

Effect of NPK Fertilizer Levels on Yields and Yield Economics, Nutrient Uptake and Post-Harvest Aspects of Banana (*Musa spp.*) Cultivars in Coastal Plain of Western India

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Abstract

The experiment was carried out in split plot statistical design with three main plot treatments *viz.*, different banana cultivars – Konkan Safed Velchi (V1), Red Banana (V2), Grand Naine (V3) and five sub-plot treatments *viz.*, different fertilizer levels – F1 (RDF 200:100:200 g NPK/plant), F2 (300:100:100 g NPK/plant), F3 (300:100:200 g NPK/plant), F4 (300:100:300 g NPK/plant) and F5 (300:100:400 g NPK/plant) and having fifteen treatment combinations which were replicated three times. The observations on yields and yields attributes, nutrient uptake and post harvest aspects were measured and results showed that the yield of banana were significantly increased with the increase of fertilizer levels. Maximum bunch length (89.4 cm), maximum bunch weight (23.1 kg), maximum hands (14.4 nos.), highest hand weight (1.54 kg), maximum finger weight (0.104 kg), maximum yield (23.89 kg/plant), maximum yield (71.08 t/ha) were recorded in treatment combination V3F4 (300:100:300 g NPK/plant and in variety Grand Naine). Highest shelf life (11.42 days) were in V1F1. Maximum TSS (25.08 °Brix), lowest titratable acidity (0.52 %), highest reducing sugar (8.74 %) and total sugars (11.48 %) were recorded in V1F4 due to interaction effect of cultivars and fertilizers. Treatment combination V3F4 (300:100:300 g NPK/plant and variety Grand Naine) recorded highest gross returns of Rs.1066200/- with highest cost benefit ratio 2.0. The present study clearly indicated that for obtaining maximum yield the cultivar Grand Naine performed the best while for maintaining quality of banana the variety Konkan Safed Velchi performed best. Fertilizer dose of 10 kg FYM + 300:100:300 g NPK/plant has been found beneficial for maximum banana yield in relation to the variety Grand Naine and fertilizer dose of 10 kg FYM + 200:100:200 g NPK/plant/year registered for obtaining better quality banana fruits.

Key words: *Banana, Grand Naine, NPK levels, yield, nutrient uptake, total sugars*

Introduction

Bananas (*Musa spp.*) are the world's most popular fruits and it is consolidated in the international market (Jaiswal et al., 2014). India is the biggest banana producers, which produced 29 million tonnes per year on average between 2010 and 2017 and China at 11 million tonnes (Anonymous, 2016). In India, banana is being grown in an area of 8.83 lakh ha with a production of about 308.07 lakh tonnes and average productivity of banana in India is 34.9 t/ha. Karnataka has the largest

area (1.10 lakh ha) under banana cultivation followed by Kerala (1.09 lakh ha). Andhra Pradesh rank first in production (50.03 lakh tonnes) followed by Gujarat (44.72 lakh tonnes) and Maharashtra (42.09 lakh tonnes), whereas Madhya Pradesh leads in productivity (69.5 t/ha) (Anonymous, 2018). Banana is considered 4th staple food after rice, corn and wheat (Falcomer et al., 2019). Its year round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favorite fruit among all classes of people. Bananas come in a variety

of sizes and colors when ripe, including yellow, purple and red (Priya et al., 2014). Due to its multifaceted uses and virtues of plant, it is referred as Adam's fig, Apple of Paradise and Kalpataru (Bhamini et al., 2016). At present banana is being cultivated throughout the warm tropical regions of the world between 30° N and 30° S of the equator. Banana can be grown in almost all types of soil provided adequate moisture is made available. Deep, well drained, friable loamy soil with adequate organic matter is ideal for its cultivation. It grows well in slightly alkaline soils, but saline soils with salinity exceeding 0.05 per cent are unsuitable. Alluvial and volcanic soils are the best for banana cultivation (Anonymous, 1974). Though there are several commercial banana varieties grown all over the world, the Cavendish groups of banana viz., Grand Naine, Williams and Robusta are grown extensively owing to comparatively higher yield potential compared to other cultivars and better marketability both in domestic and export markets (Mustaffa and Kumar, 2012). Konkan region of Maharashtra is characterized with undulated hilly terrain with hot and humid climatic conditions. By nature, banana is a heavy nutrients feeder crop due to its size, growth rate, rooting pattern and phenomenon of bud differentiation which have positive relationship with the yield (Nayyer et al. (2014). Banana cultivars are highly responsive to chemical fertilizers particularly at early stages of crop. Among the cultivars, Grand Naine the commercially popular variety is being cultivated on large scale. However, the local variety like Konkan Safed Velchi (released by DBSKKV, Dapoli) and Red Banana which is quite popular in Alibag (Raigad) are being commercially cultivated in Konkan (Navgare et al., 2021). As a quick growing crop, banana uptakes more nutrients from soil as compared to other crop due to their rapid and vigorous growth and higher yield (Navgare et al., 2021). Major nutrients like nitrogen, phosphorus and potassium play an important role in the vegetative and reproductive phases of crop growth depending on the cultivar. For better growth, yield and quality of banana, optimum levels of nutrients have to be maintained which are often supplied partly by the soil (Swennen, 1990). Among the nutrients, nitrogen is the most essential element and has a positive influence on plant growth, flowering and productivity in banana cultivars (Navgare et al., 2021). Though the requirement

