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Effect of integrated nutrient management on growth and yield of banana Cv. Grand Naine (AAA) (ratoon crop)

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Abstract
The present investigation was carried out during 2018-2019 at Horticultural Research Station, Aswaraopet, Bhadradri Kothagudem district, Telangana State. The experiment was carried by planting tissue culture banana Cv. Grand Naine plants at spacing of 1.8x1.8m with eleven treatment combinations with different fertigation levels along with organics like arka microbial consortium, neem cake, jeevamrutha with and without bunch covering which was conducted as a integrated study for ratoon crop with Randomized Block Design (RBD) and replicated thrice. For the growth characters like pseudo stem height, after three and five months of ratooning the treatment T_4 has recorded significantly highest at all the crop growth. The highest pseudo stem height (100.56 cm) was also recorded in T_4 whereas lowest pseudo stem height (95.63cm) was noticed in T_1. The likewise the other characters like pseudo stem girth, functional leaves, leaf length, leaf breadth, leaf area, leaf area index and number of suckers the results were found to be maximum in treatment which received 75 per cent fertigation with combination of all organic nutrients and minimum results were observed with Recommended Dose of Fertilizers (RDF). The maximum number of hands per bunch (10.74), highest finger length (18.80 cm) and finger girth (13.98 cm) highest finger weight (138.09 g) highest weight of hand (3.94 kg) highest yield per plant and per hectare (28.03 kg and 86.49t/ha) was noticed in While, the minimum results were obtained in T_1. The integrated use of organics *i.e*, Arka Microbial Consortium (AMC), neem cake, jeevamrutha, panchagavya and inorganic nutrients through 75 per cent fertigation along with bunch protective measures has given the good results.

Keywords: Arka microbial consortium, Arka banana special, neem cake, Jeevamrutha, INM

Introduction
Banana (*Musa* spp.) belongs to the family Musaceae is one of the oldest fruits known to mankind. It is also known as Apple of Paradise and one of the most important sources of tropical fruits in the world as it is a significant staple food as well as a major export commodity (Rahman *et al*., 2013) [8]. Banana is a fourth important food crop in terms of gross value exceeded only by paddy, wheat and milk products and forms an important crop for subsistence farmers.
Application of inorganic fertilizers though increases the yield substantially but could not able to sustain the fertility status of the soil and have caused several undesirable consequences in the fragile soil eco-system, leading to gradual decline in productivity. Chemical fertilizers have some deleterious effects on fruit quality besides adverse effects on soil, water and environmental conditions (Dutta *et al*., 2010) [3]. On the other hand, organic and microbial sources of nutrients have advantage of consistent and slow release of nutrients, maintaining ideal carbon and nitrogen ratio, improvement in water holding capacity and microbial biomass of soil profile, without having any adverse residual effects. In recent years, a new approach for utilization of available resources *viz*., organic, inorganic and microbial inoculants with an integrated approach for sustainable economic yield termed as 'Integrated Nutrient Management' (INM) has emerged which has already been receiving wide attention for contributing substantially towards acceleration of crop productivity by maintaining chemical, physical and biological balance in soil plant system (Bhalerao *et al*., 2010) [2]. The organics and biofertilizers help in better utilization of added inorganic fertilizers thus reduces its level of application as well as reduce the deleterious effect of harsh chemical residues that the inorganic fertilizers leave in the soil (Umar, 2007) [11].

Materials and Methods

The present investigation was carried at Horticultural Research Station, Ashwaraopet. The experiment field was thoroughly ploughed and was levelled and divided into plots as per the layout Field was laid out in Randomized block design with three replications and eleven treatments. The treatment combinations are T_1-100% RDF of N and K (farmers practice with fertigation), T_2-75% RDF of N and K (fertigation) + 25% Neem cake + jeevamrutha @ 3.0 percent + Arka banana special @5%foliar spray+ Bunch covering, T_3-75% RDF of N and K (fertigation) + Arka microbial consortium(300g) + jeevamrutha @3.0 percent +Arka banana special @ 5% foliar spray Bunch covering, T_4-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium (300g)+ jeevamrutha @ 3.0 percent +Arka banana special@ 5% foliar spray Bunch covering, T_5-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium (300g), T_6-75% RDF of N and K (fertigation) + Arka microbial consortium (300g), T_7-50% RDF of N and K (fertigation) + 50% Neem cake + jeevamrutha @ 3.0 percent + Arka banana special @5%foliar spray +Bunch covering, T_8- 50% RDF of N and K(fertigation) +Arka microbial consortium(300g) + jeevamrutha@ 3.0 percent +Arka banana special @ 5% foliar spray+ Bunch covering, T_9-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium (300g) + jeevamrutha @ 3.0 percent +Arka banana special@ 5% foliar spray +Bunch covering, T_{10}-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium (300g), T_{11}-50% RDF of N and K (fertigation) + Arka microbial consortium (300g).The observations were recorded for the growth and yield parameters.

