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Effect of potash fertilizers and magnesium on qua lity of banana (*Musa paradisiaca* L.) cv. Grand Naine

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Abstract
A field experiment was carried out during 2013-14 and 2014-15 at RHRS, ACHF, NAU, Navsari with a view to study the effect of potash fertilizers and magnesium on quality of banana (*Musa paradisiaca* L.) cv. 'Grand Naine'. The investigation comprised of nine treatments, each replicated thrice in RBD and treatments were applied in three and four spilt. There was a significant impact of potassic fertilizers and magnesium on all characters chosen for this study. The results of experiment revealed that marked improvement in fruit quality of banana cv. 'Grand Naine' under 100% RDK through SOP in three equal splits (T_4) as reflected by the maximum values recorded for pulp: peel ratio, ascorbic acid, reducing sugar, total sugar, sugar: acid ratio, shelf life and the lowest value for titrable acidity in pooled data. The treatment T_4 (100% of RDK through SOP in three equal splits - 4, 5 and 6 MAP) was at par with the application of 100% RDK through SOP in three equal splits with 30g $MgSO_4$ per plant (T_5) for all the quality traits.

Keywords: banana, potassium, magnesium, total sugar, sugar: acid ratio, shelf life

Introduction

Banana being a gross feeder requires high amount of nutrients for proper growth and production. Banana (*Musa* × *paradisiaca* L.) is an important fruit crop of tropical and sub-tropical regions of the world. Geographical, climatic and genetic studies of bananas indicated that all edible bananas are indigenous to the warm moist regions of tropical Asia comprising the regions of India, Myanmar, Thailand and Indo-China. In India, it is cultivated in an estimated area of 7.76 lakh ha with 265.09 lakh MT of production and productivity is 34.16 MT/ha (Anon., 2014) [2]. In India, banana is the fourth important fruit crop in terms of gross value and is exceeded only by paddy, wheat and milk products. Fruits are a rich source of minerals like magnesium, sodium, potassium, phosphorus and provide a more balanced diet containing sufficient amount of carbohydrates and essential nutrients including minerals, vitamins (Hazarika 2011) [7].

Micronutrients are key elements in plants growth and development and play a very important role in the synthesis and activities of various enzymes (Das, 2003) [5]. The ever increasing prices of various fertilizers are a major source of expenditure and eat into the profits of farmers. The farmers therefore, should be guided regarding the most efficient form of splits and methods of fertilizer application, especially for the heavy feeder crops like banana to get maximum fertilizer use efficiency and net profit. The use of soluble fertilizers helps the roots to develop extensively in a restricted soil volume wetted by drip irrigation.

About 24 bananas each weighing around 100g can fulfill the energy requirement (2400 calories per day) of a man (Singh, 2002) [27]. Banana in particular being a K-loving crop requires nearly 1000-1500 kg of K_2O per hectare. Yield and quality are strongly influenced by potassium nutrition. It improves fruit weight and number of fingers per bunch (Bhargava *et al.*, 1993) [3]. Growers across the country are applying 800 to 1600 kg of potassium per ha depending upon the available soil K status. As Muriate of Potash (MOP) is commonly used as a source of potassium, chloride toxicity is often seen in bananas, hindering the crop yield and quality (Nalina *et al.*, 2003) [19].

Magnesium is distributed uniformity all over the organs in banana varieties like Poovan and Robusta according to Hewitt (1955) [8]. Magnesium is believed to increase the chlorophyll content of leaves and is also involved in the activation of many enzymes in carbohydrate metabolism (Tisdale *et al.,* 1985).

Due to intensive agriculture and use of sulphur free fertilizers, there has been a steady decline in the sulphur status of soils leading to its deficiency, which has become more pronounced and widespread throughout India (Rajagopalan, 1985) [24]. In this context, fertilizers containing sulphur such as Sulphate of Potash (SOP), having K and S would be more useful (Zhao *et al*., 1999) [30]. However, the effect of SOP as a source of K in banana nutrition in Gujarat has not been tested. It in this context, that an investigation was initiated at Regional Horticulture Research Station, Navsari Agricultural University, Navsari to assess the comparative efficacy of potassium based fertilizers on quality of Grand Naine under South Gujarat conditions.

