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Response of banana variety Nendran (*Musa* spp.) under different sources and levels of nutrients in open field precision farming conditions

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Abstract

Banana cultivation requires precise water and nutrient management due to its shallow root system and high nutrient demand. As there is no standard fertigation schedule for Nendran banana under open field precision farming conditions, a study on soil nutrient dynamics under varying nutrient levels in banana cultivation was conducted under open-field precision farming conditions for three consecutive years from 2016 to 2018 at Agronomic Research Station, Kerala Agricultural University. The results demonstrated that through fertigation the fertilizer application could be reduced to 75% of the recommended dose of fertilizers as per the package of practices of Kerala Agricultural University. Both common and high priced water-soluble fertilizers performed similarly, indicating that cost-effective common fertilizers can be used for fertigation. Although the effect of mulching was not significant in terms of yield, it was found to be effective in controlling weeds. Economic analysis and the benefit-cost ratio revealed that cultivating Nendran banana with fertigation using common fertilizers in non-mulched conditions is profitable.

Keywords: BC ratio, Fertigation, Nendran banana, Open field precision farming, Yield

Banana is a high-calorie tropical fruit rich in antioxidants, minerals, vitamins, simplesugars and dietary fibers. Nendran, a popular banana variety, is known for its affordability, year-round availability, taste and high nutritive value (Jaya et al. 2017). India is the world's largest banana producer, with a production of 34528 MT over an area of 963,000 ha (FAO, 2022). There is a critical need for optimizing fertilizer use efficiency in banana through fertigation under open field precision farming conditions. Banana plantsare highly sensitive to water stress due to its shallow-rooted system and even minor fluctuations in soil moisture can impact growth and yield, emphasising the importance of precise irrigation. Additionally, Nendran banana requires high nutrient inputs (Bashma et al., 2019), making its cultivation challenging in areas with limited water and nutrient resources. Farmers often over use fertilizers due to inadequate knowledge about fertilizer application, leading to environmental pollution (Abraham et al., 2023). Rahman and Debnath (2015) emphasized that indiscriminate use of agrochemicals harms both ecosystems and human health. Therefore, understanding the precise quantity of water and nutrients required at different growth stages is crucial.

Nendran banana's high nutrient requirements demand precise and timely application of water and fertilizers. Micro irrigation along with fertigation can minimise nutrient loss, enhance water and nutrient use efficiency and reduce leaching and soil erosion (Asokaraja, 2012). Despite these advantages, further research is needed to optimise fertigation for banana cultivation. Precision farming improves water and nutrient absorption by the shallow roots of banana, creating a favourable rhizosphere environment for optimal input utilisation and minimising losses (Jaya et al. 2017). With this background, a study was conducted at Agronomic Research Station, Chalakudy to develop water and nutrient scheduling for drip fertigated banana under mulched and non-mulched conditions.

MATERIALS AND METHODS

The experiment was carriedout from 2016 to 2018 at the Agronomic Research Station, Kerala Agricultural University, Chalakudy, located at 10º 20' N latitude and 76º 20' E longitude, with an elevation of 3.25 m above mean sea level. The region has a sub-humid tropical climate with an average annual rainfall of 3000mm, of which approximately 80% occurs during the southwest monsoon (June-July). The soil is acidic, having a sandy clay loam texture with a pH range

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Table 1. Treatment details of the experiment

Factor A Dose of fertilizer	Factor B Mulching and non-mulching	Factor C Source of fertilizers
i. D_1 - 125 per cent of RDF ii. D_2 - 100 per cent of RDF iii. D_3 - 75 per cent of RDF	i. M_0- Without Plastic mulching ii. M_1- With>Plastic mulching	i. Common fertilizer (S_1)- Urea, Ammonium Phosphate Sulphate (Factomphos), Muriate of Potash (MOP). ii. High priced fertilizer (S_2)- Mono Ammonium Phosphate, Potassium nitrate, urea