Results and Discussion

Pseudostem height (cm)

At all the crop growth stages the different nutrient treatments significantly affected the pseudostem height. The highest pseudostem height (100.56 cm) was also recorded in T_4 at three months after ratooning and which was at par with T_3 (98.88cm) followed by T_2 (98.65 cm), whereas lowest pseudostem height (95.63cm) was noticed in T_1. At five months after ratooning and shooting stages the highest pseudostem heights (152.74 cm and 226.22cm) respectively were recorded in treatment T_4 over rest of the treatments. Whereas the lowest peseudostem height (137.51cm and185.83cm) respectively were observed in (T_1).

Pseudostem girth (cm)

T_4 has recorded significantly higher pseudostem girth (56.37cm and 64.44 cm) at 5 MAR and atshooting respectively. Among different treatments, pseudostem girth was higher in T_4 at 5 MAP which was at par with T_3 (55.33 cm), T_2 (54.08cm) and T_5 (53.95cm) and at shooting stages T_4 was found to be dominant over rest of the treatments. T_1 has recorded lowest pseudostem girth (46.08cm and 52.36cm) at these stages.

The increased growth in terms of height and girth under higher fertigation in combination with consortium of biofertilizers is be due to increased turgidity of thecells leading to better cell enlargement and cell wall development (Senthil kumar *et al*., 2016) [10].

In banana similar result was found by Yadav *et al.* (2010) [12]. Combination of micronutrients which helps to increase the plant growth like plant height, canopy spread this might be due to zinc is activator of enzyme, involve in the protein synthesis and had direct effect on the level of auxin in the plant as similar findings by Ram and Bose.

Time taken for initiation of suckers (days)

Lowest average number of days (45.47) taken for initiation of suckers in ratoon crop was found in T_4 which was statistically at par with T_2 (49.11), T_3 (45.85) and T_5 (50.15) and highest average number of days (65.44) taken for initiation of suckers was noticed in T_1.

Number of suckers per plant

The highest number of suckers (5.26) was recorded in T_4 which was significantly superior over rest of the treatments and lower number of suckers (2.32) was recorded in T_1. The number of suckers noticed per plant during 5 months after ratooning did not differed significantly with nutrient management practices. Whereas at shooting stages the highest number of suckers (11.20) per plant was recorded in T_4 which was superior compared to other treatments like T_3 (10.67) andT_2 (10.38) and are statistically at par and lower number of suckers (8.49) was recorded in T_1.

From the above results it can be concluded that early initiation and more number of suckers per plant in ratoon crop is mainly due to availability of more amount of nutrients from different sources. The presence of biofertilizers andorganic sources around the plants throughout the period of growth, which are source of humus, N- fixers and nutrients, might have resulted in the higher values of vegetative parameters like number of suckers per plant and early initiation (Naik *et al.*, 2016) [6].

Time taken for the initiation of functional leaves (days)

The days taken for initiation of functional leaves in ratoon crop differed significantly among treatments. Significantly less number of days (7.26 days) were taken for initiation of leaves in T_4 and which are at par with T_3, T_2, T_5 and T_6 over rest of the treatments and significantly more number of days (8.66 days) was observed for initiation of leaves in T_1.

Number of functional leaves

The number of leaves per plant significantly differed among the treatments at all the stages of crop growth. The differences for average number of leaves per plant were significant among treatments. There was trend of gradual increase in number of leaves per plant at different months of ratooning and shooting stages. The highest numbers of leaves (8.81,18.53 and 14.57) were found in T_4 at 3,5 months after ratooning and at shooting stages respectively and the treatment T_4 was at par with T_3(8.15) in 3MAR while at 5MAR and shooting stage T_4 recorded the highest number of leaves which was at par with T_3, T_2, T_5 and T_6. While, the least number of leaves (4.25, 15.28 and 11.53) were observed with T_1 at all crop growth stages

From the results it can be concluded that there was gradual increase in all the leaf characters like time taken for initiation of functional leaves, number of functional leaves. The trend of increase may be due to more nutrient availability and photosynthetic activity. The increase in number of leaves per plant might be due to combination of organic and inorganic nutrients facilitates the transport of carbohydrates through cell membrane *i.e.* starch and sugars as well as plays an important role in the activator for many enzymes which promote the growth of the plant. Similar trend was also reported by Khalifa *et al.* (2011) [4].