Materials and Methods

A field trail was conducted at the Regional Horticultural Research Station, Navsari Agricultural University, Navsari during 2013-14 and 2014-15. The experimental plot was prepared by deep ploughing and harrowing. Pits of 30 cm radius were dug out by tractor drawn digger at a spacing of 2.4 m × 1.2 m and well decomposed, fine textured farm yard manure @ 10 kg pit^{-1} was applied at the time of planting. Planting was carried out in the second week of June and fourth week of June in 2013 and 2014, respectively at RHRS, Navsari. Before extracting plants from the bags, the bags were properly watered, which prevented loosening of soil around the roots. The crop was irrigated at 5 days interval in winter season and at 2 days interval in summer for 2 hr through drip.

The soil (0-30 cm) of the experimental plot was moderately drained clayey soil; the available N, P and K were 316.0 kg/ha, 67.02 kg/ha and 331.0 kg/ha with 0.59 dSm^{-1} EC and pH 7.36 (first year) and second year available N, P and K were 258.48 kg/ha, 51.72 kg/ha and 326.45 kg/ha with 0.68 dSm^{-1} EC and pH 7.26. The experimental field was situated at $20^0 57'$ N latitude and $72^0 54'$ E longitude and at the elevation of 10 meter above mean sea level. The Regional Horticultural Research Station is about 11 kilometers in the East away from Arabian Sea shore, the historical place Dandi famous for *Salt Styagrah* in Indian freedom history. Tissue cultured seedlings, procured from the Tissue Culture Laboratory, Department of Biotechnology, ACHF, NAU, Navsari, Gujarat after secondary hardening were planted at a spacing of 2.4 × 1.2 m. The experiment was laid out in a Randomized Block Design (RBD) with nine treatments, each replicated thrice. The treatments vis. T_1= Control (RDF - 300:90:200 NPK g/plant/year), T_2= 100% of RDK through MOP in three equal splits (4, 5 and 6 MAP), T_3= 100% of RDK through MOP in three equal splits (4, 5 and 6 MAP) + 30 g $MgSO_4$/plant, T_4= 100% of RDK through SOP in three equal splits (4, 5 and 6 MAP), T_5= 100% of RDK through SOP in three equal splits (4, 5 and 6 MAP) + 30 g $MgSO_4$/plant, T_6= 150% of RDK through MOP in four equal splits (4, 5, 6 and 7 MAP), T_7= 150% of RDK through MOP in four equal splits (4, 5, 6 and 7 MAP) + 30 g $MgSO_4$/plant, T_8= 150% of RDK through SOP in four equal splits (4, 5, 6 and 7 MAP), T_9= 150% of RDK through SOP in four equal splits (4, 5, 6 and 7 MAP) + 30 g $MgSO_4$/plant).

Standard procedures were adopted for taking observations on various quality characters. Five plants from the middle of each plot were selected randomly for recording observation on quality characters. The different quality attributes considered for the investigation was pulp: peel ratio total soluble solids (TSS), titrable acidity, ascorbic acid, reducing sugars, total sugars and sugar: acid ratio and shelf life. Perfect fingers were allowed for natural and uniform ripening and these fruits were utilized for determining different quality parameters. For pulp: peel ratio fully ripe fruits were weighed and peeled. The peel was weighed and pulp weight was arrived at by calculating the difference between the two. The total soluble solids in a sample were recorded by using a digital hand refractometer PAL-1 (Atago, Japan). The method described by Ranganna (1979) was adopted for estimation of titrable acidity and ascorbic acid content. Titrable acidity was expressed as percentage malic acid equivalent adopting the following formula.

$$\text{Acidity (\%)} = \frac{\text{Titre x Normality of alkali}}{\text{Volme of sample taken for estimation}} \times \frac{\text{Volume made up}}{\text{Weight of sample}} \times \frac{\text{Eq. Wt. of Malic acid}}{1000} \times 100$$

Ascorbic acid content was calculated adopting the following formula:

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre} \times \text{Dye factor}}{\text{Aliquot of extract taken for estimation}} \times \frac{\text{Volume made up} \times 100}{\text{Weight or volume of sample taken for estimation}}$$

The titrimetric method proposed by Lane and Eynonand described by Ranganna (1979) was adopted for estimation of reducing sugar. The percentage of reducing sugar was calculated according to the following formula:

$$\text{Reducing sugar (\%)} = \frac{\text{Glucose Eq. (0.05)} \times \text{Total volume made up}}{\text{Titre} \times \text{Weight of the pulp}} \times 100$$

The total sugars content was expressed as percentage in terms of invert sugars according to the following formula:

$$\text{Total sugars (\%)} = \frac{\text{Glucose Eq. of Fehling's solution (0.05)} \times \text{Total volume made up} \times \text{Volume made up after inversion}}{\text{Titre} \times \text{Weight of pulp taken} \times \text{Aliquot taken for inversion}} \times 100$$

Sugar: Acid ratio was computed by dividing total sugars by acidity. The shelf life of fruits was determined by storing them at room temperature and recording the days taken from harvesting to optimum eating stage.

