treatments whereas the individual effect of irrigation treatments and interaction effect of irrigation and fertilizer treatments were statistically on par.

Key words: Banana, Irrigation, Nutrient management, Water productivity

Introduction

Banana (*Musa* spp.) commonly known as '*Poor man's apple*' is a major staple food crop for millions of people and it is mainly cultivated in tropical and sub-tropical regions of the world. It is recognized as the fourth most important food in world after paddy, wheat and milk products in terms of gross value (FAOSTAT, 2006). Banana production in India is 33062 MT from an area of 924000 ha and the productivity is 36.74 MT/ha (FAOSTAT, 2021). The major banana growing states in India are Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Madhya Pradesh, Bihar and West Bengal (Anon., 2010).

Banana is the major fruit crop of Kerala and the term 'fruit' is synonymous to "banana" here. The steady demand for banana due to its varied uses and wide adaptability to different farming situations makes it the most preferred crop of Kerala farmers. Among banana varieties, Nendran is the most popular one with multiple benefits like wide adaptability, affordability, year-round availability,

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yield stability and high nutritive value (Uma et al., 2015). The crop is sensitive to even slight variations in soil water content and that irrigation scheduling are critical in realizing better growth and yield. Also, banana variety Nendran is a heavy feeder of nutrients (Bashma et al., 2019). The rate of nutrient uptake is very high as compared to many other crops. Hence water and nutrient management plays a major role in the productivity of the crop (Pillai et al., 1977).

Presently, farmers are dumping heavy doses of fertilizers containing major and micronutrients to banana crop. This has resulted in the occurrence of several nutritional disorders, pest and disease incidences. Environmental hazards like eutrophication problems are also associated with such indiscriminate use of fertilizers. Rahman and Debnath (2015) stated that the massive application of agrochemicals in agricultural fields cause incurable risks on ecosystem and human health. Hence it is very urgent at this hour, to study the exact and quantity of fertilizer application particularly that of major nutrients along with the assessment of optimum soil moisture. Under these circumstances, a research study was conducted at Agronomic Research Station, Kerala Agricultural University, Chalakudy during the period 2016-2018 to study water and nutrient management in banana variety Nendran.

Materials and methods

The experiment was conducted for three consecutive years during 2016 to 2018 at Agronomic Research Station, Kerala Agricultural University, Chalakudy. It was laid out in factorial RBD with the objective of studying the optimum nutrient requirement under different irrigation levels for Nendran variety of banana. The soil was acidic with sandy clay loam texture. Field preparations was done by ploughing and pits of size 50 cm x 50 cm was made for planting. Applied 500g of lime followed by cattle manure @ 10 kg/plant in the pit. Healthy suckers of 3-4 months-old were planted during the month of November at a spacing of 2m x 2m. The treatment combination included two types of irrigation and six levels of fertilizer doses. The twelve treatments were replicated thrice and six plants were maintained in each replication. The irrigation systems were basin irrigation (I_1) at 100 per cent PE and drip irrigation at 75 per cent PE (I_2). Two drippers with discharge rate of 8 l/h were used to discharge water to each plant. The irrigation water requirement was calculated using the formula, (Ertek, 2011).

IR = E_{pan} x Pan coefficient x Crop coefficient (k_c) x row spacing x plant spacing x Percentage wetted area

IR = irrigation requirement (m^3)

E_{pan} = pan evaporation from US class A open pan evaporimeter (mm)

Crop coefficient (k_c)-

- Initial stage (0-2 months)- 0.50
- Middle stage (2-6 months)- 1.10
- Final stage (more than 6 months)- 1.00

Pan coefficient = 0.80

Wetted area-

- up to 2 months after planting - 10% of total area ($4m^2$)