Number of days taken for shooting

The early shooting (181.12 days) was recorded in treatment T_4 which was at par with other treatments like T_3 (184.06 days), T_2

(185.67days), T_5 (186.03days) and T_6 (186.30days) followed by T_7 (189.86 days). While late shooting was recorded in treatment T_1 (197.26 days).

Number of days taken from shooting to harvest

The number of days taken from shooting to harvest differed significantly among the treatments for the ratoon crop (table 4.4.5 and figure 4.20). The less number of days (97.54 days) from shooting to harvesting was recorded in treatment T_4 which was superior of all other treatments and it was followed by T_3 (102.80). While more number of days (119.40) from shooting to harvesting was recorded in treatment T_1.

Crop duration

The number of days taken from planting to harvest differed significantly among the different treatments for the ratoon crop. The effect of nutrients resulted in early (278.66 days) harvesting (T_4) which was significantly different from the rest of the treatments. The late harvesting was observed in T_1 which took about 316.66 days.

Early flowering in fertigated plants could be further explained by rapid production of leaves with larger leaf area which would have resulted in better photosynthetic activity, thus the required "net assimilation" presumably would have reached early in the plants receiving both nitrogen and potassium through fertigation. This might be due to extended vegetative phase, more availability of required nutrients and release of nutrients by the farm yard manure and biofertilizers (Bhalerao *et al*., 2010) [2].

Number of hands in a bunch

The soil application of nutrients and foliar spray of micronutrients along with fertigation had significant influences on the number of hands per bunch among the treatments in ratoon banana Cv. Grand Naine. The maximum number of hands per bunch (10.74) was noticed in T_4 which was significantly at par with T_3 (10.38) T_5 (10.60) and followed by T_6 (10.08). The minimum number of hands per bunch (9.25) was recorded in the treatment T_1.

Finger length (cm) and Finger girth (cm)

The highest finger length (18.80 cm) and finger girth (13.98cm) was obtained in treatment T_4 in which finger length was at par with T_2 (18.55) followed by T_3 (18.67cm) and T_6 (18.42), whereas the finger girth is statically at par with T_3, T_2, T_5 and T_6. The minimum finger length (17.81) and finger girth (12.80) was recorded in T_1.

Weight of the finger (g)

The highest finger weight (138.09g) was obtained in T_4, which was superior over other treatments and followed byT_3. While, the lowest finger weight (96.10 g) was recorded in T_1.

Weight of the hand (kg)

The highest weight of hand (3.94 kg) was obtained in T_4, which was significantly at par with T_3 (3.79 kg), T_2 (3.78kg), and T_5 (3.70kg) and T_6 (3.58 kg) followed by T_7 (3.37kg). While, the lowest weight of hand (2.54 kg) was recorded inT_1.

Fruit yield per plant (kg) and Fruit yield hectare (t)

The highest yield per plant and per hectare (28.03 kg and 86.49t/ha) was obtained in treatment T_4 which were significantly at par with T_3 (27.48kg and 84.80 tonnes/ha) and T_2 (26.66kg and 82.28 tonnes/ha). While, the minimum fruit yield (23.04 kg and 71.10 tonnes t/ha) was obtained in T_1.

Increase in the fruit length, fruit width, fruit weight and total yield might be due to better filling of finger under the bunch cover treatments which had more temperature than that of open-air temperature particularly during cold season. The higher temperature inside the bunch covers triggered the nitrate reductase activity in the plants. The reason behind this might be increased temperature within the bunch cover. There is a positive association of temperature during shooting to harvest that temperature sets a limiting factor for bunch weight. The larger size, volume and weight of individual finger had exerted influence in augmentation of bunch weight (Sarkar *et al*., 2016) [9].

Higher yield response owing to application of organics ascribed to improved physical, chemical and biological properties of soil resulting in better supply of plant nutrients, which in turn led to good crop growth and yield. All the positive effects might have facilitated quick mobilization and availability of nutrients that would aid in increased plant height, number of leaves, leaf area, leaf area index and photosynthetic rate. This in turn would have assisted for the increased yield of banana. This is in confirmation with the findings of Patel *et al*. (2010) [7] and Aba *et al.* (2011) [1].