of 5 to 6.1. The field was prepared through ploughing, followed by the establishment of planting pits with dimensions of 50 x 50 cm.A factorial randomized block design (RBD) was used, incorporating three factors: fertilizer dose, fertilizer source and mulching type. Mulching was done using double-sided polythene sheets (30 microns thickness), with black colour on the bottom and silver on the top. There were twelve treatments, each replicated three times, applied to tissue culture seedlings of Nendran banana planted in three blocks. Before planting, lime (500g/plant) and cattle manure (15kg/plant) were added to the pits. The seedlings were planted in November at a spacing of 2 x 2 m, with six plants per plot and mulching sheets(width - 1.25 m) were laid as per the treatment specifications. Drip irrigation was installed and fertigation was carried out using a fertilizer injector pump at six days interval according to the fertigation schedule (Table 1 & 2) following the recommended KAU schedule (300:115:450 g N: P_2O_5: K_2O/plant) (KAU, 2016). Irrigation was given on alternate days at 100% pan evaporation usingtwo drippers per plant with a discharge rate of 8 L/h. Fertigation started 18 days after planting and was completed 228 days after planting. Observations on growth and yield parameters were recorded. Soil moisture was determined based on the gravimetric method and soil temperature was measured using soil thermometer during March, April and May. The statistical analysis of the data was done using the statistical package WASP 2.0. Different treatments of the experiment are detailed in Table 1.

Results and discussion

The results of the experiments conducted over three years (2016–2018)aresummarized in Table 4. In 2016, application of 75% of the recommended dose of fertilizer (RDF) resulted in the highest bunch weight (9.46 kg/plant), which was>on par with the yield obtained with 100% RDF. The number of hands per bunch was higher under 100% RDF,but did not differ significantly from the treatment 75% RDF fertigation. In contrast, the number of fingers remained unaffected by the fertilizer dose. Regarding mulching, a significantly higher bunch yield (9.1 kg per plant) was observed under non-

Table 2. Fertilizer requirement of one plant for the entire crop period

Sl. No.		Fertilizers	Quantity (g/plant)
1	S_1	Urea (46% N)	405
2		Ammonium phosphate sulphate(20:20:0:13)	570
3		Muriate of Potash (60% K_2O)	760
4	S_2	Urea (46% N)	325
5		Mono Ammonium Phosphate (12:61:0)>	190
6		Potassium>nitrate (13:0:45)>	1000

Table 3. Fertigation schedule for common fertilizer (S_1) at six days interval

Month	Ist split (g/plant)			II nd split (g/plant)			III rd split (g/plant)			IV th split (g/plant)			V th split (g/plant)		
	Urea	APS	MOP	Urea	APS	MOP	Urea	APS	MOP	Urea	APS	MOP	Urea	APS	MOP
I	-	-	-	-	-	-	-	-	-	5	38	22	5	38	22
II	5	38	22	5	38	22	5	38	22	5	38	22	5	38	22
III	5	38	22	5	38	22	5	38	22	5	38	22	5	38	22
IV	5	38	22	5	38	22	5	38	22	22	-	22	22	-	22
V	22	-	22	22	-	22	22	-	22	22	-	22	22	-	22
VII	22	-	22	22	-	22	22	-	22	22	-	42	22	-	42
VIII	22	-	42	22	-	42	22	-	42	-	-	-	-	-	-
Total	81	114	152	81	114	152	81	114	152	81	114	152	81	114	152

(APS=Ammonium phosphate sulphate/Factomphos, MOP = Muriate of potash)

Table 4. Fertigation schedule for high priced fertilizer (S_2) at six days interval

Month	I st split (g/plant)			II nd split (g/plant)			III rd split (g/plant)			IV th split (g/plant)			V th split (g/plant)		
	Urea	MAP	PN	Urea	MAP	PN	Urea	MAP	PN	Urea	MAP	PN	Urea	MAP	PN
I	-	-	-	-	-	-	-	-	-	5	12	30	5	12	30
II	5	12	30	5	12	30	5	12	30	5	13	30	5	13	30
III	5	13	30	5	13	30	5	13	30	5	13	30	5	13	30
IV	5	13	30	5	13	30	5	13	30	16	-	30	16	-	30
V	16	-	30	16	-	30	16	-	30	17	-	30	17	-	30
VII	17	-	30	17	-	30	17	-	30	17	-	50	17	-	50
VIII	17	-	50	17	-	50	17	-	50	-	-	-	-	-	-
Total	65	38	200	65	38	200	65	38	200	65	38	200	65	38	200

(MAP = Mono Ammonium Phosphate,PN = Potassium nitrate) mulched conditions, whereas the number of hands and fingers per bunch showed no significant variation. When comparing fertilizer sources, treatments withwater-soluble fertilizers (8.99 kg/plant) recorded slightly higher bunch weight compared to those with conventional fertilizers (8.84 kg/plant). However, the fertilizer sources did not significantly influence the number of hands per bunch and fingers. These findings suggest that both 100% and 75% RDF resulted in better yield than the higher dose of 125%, indicating excessive fertilizer application can reduce yield. Additionally, the study demonstrates that fertigation can effectively reduce fertilizer requirements to 75% RDF, saving 25% of the fertilizer dose. Although mulching did not significantly impact yield, it was found to be effective in weed control. By reducing weed population, mulching can indirectly benefit crop yield (Mahesh et al., 2020).