of phosphorous is low, it helps to produce healthy rhizome, strong root system and prevents lodging. It also plays a vital role in overall development of the plant and flower set. The plant can store phosphorus longer and can utilize it for fruit production and development. Another element of high importance for growth of banana is potassium 'a quality mineral nutrients' (Lopez and Espinosa, 1998) and its requirement is very high during the flowering period. Supply of potassic fertilizers in adequate quantity not only increases growth and yield in banana but also the physiology of plant and offers resistance against biotic and abiotic stresses (Mustaffa and Kumar, 2012). It is also known for stimulating early shooting, increasing number of hands, finger size, quality and sweetness apart from increasing the keeping quality and reducing the total water uptake (Radha and Mathew, 2007). Hence the fertilizer application should contain more amounts of potassium and nitrogen (Santos et al., 2009). The choice and dosage of nutrients, time, mode and frequency of application vary depending upon the cultivars, soil fertility status, production system and agro-climatic conditions. In view of the above context the experiment on effect of different NPK fertilizer levels on yields and yield economics, nutrient uptakes and post-harvest aspects of banana cultivars was carried out to find out the optimum dose of NPK and suitable variety for maximizing yield, nutrient uptakes and post-harvest aspects of banana in the Konkan region.

Materials and method

Field study was carried out at College of Horticulture, Dr. B.S.K.K.V., Dapoli, Ratnagiri during the year of 2019-2021. Experimental site was situated on 17° 45' North latitude and 73° 12' East longitude. It has an altitude of 88.55 meter above sea level. The region is characterized by a warm and humid tropical climate. The soils of this region are lateritic, deep, porous and acidic in reaction having pH range of 5.6-6.5. The average minimum and maximum temperature are 18.5°C and 30°C respectively. Average annual rainfall is 3500-4000 mm distributed mainly during South West monsoon from June to October. The experiment was carried out in split plot statistical design with three main plot treatments viz., different banana cultivars – Konkan Safed Velchi (V1), Red Banana

(V2), Grand Naine (V3) and five sub-plot treatments viz., different fertilizer levels – F1 (RDF 200:100:200 g NPK/plant), F2 (300:100:100 g NPK/plant), F3 (300:100:200 g NPK/plant), F4 (300:100:300 g NPK/plant) and F5 (300:100:400 g NPK/plant) and having fifteen treatment combinations which were replicated three times. The recommended spacing of 1.8 m x 1.8 m was adopted for planting. Suckers of banana obtained from disease free field were planted in all the treatments. Suckers of uniform size were selected for planting. Four plants per treatment were used and having 180 numbers of total plant population were maintained. Before planting, 10 kg of FYM, 100 g of Phosphorus in the form of SSP + 5g phorate was applied to each pit as basal. NPK fertilizers were applied in 4 splits doses (30 DAP, 60 DAP, 90 DAP and 120 DAP) by ring placement method. Recommended cultural practices were carried out regularly. Yield and quality attributing characters of banana viz. bunch length, bunch weight, number of hands/bunch, hand weight, finger weight, yields, available N, P, K, economics of cultivation, shelf life, total soluble solid, acidity, reducing sugar, total sugars were measured. The data obtained in

the present study was statistically analyzed as per the methods suggested by Panse and Sukatme (1995) using split plot design and valid conclusions were drawn only on significance differences between treatment mean at 0.05 % level of significance.