Table 1: Effect of integrated nutrient management on pseudostem height (cm) and pseudostem girth (cm) at different growth stages of banana Cv. Grand Naine in ratoon crop

Treatments	Pseudostem height (cm)			Pseudostem girth (cm)		
	3 MAR	5MAR	Shooting stage	3 MAR	5 MAR	Shooting stage
T_1	95.63	137.51	185.83	31.80	46.08	52.36
T_2	98.65	145.25	208.23	34.79	54.08	59.62
T_3	98.88	149.33	216.98	35.33	55.33	61.27
T_4	100.56	152.74	226.22	35.47	56.37	64.44
T_5	98.08	145.10	196.53	34.77	53.95	58.59
T_6	96.78	142.34	196.22	34.73	53.07	56.49
T_7	96.09	140.25	191.01	34.55	50.28	54.77
T_8	96.23	140.62	192.33	34.63	50.96	55.44
T_9	96.70	141.34	193.58	34.67	51.23	56.35
T_{10}	96.04	139.59	189.95	33.27	47.12	54.62
T_{11}	96.03	139.26	189.21	32.77	46.83	54.33
CD(p=0.05)	1.85	2.7	2.81	NS	2.68	2.13
S.Em±	0.63	0.92	0.95	0.75	0.91	0.72

Table 2: Effect of integrated nutrient management on time taken for initiation of suckers (days) and number of suckers at different growth stages of banana Cv. Grand Naine in ratoon crop

Treatments	Time taken for initiation of suckers (days)	Number of suckers per plant		
		3 MAR	5 MAR	Shooting stage
T_1	65.44	2.33	8.13	8.49
T_2	49.11	4.18	9.43	10.38
T_3	45.85	4.43	10.00	10.67
T_4	45.47	5.26	10.40	11.20
T_5	50.15	4.15	9.40	10.11
T_6	51.93	4.07	9.20	9.77
T_7	58.63	3.03	8.85	9.08
T_8	56.44	3.20	8.90	9.27
T_9	54.73	3.20	9.20	9.63
T_{10}	61.54	2.56	8.73	8.66
T_{11}	64.43	2.32	8.40	8.50
CD(p=0.05)	5.22	0.37	NS	1.13
SE.m±	1.77	0.13	0.48	0.38

T_1-100% RDF of N and K (farmers practice with fertigation)
T_2-75% RDF of N and K (fertigation) + 25% Neem cake + jeevamrutham @ 3.0% + Arka banana special @5%foliar spray+Bunch covering
T_3-75% RDF of N and K (fertigation) + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_4-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_5-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium
T_6-75%RDF of N and K (fertigation) + Arka microbial consortium
T_7- 50% RDF of N and K (fertigation) + 50% Neem cake + jeevamrutham @ 3.0% + Arka banana special @5%foliar spray+Bunch covering
T_8-50% RDF of N and K (fertigation) + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_9-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_{10}-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium
T_{11}-50%RDF of N and K (fertigation) + Arka microbial consortium

MAR- Months After Ratooning

Table 3: Effect of integrated nutrient management on time taken for initiation of functional leaves and number of functional leaves at different growth stages of banana Cv. Grand Naine in ratoon crop

Treatments	Initiation of functional leaves	Number of functional leaves		
		3 MAR	5 MAR	Shooting stage
T_1	8.66	4.25	15.28	11.53
T_2	7.46	8.08	18.37	14.29
T_3	7.30	8.15	18.45	14.45
T_4	7.26	8.81	18.53	14.57
T_5	7.58	7.75	18.07	14.25
T_6	7.60	7.08	17.60	14.02
T_7	8.23	6.01	16.93	12.38
T_8	8.00	6.33	17.17	12.70
T_9	7.83	6.84	17.32	13.73
T_{10}	8.31	5.45	16.50	11.93
T_{11}	8.41	4.61	15.75	11.56
CD(p=0.05)	0.45	0.83	1.63	1.17
SE.m±	0.15	0.8	0.55	0.4

T_1-100% RDF of N and K (farmers practice with fertigation)
T_2-75% RDF of N and K (fertigation) + 25% Neem cake + jeevamrutham @ 3.0% + Arka banana special @5%foliar spray+Bunch covering
T_3-75% RDF of N and K (fertigation) + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_4-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_5-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium
T_6-75%RDF of N and K (fertigation) + Arka microbial consortium
T_7- 50% RDF of N and K (fertigation) + 50% Neem cake + jeevamrutham @ 3.0% + Arka banana special @5%foliar spray+Bunch covering
T_8-50% RDF of N and K (fertigation) + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_9-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_{10}-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium
T_{11}-50%RDF of N and K (fertigation) + Arka microbial consortium