During the second year (2017), the results showed that 125% RDF gave the highest yield (9.65 kg/plant) which was found to be on par with75% RDF (8.91 kg/plant). The number of hands and fingers per bunch was unaffected by nutrient dose, mulching or fertilizer source. Both common fertilizers and water soluble, high priced fertilizers showed similar performance, confirming the suitability of cost effective common fertilizers for fertigation. Studies showed that irrespective of the fertilizer source, growth parameters were improved with increased fertigation doses, suggesting the fact that common and high priced fertilizer sources perform similarly when applied through fertigation (Pawar et al., 2017)

In 2018, it was observed that the application of 125% RDF resulted in higher yield, which were statistically similar to those achieved with 75% RDF, confirming that both 75% and 125% RDF had comparable effects on bunch weight when fertigation practices were implemented. Therefore, applying 75% RDF as fertigation is considered optimal for plant growth, as it provides comparable yield results and reduces fertilizer costs by 25%. However, plastic mulching resulted in a significant increase in crop yield compared to non-mulched conditions. Additionally, the mulched plots exhibited a considerable reduction in weed population. According to the study by Santhosh and Tiwari (2017), treatments under mulched conditionsshowed higher growth and yield compared to non-mulched conditions. Maximum yield parameters were observed in plastic mulched treatments, while other parameters were unaffected by the mulching situation.

The statistical analysis of the pooled data (Table 5) indicated that yield was not significantly influenced by the fertilizer dose, crop field mulching or the fertilizer source. When

Table 5. Effect of treatments on yield and growth characteristics of banana during 2016, 2017 and 2018 (kg/plant)

Treatments	Bunch weight (kg/plant)			No. of fingers			No. of hands		
	2016	2017	2018	2016	2017	2018	2016	2017	2018
Dose of fertilizers									
D_1-125% of RDF	7.92	9.65	7.52	43.26	55.59	48.19	5.30	5.47	4.97
D_2-100% of RDF	9.37	8.44	6.78	51.23	55.38	46.75	5.27	5.49	4.83
D_3-75% of RDF	9.46	8.91	7.20	49.02	53.82	49.09	5.15	5.19	5.08
CD>(0.05)	0.451	0.85	0.57	5.02	NS	NS	NS	NS	NS
With/without mulch									
M_0 (without plastic mulching)	9.10	9.07	6.75	47.08	57.47	48.01	5.29	5.50	4.87
M_1 (with plastic mulching)	8.73	8.93	7.58	48.61	52.39	48.01	5.19	5.26	5.04
CD (0.05)	0.369	NS	0.47	NS	3.486	NS	NS	NS	NS
Source of fertilizers									
S_1 (Common)	8.84	8.76	7.08	46.56	54.32	47.55	5.19	5.36	4.85
S_2 (Water soluble)	8.99	9.24	7.25	49.13	55.54	48.47	5.29	5.40	5.07
CD (0.05)	0.369	NS	NS	NS	NS	NS	NS	NS	NS
Interaction effects									
$D_1M_0S_1$	8.08	9.80	7.54	43.25	56.96	48.65	5.26	5.52	4.75
$D_1M_0S_2$	8.25	9.67	6.66	46.75	58.38	46.15	5.39	5.68	4.82
$D_1M_1S_1$	7.59	8.38	8.65	37.00	53.58	50.15	5.27	5.33	5.15
$D_1M_1S_2$	7.77	10.75	7.23	46.10	53.42	47.82	5.27	5.33	5.16
$D_2M_0S_1$	9.40	8.00	5.83	49.79	56.20	44.69	5.12	5.45	4.47
$D_2M_0S_2$	9.82	8.28	6.94	50.04	58.15	48.03	5.47	5.68	5.04
$D_2M_1S_1$	8.72	8.33	6.60	49.35	54.94	45.23	5.19	5.44	4.69
$D_2M_1S_2$	9.57	9.14	7.76	55.75	52.23	49.06	5.30	5.38	5.13
$D_3M_0S_1$	9.63	8.91	6.63	48.63	55.21	50.42	5.22	5.34	4.99
$D_3M_0S_2$	9.45	9.75	6.90	44.00	59.90	50.13	5.30	5.35	5.19
$D_3M_1S_1$	9.67	9.12	7.26	51.34	49.00	46.17	5.07	5.08	5.05
$D_3M_1S_2$	9.09	7.88	8.01	52.13	51.17	49.66	5.03	5.00	5.08
CD (0.05)	0.903	1.707	NS	10.03	NS	NS	NS	NS	0.42