Results and discussion

Banana bunch length (cm)

The significantly highest bunch length (85.51 cm) was recorded in Grand Naine (V3) whereas the lowest (43.51 cm) was in Red Banana (V2) (Table 1). Consideration of the different NPK fertilizer levels the significantly highest bunch length (60.38 cm) was recorded in F4 (300:100:300 g NPK/plant) and was at par with F3 (59.44 cm) while lowest (54.34 cm) was in F1. Due to interaction effect of varieties and NPK fertilizer levels the significantly highest bunch length (89.38 cm) were in V3F4 (300:100:300 g NPK/plant) in Grand Naine whereas lowest 40.48 cm was in V2F1. Similar findings were reported by Rahate et al., (2020) in Red Banana. and Navgare et al., (2021) in Grand Naine.

Table 1. Effect of different varieties, NPK fertilizer levels and their interactions on bunch length and weight of banana

Treatments	Bunch length (cm)				Bunch weight (kg)			
	V1	V2	V3	Mean	V1	V2	V3	Mean
F ₁	40.73	40.48	81.83	54.34	9.59	10.90	20.39	13.62
F ₂	45.05	43.23	84.30	57.53	10.14	11.60	21.82	14.52
F ₃	48.04	43.66	86.62	59.44	10.77	11.89	22.81	15.16
F ₄	46.17	45.58	89.38	60.38	10.44	12.11	23.13	15.22
F ₅	44.73	44.61	85.43	58.25	10.43	11.72	21.97	14.71
Mean	44.94	43.51	85.51	57.99	10.27	11.64	22.02	14.65
	Varieties (V)	Fertilizer levels (F)	V x F		Varieties (V)	Fertilizer levels (F)	V x F	
S.Em±	0.07	1.07	0.36		0.07	0.37	0.12	
C.D. (P=0.05)	0.26	3.13	1.04		0.27	1.08	0.36	

Banana bunch weight (kg/plant)

The significantly maximum bunch weight (22.02 kg) was recorded in Grand Naine (V3) and minimum 10.27 kg was in Konkan Safed Velchi (V1) (Table 1). In view of the different NPK fertilizer levels the significantly maximum bunch weight (15.22 kg) was recorded in F4 (300:100:300 g NPK/plant) whereas minimum (13.62 kg) was in F1 (200:100:200 g NPK/plant). Due to interaction effect of varieties and fertilizer levels maximum bunch weight (23.12 kg) was in V3F4 (300:100:300 g NPK/plant) in Grand Naine whereas minimum (9.59 kg) was in V1F1 (200:100:200 g NPK/plant) in Konkan Safed Velchi. Increased availability and nutrients uptake led to the better expression of growth and yield attributes which ultimately resulted in higher yield. Similar findings were reported by Ebeed et al., (2008) in Grand Naine, Rahate et al., (2020) and Navgare et al., (2021) in Grand Naine.

Number of hands/bunch (nos.)

The significantly maximum numbers of hands/bunch (13.84 nos.) were recorded in Grand Naine (V3) and minimum hands/bunch (9.0 nos.) were in Konkan Safed Velchi (V1) (Fig. 1). Significantly maximum number of hands/bunch (11.0 nos.) due to different NPK fertilizer levels were recorded in F3 (300:100:200 g NPK/plant) and it was at par with F1 (10.3 nos.), F2 (10.8 nos.), F4 (10.9 nos.) and F5 (10.7 nos.) whereas the minimum hands/bunch (10.3 nos.) were in F1. The significantly maximum numbers of hands (14.4 nos.) due to interaction effect of varieties and different NPK fertilizer levels were in V3F3 (300:100:200 g NPK/plant) and it was at par with V3F4 (14.3 nos.) whereas minimum hands/bunch (8.8 nos.) in V1F1. Maximum numbers of hands might be due to genetic character of variety and proper nutrient management which ultimately resulted in higher yield. Similar findings were reported by Nalina et al., (2009) in Robusta and Rahate et al., (2020) and Navgare et al., (2021) in Grand Naine.