Time of application	N: $P_2 0_5$: K_2O (g/plant)					
	T_1	T_2	T_3	T_4	T_5	T_6
One month after planting	40:65:60	40:65:75	40:49:60	40:49:75	40:33:60	40:33:75
Two months after planting	30:50:60	30:50:75	30:38:60	30:38:75	30:25:60	30:25:75
Three months after planting	30:00:60	30:00:75	30:00:60	30:00:75	30:00:60	30:00:75
Four months after planting	30:00:60	30:00:75	30:00:60	30:00:75	30:00:60	30:00:75
Five months after planting	30:00:60	30:00:75	30:00:60	30:00:75	30:00:60	30:00:75
Just after complete emergence of bunch	30:00:00	30:00:00	30:00:00	30:00:00	30:00:00	30:00:00
Total	190:115:300	190:115:375	190:87:300	190:87:375	190:58:300	190:58:375

Soil samples were collected and analyzed. Observations on different parameters were recorded and tabulated.

- 2-6 months - 60% of total area
- After 6 months - 100% of total area

The fertilizer treatments were 100 per cent recommended NPK (190: 115:300g/ plant) (KAU, 2016) (T_1), 100:100:125 per cent NPK (T_2), 100:75:100 per cent NPK (T_3), 100:75:125 per cent NPK (T_4), 100:50:100 per cent NPK (T_5) and 100:50:125 per cent NPK (T_6) applied as urea, rock phosphate and muriate of potash. Treatments were applied as per the Package of practices recommendations of Kerala Agricultural University (POP 2016). Details are given above.

Results and discussion

The observations on yield parameters for three years are given in the Tables 1, 2 and 3. Analysis of the data for three years showed that application of P at 75 per cent and K at 125 per cent (T_4) of recommended dose of fertilizer recorded significantly higher banana yield when compared to other treatments. It was also seen that higher level of K (125 %) always resulted in better yield at all the three levels of P (Table5.). The higher dose of K fertilizers imparted disease resistance to the crop leading to higher economic yield. This statement was supported by the results of experiments conducted in different fruit crops including banana by Ganeshamurthy et al. (2011) in which they have mentioned potassium as one of the most important plant nutrients which has a significant influence in improving resistance to diseases such as leaf spot and banana wilt. Reducing the level of P below 75 per cent reduced the yield considerably as in the case of first and second year. Observations on yield parameters such as D finger characters showed better performance in the treatment T_4. Pooled

Table 1. Effect of irrigation methods and fertilizer levels on yield of banana (kg/plant) during 2016

Factor-B Fertilizer levels	FactorA- irrigation methods		Mean
	Basin	Drip at 75%PE	
NPK-100-100-100	6.55	7.33	6.94
NPK-100-100-125	7.77	7.69	7.73
NPK-100-75-100	7.92	6.62	7.27
NPK-100-75-125	8.77	7.53	8.15
NPK-100-50-100	7.63	6.64	7.13
NPK-100-50-125	7.77	7.25	7.51
Mean	7.73	7.17	

CD (0.05) - Factor-A-0.171 Factor-B-0.296
A XB -0.419 CV- 3.319

Table 2. Effect of irrigation methods and fertilizer levels on yield of banana (kg/plant) during 2017

Factor-B Fertilizer levels	FactorA- irrigation methods		Mean
	Basin	Drip at 75%PE	
NPK-100-100-100	8.89	7.68	8.29
NPK-100-100-125	9.32	8.68	9.00
NPK-100-75-100	9.27	8.24	8.76
NPK-100-75-125	9.59	8.18	8.89
NPK-100-50-100	8.63	7.46	8.05
NPK-100-50-125	9.07	7.70	8.38
Mean	9.13	7.99	

CD (0.05) - Factor-A- 0.160 Factor B - 0.277
AXB - 0.391 CV- 2.699

Table 3. Effect of irrigation methods and fertilizer levels on yield of banana (kg/plant) during 2018