analysing the Benefit Cost (B:C) ratio, fertigation dose 75% RDF showed the highestB:C ratio (1.76), followed by 100% (1.56) and 125% (1.52) RDF. This suggests that application of 75% RDF through fertigation is sufficient for optimal crop growth andis economically feasible for farmers, as it reduces fertilizer costs by 25%. According to the study byAl-Harthi and Al-Yahyai(2009) on the effect of NPK fertilizers on banana growth and yield, higher bunch weight and more hands and fingers were observed in the treatment with 600g N, 100g P and 500g K compared to the treatment with 900g N, 150g P and 750g K. Treatments that resulted in reduced yield support the statement that higher dose of fertilizer application can reduce yield. A study by Kumar et al. (2009) on the effect of fertigation in banana demonstrated that biometric characteristics and fertilizer use efficiency supported the conclusion that 75% of RDF is optimal for tissue culture Nendran banana.The study bySanthosh and Tiwari (2017) also found that the optimum rate of fertilizer application increased yield,while excessive potassium application reduced yield in banana.Fertigation with 125% RDF had a negative effect, reducing both yield and the B:C ratio. Therefore, 75% is more cost-effective, providing higher yield and significantly improving the B:C ratio. A similar study by Kuttimani et al. (2013)on integrated nutrient

Table 6. Effect of treatments on yield parameters and B C ratio of banana (Pooled value).

Treatments	Yield/ Plant (kg)	No. of Fingers per plant	Yield (t ha^{-1})	BC ratio
Dose of nutrients				
D_1-125%	8.01	48.88	20.89	1.52
D_2-100%	8.73	52.21	20.49	1.56
D_3-75%	8.33	46.07	21.30	1.76
CD (0.05)	NS	NS	NS	0.11
Mulched/non-mulched				
M_0 (without plastic mulching)	8.34	49.26	20.76	1.86
M_1 (with plastic mulching)	8.37	48.85	21.03	1.37
CD (0.05)	NS	NS	NS	0.09
Source of fertilizers				
S_1-common	8.70	48.56	20.56	1.90
S_2-Water soluble	8.01	49.54	21.23	1.33
CD (0.05)	NS	NS	NS	0.09
Interaction effects				
D_1M_0	8.67	52.80	20.81	1.74
D_1M_1	7.36	44.95	20.98	1.29
D_2M_0	8.94	52.56	20.11	1.78
D_2M_1	8.51	51.86	20.88	1.35
D_3M_0	7.41	42.41	21.36	2.06
D_3M_1	9.25	49.73	21.24	1.47
CD (0.05)	1.52	NS	7.12	NS
D_1S_1	7.80	46.20	20.83	1.86
D_1S_2	8.23	51.55	20.96	1.17
D_2S_1	9.15	54.26	19.53	1.80
D_2S_2	8.30	50.16	21.46	1.33
D_3S_1	9.16	45.23	21.33	2.04
D_3S_2	7.50	46.91	21.28	1.48
CD (0.05)	NS	NS	NS	NS
M_0S_1	8.26	48.01	20.49	2.24
M_0S_2	8.42	50.51	21.02	1.48
M_1S_1	9.15	49.12	20.63	1.57
M_1S_2	7.60	48.57	21.44	1.17
CD (0.05)	1.24	NS	NS	0.13
$D_1M_0S_1$	7.54	48.65	21.16	2.21
$D_1M_0S_2$	9.80	56.96	20.46	1.27
$D_1M_1S_1$	8.06	43.75	20.51	1.51
$D_1M_1S_2$	6.66	46.15	21.45	1.07
$D_2M_0S_1$	9.66	58.38	19.35	2.11
$D_2M_0S_2$	8.22	46.75	20.86	1.45
$D_2M_1S_1$	8.65	50.15	19.71	1.50
$D_2M_1S_2$	8.37	53.58	22.05	1.20
$D_3M_0S_1$	7.59	37.00	20.97	2.39
$D_3M_0S_2$	7.23	47.82	21.75	1.72
$D_3M_1S_1$	10.74	53.46	21.68	1.70
$D_3M_1S_2$	7.77	46.00	20.80	1.25
CD (0.05)	NS	NS	10.06	0.231