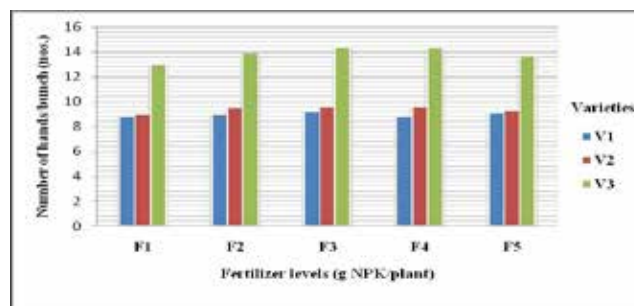


Fig. 1. Effect of different varieties, NPK fertilizer levels and their interactions on number of hands/bunch of banana

Hand weight (kg)

The significantly highest hand weight (1.52 kg) was recorded in Grand Naine (V3) and lowest (1.06 kg) was in Konkan Safed Velchi (V1) (Table 2). The significantly highest hand weight (1.26 kg) due to NPK fertilizer levels were recorded in F4 (300:100:300 g NPK/plant) and it was at par with F3 (1.24 kg) and F5 (1.25 kg) whereas lowest hand weight (1.20 kg) was in F1. Highest hand weight (1.54 kg) due to interaction effect of varieties and NPK fertilizer levels were in V3F4 (300:100:300 g NPK/plant) in Grand Naine and it was at par with V3F5 (1.53 kg) while lowest hand weight (1.0 kg) in V1F1 (200:100:200 g NPK/plant) in Konkan Safed Velchi. Similar results were reported by Pathak et al., (1992) in Harichal and Rahate et al., (2020) in Grand Naine.

Finger weight (kg)

Significantly highest finger weight (0.098 kg) was recorded in Grand Naine (V3) and lowest finger weight (0.073 kg) was in Konkan Safed Velchi (V1) (Table 2). Significantly highest finger weight (0.085 kg) due to NPK fertilizer levels were recorded in F1 (200:100:200 g NPK/plant) and it was at par with F2 (0.085 kg), F3 (0.079 kg), F4 (0.081 kg) and F5 (0.083 kg) and lowest finger weight (0.081 kg) was in F4. Significantly maximum finger weight (0.104 kg) due to interaction effect of varieties and NPK fertilizer levels were in V3F1 (200:100:200 g NPK/plant) in Grand Naine whereas minimum finger weight (0.0716 kg) was in V2F4 (300:100:300 g NPK/plant) in Red Banana. Similar findings were reported by Pathak et al., (1992) in Harichal and Rahate et al., (2020) in Grand Naine

Table 2. Effect of different varieties, NPK fertilizer levels and their interactions on hand weight and finger weight of banana

Treatments	Hand weight (kg)				Finger weight (kg)			
	V1	V2	V3	Mean	V1	V2	V3	Mean
F ₁	1.00	1.10	1.49	1.20	0.074	0.078	0.104	0.085
F ₂	1.04	1.11	1.50	1.22	0.074	0.073	0.097	0.082
F ₃	1.08	1.14	1.52	1.24	0.073	0.073	0.092	0.079
F ₄	1.09	1.16	1.54	1.26	0.072	0.072	0.098	0.081
F ₅	1.06	1.15	1.53	1.25	0.074	0.074	0.101	0.083
Mean	1.06	1.13	1.52	1.23	0.073	0.074	0.098	0.082
	Varieties (V)	Fertilizer levels (F)	V x F		Varieties (V)	Fertilizer levels (F)	V x F	
S.Em±	0.001	0.013	0.004		0.0002	0.002	0.001	
C.D. (P=0.05)	0.003	0.038	0.013		0.001	0.007	0.002	

Banana yield (kg/plant)

Significantly highest yield (19.48 kg/plant) was recorded in Grand Naine (V3) and lowest yield (8.98 kg/plant) was in Konkan Safed Velchi (V1) (Table 3). Significantly highest yield (15.12 kg/plant) due to NPK fertilizer levels were recorded in F4 (300:100:300 g NPK/plant) whereas the lowest yield (10.39 kg/plant) was in F1. Significantly highest banana yield (23.89

kg/plant) due to interaction effect of varieties and NPK fertilizer levels were in V3F4 (300:100:300 g NPK/plant) in Grand Naine whereas lowest yield (7.28 kg/plant) was in V1F1 (200:100:200 g NPK/plant) in Konkan Safed Velchi. Increased availability and nutrients uptake led to the better expression of growth and yield attributes which ultimately resulted in higher yield. Similar results were reported by Rahate et al., (2020) in Grand Naine.