Results and Discussion

In high value crop species like banana, quality standards have become the most important factor influencing monetary yield and farmer's income. Any management system should aim to produce quality fruits, besides maximizing the productivity.

In banana, fruit quality is mainly judged by the sugar content and acidity in the pulp and other quality parameters like pulp: peel ratio, TSS (ºBrix), reducing sugar (%), ascorbic acid (mg/100g), sugar: acid ratio and shelf life (days) of fruit.

Pulp: peel ratio

Data pertaining to the effect of various treatments on pulp: peel ratio of banana fruits are presented in table 1. The data revealed a significant effect of different treatment on pulp: peel ratio during the first year and in pooled analysis. Maximum pulp: peel ratio (3.40 and 3.39) was noted with T_4 treatment during the first year and in pooled data, respectively. This treatment was statistically at par with T_3 and T_5 treatments during 2013-14 and with T_5 in pooled data. During the second year (*i.e.* 2014-15), pulp: peel ratio was unaffected by different treatments. However, maximum value of pulp: peel ratio was recorded with T_5 treatment. The increase in pulp: peel ratio with higher K levels was mainly due to the increase in pulp weight which was the consequence of satisfactory activity of the enzymes involved in starch and protein synthesis under an adequate supply of K. Similar observations were previously noted by Natesh *et al.,* (1993), Moitra *et al.,* (1996), Agarwal *et al.,* (1997), Srinivas *et al.,* (2001) [27], Sumam and Padmaja (2005) and Mulagund *et al.,* (2015); [16]. Pulp: peel ratio was found non-significant in the interaction between year and treatments.

Total soluble solids (ºBrix)

The data pertaining to total soluble solids of banana cv. Grand Naine as influenced by various potassic fertilizer treatments are presented in table 1. Total soluble solids was significantly influenced by various treatments during the second year and in pooled analysis. During the first year, treatments failed to produce any significant effect on TSS. However, highest value of TSS (21.91ºBrix) was recorded with treatment T_4. The application of treatment (T_5) had higher value of TSS *i.e.* 22.79 and 22.10 ºBrix during the second year and in pooled analysis, respectively. This treatment was at par with T_4 in pooled analysis only. The increase in TSS may be due to respiration demand and adequate supply of nutrients, synthesis of inverters and starch splitting enzymes (Ram and Prasad, 1988). The interaction between year × treatments was non-significant for TSS of banana fruits.

Titrable acidity (%)

The mean data of titrable acidity content of banana fruit as affected by different treatments are presented in table 1. There was a non-significant effect of various sources and levels of potassic fertilizer with and without $MgSO_4$ in titrable acidity during both the years of study. However, minimum titrable acidity content (0.162 and 0.157%) was observed in T_4 followed by T_5, respectively. In pooled result, fertilizer treatments significantly altered titrable acidity content of banana. Minimum value of titrable acidity was registered with T_4 followed by T_5 treatment. Both these treatment were at par. There was a reduction in acidity content of fruits with 100 per cent of RDK through SOP in three equal splits - 4, 5 and 6 MAP in the present study. This may be due to neutralization of organic acids due to K level in the tissues. (Tisdale and Nelson, 1966) [29]. The interaction between Y × T was non-significant with respect to titrable acidity content of banana fruits during the present study.