Factor-B Fertilizer levels	FactorA- irrigation methods		Mean
	Basin	Drip at 75%PE	
NPK-100-100-100	6.38	6.56	6.47
NPK-100-100-125	6.35	5.20	5.78
NPK-100-75-100	6.59	6.43	6.51
NPK-100-75-125	7.56	7.25	7.40
NPK-100-50-100	6.38	7.14	6.76
NPK-100-50-125	5.98	6.31	6.15
Mean	6.54	6.48	

CD (0.05)-Factor-A-NSFactor B-1.343 CV-17.227

Table 4. Effect of irrigation methods and fertilizer levels on soil chemical properties of banana pooled for three years

Treatments	pH	Org C	P(kg/ha)	K((kg/ha)
Basin irrigation				
NPK-100-100-100	5.02	1.11	128.27	131.75
NPK-100-100-125	4.88	1.14	105.89	76.91
NPK-100-75-100	4.90	1.21	122.35	130.70
NPK-100-75-125	4.97	1.06	117.83	94.34
NPK-100-50-100	4.98	1.04	99.62	88.89
NPK-100-50-125	5.00	0.98	99.76	173.90
Drip irrigation				
NPK-100-100-100	5.30	1.28	97.63	138.84
NPK-100-100-125	5.18	1.30	87.26	129.10
NPK-100-75-100	5.11	1.21	121.98	92.00
NPK-100-75-125	5.03	1.19	87.73	111.44
NPK-100-50-100	5.08	1.25	85.88	209.21
NPK-100-50-125	5.08	1.32	79.84	104.57

Table 5. Effect of irrigation methods and fertilizer levels on yield, Irrigation water productivity and economics of banana pooled for three years

Treatments	Yield /plant (bunch wt. in kg)	Yield (kg/ha)	Water used in ha. cm	IWP (kg/ha. cm)	Net returns in Rs. Per ha	BC ratio
Irrigation						
Basin(I_1)	7.78	19458.49	71.00	274.06	604046.71	2.30
Drip-75% PE (I_2)	7.17	18123.50	53.25	340.35	560682.61	2.29
CD (0.05)	0.34	845.20		13.93	NS	NS
Fertilizer levels						
NPK-100-100-100(F_1)	7.20	17995.14		294.98	536793.75	2.19
NPK-100-100-125(F_2)	7.42	18542.85		302.02	564855.67	2.24
NPK-100-75-100(F_3)	7.33	18921.30		309.23	590612.41	2.31
NPK-100-75-125(F_4)	8.28	20708.10		336.87	686824.52	2.52
NPK-100-50-100(F_5)	7.37	18419.68		302.36	565903.29	2.27
NPK-100-50-125(F_6)	7.26	18158.88		297.76	549198.34	2.22
CD (0.05)	0.59	1463.93		24.13	80483.38	0.18
Irrigation x fertilizer						
I_1x F_1	7.32	18298.61	71.00	257.73	538623.61	2.15
I_1x F_2	7.87	19681.53	71.00	277.21	612184.39	2.30
I_1x F_3	7.86	19636.57	71.00	276.57	615091.58	2.32
I_1x F_4	8.86	22159.26	71.00	312.10	751339.32	2.61
I_1x F_5	7.42	18551.39	71.00	261.29	558286.39	2.21
I_1x F_6	7.37	18423.55	71.00	259.49	548754.97	2.18
I_2x F_1	7.08	17691.67	53.25	332.24	534963.89	2.22
I_2x F_2	6.96	17404.17	53.25	326.84	517526.94	2.18
I_2x F_3	6.81	18206.02	53.25	341.90	566133.24	2.30
I_2x F_4	7.70	19256.94	53.25	361.63	622309.72	2.43
I_2x F_5	7.32	18287.96	53.25	343.44	573520.19	2.33
I_2x F_6	7.16	17894.21	53.25	336.04	549641.71	2.27
CD (0.05)	NS	NS		NS	NS	NS