Table 3. Effect of different varieties, NPK fertilizer levels and their interactions on yield of banana

Treatments	Yield (kg/plant)				Yield (t/ha)			
	V1	V2	V3	Mean	V1	V2	V3	Mean
F ₁	7.28	7.88	16.02	10.39	25.22	29.21	58.29	37.57
F ₂	8.66	8.81	17.12	11.53	26.50	30.16	60.15	38.94
F ₃	8.93	9.50	19.21	12.55	28.09	30.56	62.54	40.40
F ₄	10.76	10.72	23.89	15.12	33.22	34.90	71.08	46.40
F ₅	9.28	10.36	21.13	13.59	30.38	31.05	65.02	42.15
Mean	8.98	9.45	19.48	12.64	28.68	31.18	63.42	41.09
	Varieties (V)	Fertilizer levels (F)	V x F		Varieties (V)	Fertilizer levels (F)	V x F	
S.Em±	0.03	0.30	0.10		0.02	0.67	0.22	
C.D. (P=0.05)	0.13	0.89	0.30		0.07	1.96	0.65	

Banana yield (t/ha)

Significantly highest yield (63.42 t/ha) was recorded in Grand Naine (V3) whereas the lowest yield (28.68 t/ha) was in Konkan Safed Velchi (V1) (Table 3). Significantly highest banana fruit yield (46.4 t/ha) due to NPK fertilizer levels were recorded in F4 (300:100:300 g NPK/plant) and lowest yield (37.57 t/ha) was in F1. Significantly highest banana yield (71.08 t/ha) due to interaction effect of varieties and NPK fertilizer levels were in V3F4 (300:100:300 g NPK/plant) in Grand Naine whereas the lowest banana yield (25.22 t/ha) in V1F1 (200:100:200 g NPK/plant) in Konkan Safed Velchi. Similar results reported by Ray et al., (1993) in Basrai and Rahate et al. (2020) and Navgare et al., (2021) in Grand Naine.

Available nitrogen (kg/ha)

In banana, nitrogen is the chief promoter of growth. It induces the vegetative growth and increases bunch grade

and sucker production. The initial available nitrogen present in soil was 351.02 kg/ha and the available nitrogen after fruit harvest varied from 368.4 to 407.8 kg/ha (Table 4). The significantly highest available nitrogen content (407.8 kg/ha) was observed in Red Banana (V2) whereas lowest available nitrogen (368.4 kg/ha) was in Grand Naine (V3). Significantly highest available nitrogen content (410.3 kg/ha) was reported in fertilizer F5 (300:100:400 g NPK/plant) whereas lowest available nitrogen (356.2 kg/ha) was recorded in F1 (200:100:200 g NPK/plant). Highest available nitrogen content (438.2 kg/ha) due to interaction effect of varieties and NPK fertilizer levels were in V2F5 (300:100:400 g NPK/plant) in Red Banana whereas the lowest available nitrogen (338.7 kg/ha) was V3F1 (200:100:200 g NPK/plant) in Grand Naine. Similar results reported by Rahate (2020) in Red banana.

Table 4. Effect of different varieties, NPK fertilizer levels and their interactions on available nitrogen, phosphorous and potassium content of soil in experimental block of banana

Treatments	Available nitrogen (kg/ha)				Available phosphorus (kg/ha)				Available potassium (kg/ha)			
Pre-experimental	351.02 kg/plant				8.25 kg/plant				409.86 kg/plant			
Post-experimental	V1	V2	V3	Mean	V1	V2	V3	Mean	V1	V2	V3	Mean
F ₁	342.1	387.9	338.7	356.2	7.9	11.1	9.5	9.5	405.9	448.8	411.3	422.0
F ₂	354.6	392.5	348.7	365.3	8.2	10.1	8.9	9.0	413.4	452.0	425.8	430.4
F ₃	362.8	408.9	350.1	373.9	9.0	8.8	10.2	9.3	428.8	469.1	429.6	442.5
F ₄	378.4	411.3	368.0	385.9	8.5	8.4	8.5	8.5	445.2	481.3	442.0	456.2
F ₅	404.3	438.2	388.5	410.3	8.7	10.2	8.1	9.0	457.7	493.2	448.9	466.6
Mean	368.4	407.8	358.8	378.3	8.5	9.7	9.0	9.1	430.2	468.9	431.5	443.5
	Varieties (V)	Fertilizer levels (F)	V x F		Varieties (V)	Fertilizer levels (F)	V x F		Varieties (V)	Fertilizer levels (F)	V x F	
S.Em±	0.30	6.19	2.06		0.01	0.14	0.05		0.68	4.49	1.50	
C.D. (P=0.05)	1.19	18.07	6.02		0.02	0.41	0.14		2.66	13.11	4.37	

Available phosphorus (kg/ha)