Table 7. Effect of treatments on soil temperature and moisture in the root zone of banana during 2018

Treatments	Soil moisture			Soil temperature		
Dose of nutrients	March	April	May	March	April	May
D_1-125%	3.92	10.97	5.39	32.23	31.81	37.43
D_2-100%	3.95	7.87	3.88	30.30	32.43	37.50
D_3-75%	4.30	9.62	4.60	32.08	31.21	38.43
CD (0.05)	NS	2.03	0.75	NS	NS	NS
Mulched/non-mulched						
M_0 (without plastic mulching)	4.00	9.02	4.34	31.50	31.38	36.79
M_1 (with plastic mulching)	4.11	9.95	4.90	31.60	32.25	38.79
CD (0.05)	NS	NS	0.613	NS	NS	1.03
Source of fertilizers						
S_1-common	3.87	9.28	4.54	31.87	31.40	37.83
S_2-Water soluble	4.24	9.70	4.71	31.20	32.24	37.75
CD (0.05)	NS	NS	NS	0.62	NS	NS
Interaction effects						
D_1M_0	3.65	10.75	4.94	32.05	31.77	36.37
D_1M_1	4.19	11.20	5.84	32.42	31.85	38.50
D_2M_0	4.86	7.19	3.50	30.57	31.82	36.25
D_2M_1	3.04	8.55	4.26	30.02	33.05	38.75
D_3M_0	3.50	9.13	4.59	31.87	30.55	37.75
D_3M_1	5.11	10.12	4.60	32.3	31.87	39.12
CD (0.05)	1.191	NS	NS	NS	NS	NS
D_1S_1	4.12	11.10	5.70	32.37	31.80	37.87
D_1S_2	3.72	10.84	5.08	32.10	31.82	37.00
D_2S_1	3.10	7.40	3.21	31.00	31.77	37.87
D_2S_2	4.80	8.35	4.55	29.60	33.10	37.12
D_3S_1	4.40	9.33	4.70	32.25	30.62	37.75
D_3S_2	4.21	9.91	4.50	31.92	31.80	39.12
CD (0.05)	1.191	NS	1.06	NS	NS	NS
M_0S_1	3.38	8.85	4.41	32.03	30.45	36.66
M_0S_2	4.63	9.19	4.28	30.96	32.317	36.91
M_1S_1	4.36	9.70	4.67	31.71	32.35	39.00
M_1S_2	3.86	10.21	5.14	31.45	32.16	38.58
CD (0.05)	0.97	NS	NS	NS	NS	NS
Treatment combinations						
$D_1M_0S_1$	3.11	10.71	5.32	32.60	30.65	36.75
$D_1M_0S_2$	4.19	10.78	4.56	31.50	32.90	36.00
$D_1M_1S_1$	5.12	11.49	6.09	32.15	32.95	39.00
$D_1M_1S_2$	3.25	10.91	5.60	32.70	30.75	38.00
$D_2M_0S_1$	3.54	6.71	2.80	31.25	30.30	36.25
$D_2M_0S_2$	6.19	7.68	4.21	29.90	33.35	36.25
$D_2M_1S_1$	2.67	8.08	3.63	30.75	33.25	39.50
$D_2M_1S_2$	3.42	9.02	4.90	29.30	32.85	38.00
$D_3M_0S_1$	3.49	9.14	5.11	32.25	30.40	37.00
$D_3M_0S_2$	3.51	9.12	4.08	31.50	30.70	38.50
$D_3M_1S_1$	5.31	9.52	4.29	32.25	30.85	38.50
$D_3M_1S_2$	4.91	10.71	4.92	32.35	32.9	39.75
CD (0.05)	NS	NS	NS	NS	NS	NS

management in banana concluded that applying 75% of RDF along with 40% organic manures resulted in the highest B:C ratio, comparable to the application of 100% RDF+40% organic manures. Similarly, Hazarika et al. 2014 reported a high B:C ratio and increased yield in tissue culture banana treated with 75% RDF supplemented with VAM, *Azospirillum* sp., PSB and *Trichoderma harzianum.*