analysis of the experiment data for three years showed that bunch yield and other yield parameters were significantly highest for the treatment in which P at 75 per cent and K at 125 per cent (T_4) of recommended dose of fertilizer was applied (Table 4.). The results also emphasize that reducing P to 75 % is a better option to increase the yield and profit of farmers in soils high in available P status. The initial status of available P in soil was high (80.06 kg/ha) and hence reducing the level of P to 75 per cent of RDF was optimum. Accordingly, the recommendation of P_2O_5 could be reduced to 86 g/ plant instead of the present 115 g/plant. Navaneetha krishnan et al. (2016) also found that when two levels of phosphorus (60 g and 90 g per plant) were used in banana, the treatment with 60 g P_2O_5 recorded significantly higher bunch weight, number of hands per bunch, hand weight and number of fingers per bunch.

As banana is a potassium loving fruit crop, the crop responded well to a higher level of potassium fertilizer (125 per cent). Ganeshamoorthy *et al*. (2011) also reported that providing potassium at higher rate can enhance the yield and quality of fruits as the nutrient removal of phosphate and potash by banana is 1.3 and 20.3 kg/tonne of produce respectively. This shows the importance of providing high amount of potassium and reducing the amount of phosphorus in banana. Hence increasing the amount of potassium fertilizers could be concluded as beneficial to banana for increasing the yield.

Between the irrigation treatments, basin irrigation (100% PE) resulted in significantly higher yield than drip irrigation at 75% PE (Table 1 and 2). This suggests that water requirement for banana is very high. Banana, being a succulent water loving plant, responds well to irrigation. Bhattacharya and

Madhava Rao (1985) stated that banana needs a plentiful supply of water for its higher production and growing banana under marginal water supply may undergo uneconomical to the farmers. As water being a limited resource, its efficient use is inevitable. Drip irrigation at 75 per cent pan evaporation could save irrigation water and it recorded higher water productivity (Table 5). The study conducted during 2018 showed that bunch yield was found statistically on par when banana was grown in 100 % irrigation through basin and 75 % irrigation through drip (Table 3). Pooled analysis of the experiment data for three years showed that bunch yield and other yield parameters were significantly highest for the treatment; basin irrigation with 100 % PE (Table 4). According to Pramanik and Patra (2016), drip irrigation at 60% CPE recorded higher irrigation water use efficiency in banana compared to surface irrigation. They also reported that water saving of 41.7% for plant and 40.4% for ratoon crop of banana was observed when drip irrigation was used.

Considering the economics of cultivation and B:C ratio, the treatment with P at 75 per cent and K at 125 per cent of Recommended Dose of Fertilizer (RDF) recorded significantly higher value than all other treatments whereas the individual effect of irrigation treatments and interaction effect of irrigation and fertilizer treatments were statistically on par.

The study on soil nutrient dynamics under varying moisture regimes in banana has shown that P at 75 per cent and K at 125 per cent of Recommended Dose of Fertilizer (RDF) can increase yield to an extent of 15.2 per cent over the present recommendation. The results suggest that the recommendation of P_2O_5 could be reduced to 86 g/ plant instead of the present 115 g/plant because in all the treatments it was observed that the phosphorus content in soil was optimum (Table 6). Reducing the level of P below 75 per cent reduced the yield considerably. Considering the irrigation methods, basin irrigation with 100 % PE recorded significantly higher yield. But the water productivity was found to be highest for drip irrigation with 75 % PE.

Table 6. Effect of irrigation methods and fertilizer levels on P content (kg/ ha) in soil after harvest

Factor-A Fertilizer levels	FactorB- irrigation methods		Mean
	Basin	Drip at 75%PE	
NPK-100-100-100	128.27	97.63	112.95
NPK-100-100-125	105.89	87.26	96.58
NPK-100-75-100	122.35	121.98	112.17
NPK-100-75-125	117.83	87.73	102.78
NPK-100-50-100	99.62	85.88	92.75
NPK-100-50-125	99.76	79.84	89.80
	112.29	93.39	102.84
CD (0.05) – Irrigation – 11.51 Fertilizer- 19.93			

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