Phosphorus helps to produce healthy rhizomes and a strong root system in banana. The initial available phosphorus present in soil was 8.25 kg/ha and after fruit harvest varied from 8.5 to 9.7 kg/ha (Table 4). Significantly highest available phosphorus content (9.7 kg/ha) was observed in Red Banana (V2) while the lowest available phosphorus content (8.5 kg/ha) was in Konkan Safed Velchi (V1). Significantly highest available phosphorus (9.5 kg/ha) was in F1 (200:100:200 g NPK/plant) and it was at par with F3 (9.3 kg/ha) whereas the lowest available phosphorus (8.5 kg/ha) was in F4 (300:100:300 g NPK/plant). Significantly highest available phosphorus content (11.1 kg/ha) due to interaction effect of varieties and NPK fertilizer levels were recorded in the V2F1 (200:100:200 g NPK/plant) in Red Banana whereas lowest available phosphorus content (7.9 kg/ha) was in V1F1 (200:100:200 g NPK/plant) in Konkan Safed Velchi. Similar results reported by Rahate (2020) in Red banana.

Available potassium (kg/ha)

In banana crop potassium stimulates early shooting and significantly shortens the time required for fruit maturity. It also improves bunch quality, grade and size of fingers. The initial available potassium present in soil was 409.86 kg/ha and the available potassium after fruit harvest varied from 430.2 to 468.9 kg/ha (Table 4). Significantly highest available potassium content (468.9 kg/ha) was observed in Red Banana (V2) whereas the lowest available potassium content (430.2 kg/ha) was in Konkan Safed Velchi (V1). Significantly highest available potassium (466.6 kg/ha) was in F5 (300:100:400 g NPK/plant) and it was at par with F4 (456.2 kg/ha) whereas the lowest available potassium (422.0 kg/ha) was in F1 (200:100:200 g NPK/plant). Significantly highest available potassium content (493.2 kg/ha) due to interaction effect of varieties and NPK fertilizer levels were in V2F5 (300:100:400 g NPK/plant) in Red Banana whereas the lowest available potassium content (405.9 kg/ha) was in V1F1 (200:100:200 g NPK/plant) in Konkan Safed Velchi. Similar results reported by Rahate (2020) in Red banana.

Shelf life (days)

Significantly highest shelf life (10.62 days) was recorded in Konkan Safed Velchi (V1) whereas the lowest shelf life (8.20 days) was in Grand Naine (V3) (Fig. 2). Significantly highest shelf life (10.53 days) was recorded in F1 (200:100:200 g NPK/plant) which was at par with F2 (10.22 days), F3 (9.64 days) and F4 (9.83 days) while the lowest shelf life (8.67 days) was in F5 (300:100:400 g NPK/plant). Highest banana shelf life (11.42 days) due to interaction effect of varieties and NPK fertilizer levels were in V1F1 (200:100:200 g NPK/plant) in Konkan Safed Velchi which was followed by V2F1 (11.17 days) and V1F2 (11.08 days) whereas the lowest shelf life (7.08 days) were in V3F5 (300:100:400 g NPK/plant) in Grand Naine. Shelf life of fruit depends upon the proper nutrient management and the genetic characters of variety. Similar results reported by Rahate (2020) in Konkan Safed Velchi.

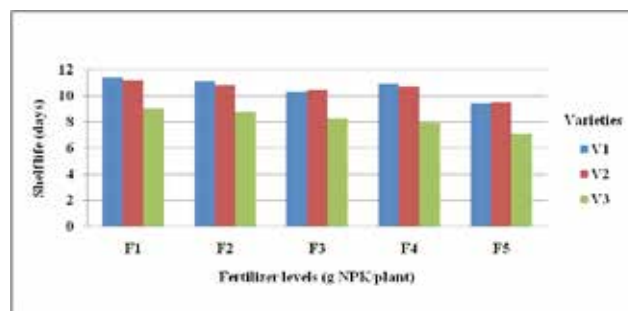


Fig 2. Effect of different varieties, NPK fertilizer levels and their interactions on shelf life of banana

Total soluble solids (°Brix)

Significantly maximum TSS (24.0 °Brix) was recorded in Konkan Safed Velchi (V1) whereas the minimum TSS (22.0 °Brix) was in Grand Naine (V3) (Table 5). Significantly maximum TSS (23.71 °Brix) was recorded in F4 (300:100:300 g NPK/plant) and it was at par with F2 (22.39 °Brix), F3 (23.05 °Brix) and F5 (23.04 °Brix) whereas the minimum TSS (21.81 °Brix) was in F1 (200:100:200 g NPK/plant). Maximum TSS (25.08 °Brix) due to interaction effect of varieties and NPK fertilizer levels were recorded in V1F4 (300:100:300 g NPK/plant) in Konkan Safed Velchi whereas minimum TSS (20.92 °Brix) in V3F1 (200:100:200 g NPK/plant) in Grand Naine. Similar results reported by Rahate (2020) in banana Cv. Konkan Safed Velchi.