MAR- Months After Ratooning

Table 4: Effect of integrated nutrient management on flowering characters and crop duration (days) of banana Cv. Grand Naine in ratoon crop

Treatments	Days taken for shooting	Days taken from shooting to harvest	Crop duration (days)
T_1	197.26	119.40	316.66
T_2	185.67	103.12	288.79
T_3	184.06	102.80	286.86
T_4	181.12	97.54	278.66
T_5	186.03	103.84	289.87
T_6	186.30	113.98	300.28
T_7	189.86	115.96	305.82
T_8	188.10	114.25	302.35
T_9	187.70	114.11	301.81
T_{10}	193.26	116.69	309.95
T_{11}	195.22	118.27	313.49
CD(p=0.05)	7.95	4.26	4.82
SE.m±	2.69	1.44	1.63

T_1-100% RDF of N and K (farmers practice with fertigation)
T_2-75% RDF of N and K (fertigation) + 25% Neem cake + jeevamrutham @ 3.0% + Arka banana special @5%foliar spray+Bunch covering
T_3-75% RDF of N and K (fertigation) + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_4-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special@ 5% foliar spray+Bunch covering
T_5-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium
T_6-75%RDF of N and K (fertigation) + Arka microbial consortium
T_7- 50% RDF of N and K (fertigation) + 50% Neem cake + jeevamrutham @ 3.0% + Arka banana special @5%foliar spray+Bunch covering
T_8-50% RDF of N and K (fertigation) + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_9-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special@ 5% foliar spray+Bunch covering
T_{10}-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium
T_{11}-50%RDF of N and K (fertigation) + Arka microbial consortium

Table 5: Effect of integrated nutrient management on fruit characters of banana Cv. Grand Naine in ratoon crop

Treatments	Number of hands in a bunch	Finger length (cm)	Finger girth (cm)	Weight of finger (g)	Weight of hand (kg)	Fruit yield per plant (kg)	Fruit yield (t/ha)
T_1	9.25	17.81	12.80	96.10	2.54	23.04	71.10
T_2	10.38	18.55	13.70	125.50	3.78	26.66	82.28
T_3	10.60	18.67	13.84	127.04	3.79	27.48	84.80
T_4	10.74	18.80	13.98	138.09	3.94	28.03	86.49
T_5	10.08	18.55	13.65	124.63	3.70	25.33	78.18
T_6	9.94	18.42	13.57	111.05	3.58	25.29	78.05
T_7	9.33	17.97	13.37	104.43	3.37	24.82	76.58
T_8	9.44	18.11	13.38	106.00	3.48	25.03	77.23
T_9	9.64	18.17	13.52	106.33	3.53	25.24	77.67
T_{10}	9.28	17.93	13.24	100.61	3.14	24.75	76.37
T_{11}	9.28	17.90	13.16	98.43	2.74	24.43	75.38
CD(p=0.05)	0.53	0.32	0.52	5.22	0.54	2.06	6.37
SE.m±	0.18	0.11	0.17	1.77	0.18	0.70	2.16

T_1-100% RDF of N and K (farmers practice with fertigation)
T_2-75% RDF of N and K (fertigation) + 25% Neem cake + jeevamrutham @ 3.0% + Arka banana special @5%foliar spray+Bunch covering
T_3-75% RDF of N and K (fertigation) + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_4-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special@ 5% foliar spray+Bunch covering
T_5-75% RDF of N and K (fertigation) + 25% Neem cake + Arka microbial consortium
T_6-75%RDF of N and K (fertigation) + Arka microbial consortium
T_7- 50% RDF of N and K (fertigation) + 50% Neem cake + jeevamrutham @ 3.0% + Arka banana special @5%foliar spray+Bunch covering
T_8-50% RDF of N and K (fertigation) + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special @ 5% foliar spray+Bunch covering
T_9-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium + jeevamrutham @ 3.0% +Arka banana special@ 5% foliar spray+Bunch covering
T_{10}-50% RDF of N and K (fertigation) + 50% Neem cake + Arka microbial consortium
T_{11}-50%RDF of N and K (fertigation) + Arka microbial consortium

Conclusion

From the investigation, it is concluded that banana responded favourably to organic nutrients in combination with chemical fertilizers. The integrated use of organics *i.e*, Arka Microbial Consortium (AMC), neem cake, jeevamrutha, panchagavya and inorganic nutrients through 75 per cent fertigation along with bunch protective measures has given the good results. Hence the integrated nutrient management practices in banana crop have been found to be an ideal option to improve yield.

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