No significant difference in yield parameters was observed when using water-soluble high-priced fertilizers and common conventional fertilizers. Both types of fertilizers performed similarly, showing that high-priced water-soluble fertilizers can be replaced with cheaper common conventional water-soluble fertilizers. When conventional fertilizers were available in a price range of 8 – 32 Rs./kg, the cost of fully water-soluble costly fertilizers was in the range of 150 – 250 Rs/kg. The cost of conventional fertilizers was around one-tenth of that of costly fertilizers. This finding can help farmers to reduce the cost of cultivation with minimal investment in fertilizers. The B:C ratio significantly differed based on the fertilizer source, with common fertilizers (1.9) showing a higher B:C ratio than high-priced fertilizers (1.33).

This indicates that banana cultivation using common fertilizers is more profitable than using high-priced water-soluble fertilizers. This finding is supported by a study conducted by Pawar et al. (2017)on tissue culture banana, where bothhigh-priced soluble fertilizers and straight fertilizers improved growth parameters when fertigation doses were increased. The study also reported that fertigation using high-priced water-soluble fertilizers showed a lower B:C ratio because of the exorbitant cost of such fertilizers. The interaction effect of the three factors showed that plastic mulching with 100% RDF produced highest yield (22.05 t/ha), which was on par with the application of 75% RDF with and without mulch. Similarly, application of common fertilizers along with plastic mulchingresulted in the highest yield, which was on par with the application of high-priced fertilizer without mulching. The interaction effect of the three factors showed that the highest B: C ratio obtained under no mulching.

Regarding mulching and non-mulching conditions, growth parameters were not significantly influenced by mulching, while the B:C ratio was higher under non-mulched conditions than under plastic mulching. This may be due to the higher cost of plastic mulch material. Plastic mulching increases the cost of cultivation, thereby reducing the B:C ratio compared to non-mulched situations. Hence, banana cultivation is more economical under non-mulched conditions without influencing yield parameters. This findingis supported by a study conducted on okra under different mulching conditions, where the B:C ratio was higher in treatments with drip irrigation under non-mulched conditions (Tiwari et al. 1998). Studies on the economics and B:C ratio over three years showed that cultivating Nendran banana with 75% RDF of common fertilizers under non-mulched conditions is profitable. This is due to the higher fertilizer use efficiency in fertigation wherein fertilizers are supplied at lower doses in more number of splits, that too specifically at the root zone. There are reports that the fertilizer use efficiency of all fertilizers, especially nitrogenous fertilizers, are much higher compared to conventional methods in which fertilizers are applied in split doses.

In 2018, soil moisture and temperature were assessed for all treatment plots. Observations on soil moisture and temperature (Table 6) indicated that plastic mulching helps in conserving soil moisture. The temperature under plastic mulching (38.79ºC) was found to be higher compared to non-mulched (36.79ºC) fields. This finding is supported by the study of Santhosh and Tiwari (2017), which reported higher yields under plastic mulching. The improved performance under plastic mulching can be attributed to reduced volatilization and leaching losses of nutrients, along with better moisture conservation. Plastic mulching creates a barrier that minimizes nutrient losses through volatilization and prevents leaching during irrigation or rainfall, thereby enhancing nutrient availability to the plants. However, the higher soil temperature under plastic mulching can be detrimental to root growth and plant metabolism, potentially offsetting the benefits of improved moisture and nutrient conservation. This explains why there was no significant difference in yield parameters between mulched and non-mulched conditions, as the negative effects of elevated soil temperature counterbalanced the positive effects of reduced nutrient losses and better moisture retention.

Conclusion

The study on soil nutrient dynamics in banana cultivation, under open field precision farming conditions demonstrated that fertilizer application could be effectively reduced to 75% of the recommended dose (RDF) through fertigation. Both common fertilizers and water-soluble high-priced fertilizers exhibitedcomparable performance, indicating that the use of common fertilizers is a more cost-effective alternative. Although mulching did not significantly influence yield, it was found to be effective in controllingthe weed population. Economic analysis further revealed that fertigation with 75%

Plate 1. Field view of the experiment plot

RDF using common fertilizers in non-mulched conditions recorded the highest B:C ratio (2.39), establishing it as the profitable cultivation.

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