Table 5. Effect of different varieties, NPK fertilizer levels and their interactions on total soluble solids and titratable acidity of banana

Treatments	Total soluble solids (°Brix)				Titratable acidity (%)			
	V1	V2	V3	Mean	V1	V2	V3	Mean
F ₁	22.83	21.67	20.92	21.81	0.61	0.61	0.66	0.63
F ₂	24.17	21.33	21.68	22.39	0.56	0.60	0.64	0.60
F ₃	24.25	22.82	22.08	23.05	0.54	0.56	0.62	0.58
F ₄	25.08	23.28	22.75	23.71	0.52	0.54	0.62	0.56
F ₅	23.67	22.88	22.58	23.04	0.60	0.59	0.61	0.60
Mean	24.00	22.40	22.00	22.80	0.57	0.58	0.63	0.59
	Varieties (V)	Fertilizer levels (F)	V x F		Varieties (V)	Fertilizer levels (F)	V x F	
S.Em±	0.02	0.49	0.16		0.0004	0.02	0.01	
C.D. (P=0.05)	0.06	1.42	0.47		0.002	0.06	0.02	

Titratable acidity (%)

Significantly lowest titratable acidity (0.57 %) was recorded in Konkan Safed Velchi (V1) whereas the highest titratable acidity (0.63 %) in Grand Naine (V3) (Table 5). Significantly minimum titratable acidity (0.56 %) was recorded in F4 (300:100:300 g NPK/plant) whereas the highest titratable acidity (0.63 %) was in F1 (200:100:200 g NPK/plant). The lowest titratable acidity (0.52 %) due to interaction effect of varieties and NPK fertilizer levels were in V1F4 (300:100:300 g NPK/plant) in Konkan Safed Velchi whereas the highest titratable acidity (0.66 %) was in V3F1 (200:100:200 g NPK/plant) in Grand Naine. Similar results reported by Gogoi et al., (2015) in banana Cv. Rasthali and Rahate (2020) in banana Cv. Konkan Safed Velchi.

Reducing sugars (%)

Significantly highest reducing sugars (7.79 %) were recorded in Konkan Safed Velchi (V1) whereas the lowest reducing sugars (6.03 %) were in Red Banana (V2) (Table 6). Significantly highest reducing sugars (7.70 %) were recorded in F4 (300:100:300 g NPK/plant) which was at par with F3 (7.38%) whereas the lowest reducing sugars (6.35 %) were in F1 (200:100:200 g NPK/plant).

Significantly highest reducing sugars (8.74 %) due to interaction effect of varieties and NPK fertilizer levels were in V1F4 (300:100:300 g NPK/plant) in Konkan Safed Velchi whereas lowest reducing sugars (5.81 %) was in V3F1 (200:100:200 g NPK/plant) in Grand Naine. Similar results reported by Tirkey et al., (2003) in Dwarf Cavendish, Gogoi et al., (2015) in banana Cv. Jahaji and Parmar et al. (2019) in banana Cv. Mahalaxmi.

Total sugars (%)

Significantly highest total sugars (10.01 %) were recorded in Konkan Safed Velchi (V1) whereas the lowest total sugars (8.0 %) were in Grand Naine (V2) (Table 6). Significantly highest total sugars (9.96 %) were recorded in F4 (300:100:300 g NPK/plant) which was at par with F3 (9.49 %) whereas lowest total sugars (8.34 %) were in F1 (200:100:200 g NPK/plant). Significantly highest total sugars (11.48 %) due to interaction effect of varieties and NPK fertilizer levels were in V1F4 (300:100:300 g NPK/plant) in Konkan Safed Velchi which was followed by V1F3 (10.85 %) and V2F4 (10.12 %) whereas the lowest total sugars (7.77 %) was in V3F5 (300:100:400 g NPK/plant) in Grand Naine. Similar results reported by Tirkey et al., (2003) in Dwarf Cavendish, Gogoi et al., (2015) in banana Cv. Jahaji and Parmar et al., (2019) in banana Cv. Mahalaxmi.

Table 6. Effect of different varieties, NPK fertilizer levels and their interactions on reducing and total sugars of banana

Treatments	Reducing sugars (%)				Total sugars (%)			
	V1	V2	V3	Mean	V1	V2	V3	Mean
F ₁	6.92	6.32	5.81	6.35	8.91	8.32	7.78	8.34
F ₂	7.36	7.12	6.02	6.83	9.40	9.25	8.02	8.89
F ₃	8.52	7.44	6.18	7.38	10.85	9.46	8.17	9.49
F ₄	8.74	8.10	6.27	7.70	11.48	10.12	8.29	9.96
F ₅	7.44	7.81	5.90	7.05	9.41	9.70	7.77	8.96
Mean	7.79	7.36	6.03	7.06	10.01	9.37	8.00	9.13
	Varieties (V)	Fertilizer levels (F)	V x F		Varieties (V)	Fertilizer levels (F)	V x F	
S.Em±	0.01	0.15	0.05		0.01	0.16	0.05	
C.D. (P=0.05)	0.03	0.42	0.14		0.03	0.48	0.16	

Economics of banana cultivation

The cultivar Grand Naine recorded highest gross returns of Rs. 951300/- with cost benefit ratio 1.9 (Table 7). Among NPK fertilizer levels, F4 (300:100:300 g NPK/plant) recorded highest gross returns of Rs. 928000/-

with cost benefit ratio 1.8 whereas among the interaction effect of varieties and NPK fertilizer levels, treatment combination V3F4 (300:100:300 g NPK/plant) in Grand Naine recorded highest gross returns of Rs.1066200/- with highest cost benefit ratio 2.0. The present findings are in conformity with findings of Rahate (2020).

Table 7. Economics of banana cultivation under the influence of different varieties and NPK fertilizer levels

Treatments	Yield (t/ha)	Gross returns (Rs)	Cost of cultivation (Rs)	Net profit (Rs)	C:B ratio
Varieties (V)					
V1-Konkan Safed Velchi	28.68	717000	465627.6	251372.4	1.5
V2-Red Banana	31.18	623600	450060.9	173539.1	1.4
V3-Grand Naine	63.42	951300	504677.6	446622.4	1.9
Fertilizers levels (F)					
F1-RDF (200:100:200 g NPK/plant)	37.57	751400	471360.9	280039.1	1.6
F2-300:100:100 g NPK/plant	38.94	778800	475214.3	303585.7	1.6
F3-300:100:200 g NPK/plant	40.40	808000	488870.0	319130.0	1.7
F4-300:100:300 g NPK/plant	46.40	928000	511007.8	416992.2	1.8
F5-300:100:400 g NPK/plant	42.15	843000	502347.7	340652.3	1.7

Interaction (V x F)					
V1F1	25.22	630500	451210.9	179289.1	1.4
V1F2	26.50	662500	455831.0	206669.0	1.5
V1F3	28.09	702250	471245.0	231005.0	1.5
V1F4	33.22	830500	494757.8	335742.2	1.7
V1F5	30.38	759500	488431.0	271069.0	1.6
V2F1	29.21	584200	443494.2	140705.8	1.3
V2F2	30.16	603200	445947.6	157252.4	1.4
V2F3	30.56	611200	456070.0	155130.0	1.3
V2F4	34.90	698000	472674.4	225325.6	1.5
V2F5	31.05	621000	465347.7	155652.3	1.3
V3F1	58.29	874350	491852.6	382497.4	1.8
V3F2	60.15	902250	495789.3	406460.7	1.8
V3F3	62.54	938100	510553.3	427546.7	1.8
V3F4	71.08	1066200	534041.1	532158.9	2.0
V3F5	65.02	975300	524397.7	450902.3	1.9

Conclusion

The results of this study revealed that for obtaining maximum yield the cultivar Grand Naine performed the best while for maintaining quality of banana Konkan Safed Velchi performed best. From fertilizer dose 10 kg FYM + 300:100:300 g NPK/plant has been found beneficial for maximum banana yield in relation to the variety Grand Naine which was proved to be the superior combination for vigorous growth and highest yield whereas fertilizer dose of 10 kg FYM + 200:100:200 g NPK/plant registered for obtaining better quality banana fruits.

Acknowledgements

This work is a part of M.Sc research work, at College of Horticulture, DBSKKV, Dapoli, (M.S.), India. The authors are thankful to the Head and Associate Dean, College of Horticulture, DBSKKV, Dapoli and Research Guide for providing the facilities. Authors extend their sincere thanks to the colleagues of M.Sc. student, Department of Horticulture, Dapoli for their support in field data collection.

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