Ascorbic acid content (mg/100g)

The data related to ascorbic acid content of banana fruit as influenced by various treatments of potash fertilizers are presented in table 2 and a perusal of data revealed that ascorbic acid content of fruit was not significantly affected by various treatments during the first year of study. However, maximum value of ascorbic acid content (5.01 mg/100g) was observed in T_3 treatment. During the second year and in pooled result, it was found significant and the highest value of ascorbic acid content (5.36 and 5.17mg/100g) was noted with treatment T_4, respectively. This treatment was at par with T_3 treatment in pooled analysis only. Increased ascorbic acid content in the fruits due to Potassium and sulphur could have helped slow down the enzymatic system that encouraged the oxidation of ascorbic acid, thus helping the plants to accumulate more ascorbic acid content in the fruits (Ananthi, 2002). The interaction effect of Y × T failed to elicit any significant effect on ascorbic acid content of banana fruit cv. Grand Naine.

Reducing sugar (%)

The mean data of reducing sugar in banana fruit as affected by different potash sources and levels with and without $MgSO_4$ are presented in 2 and data revealed that different fertilizers did not exert any significant affect on reducing sugar content of fruit during the first year of study. However, higher value of reducing sugar content (7.73%) was recorded with T_4 treatment. During the second year and in pooled result, it was found significant. The highest values of reducing sugar content of fruit (7.78 and 7.75 %) during the second year and in pooled analysis was recorded in T_4. This treatment was at par with T_6, T_5, T_4 and T_7 treatments during the second year and T_6 and T_5 in pooled analysis. Minimum reducing sugar content was registered by T_2 and T_1 treatments as 6.58 and 6.80% in the second year and pooled analysis, respectively. The interaction between Y × T failed to produce any significant effect on reducing sugar content of banana fruit.

Total sugar (%)

The data for total sugar content of banana fruit as influenced by various fertilizer treatments is given in table 2. There was a significant effect of different sources and levels of potassic fertilizers with and without $MgSO_4$ on total sugar content of fruit either in individual years or in pooled analysis. The highest total sugar content of fruit *i.e.* 17.85, 17.81 and 17.69% was observed in treatment T_5 during the first year and with treatment T_4 during second year and in pooled data, respectively. Both these treatments *i.e.* T_4 and T_5 were at par with each other. Higher sugar content can be explained by the role of potassium which is involved in carbohydrate synthesis, breakdown and translocation and synthesis of protein and neutralization of physiologically important organic acids (Tisdale and Nelson, 1966) [29]. Potassium is responsible for energy production in the form of ATP and NADPH in chloroplasts by maintaining balanced electric charges. Besides, K is involved in phloem loading and unloading of sucrose and amino acids and storage in the form of starch in developing fruits by activating the enzyme starch synthesis (Mengel and Kirkby, 1987) [14]. The interaction effect between Y × T was found non-significant with respect to total sugar content of banana fruit.

Sugar: acid ratio

The data related to sugar: acid ratio of banana fruit cv. Grand Naine as influenced by various fertilizer treatments are presented in graphically depicted in fig. 1. The data indicated that various levels and sources of potash fertilizers significantly influenced the sugar: acid ratio of banana fruit during individual years and in pooled analysis. Maximum sugar: acid ratio was obtained in T_5 treatment during first year and it was at par with treatment T_4. While, during the second year and in pooled result, maximum sugar: acid ratio was recorded in T_4 treatment, respectively. But this treatment was at par with treatment T_5 during second year and in pooled data. The interaction effect between Y × T failed to produce any significant on sugar: acid ratio of banana fruit.

Shelf life (days)

Data pertaining to the effect of various treatments on shelf life of banana fruit are presented in graphically depicted in fig. 2. The result indicated that significantly affected the shelf life of banana fruit during the present investigation. An application 100% of RDK through SOP in three equal splits - 4, 5 and 6 MAP (T_4) resulted in maximum shelf life of banana fruits during the individual year and in pooled results, respectively. During the first year, treatment T_4 was on same bar with T_5, T_7 and T_3, whereas, during the second year, it was at par with T_6 and T_7. The interaction between Y × T was found non-significant with respect to shelf life of banana fruits.

Table 1: Effect of potash fertilizers and magnesium on Pulp:Peel ratio, Total Soluble Solids (°Brix) and Titrable Acidity (%) in banana cv. Grand Naine.

Treatments	Pulp:Peel ratio			Total Soluble Solids (°Brix)			Titrable Acidity (%)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	2.87	2.86	2.86	20.56	20.36	20.46	0.181	0.178	0.180
T_2	2.88	2.74	2.81	20.84	20.24	20.54	0.178	0.180	0.179
T_3	3.31	3.20	3.26	21.21	21.48	21.35	0.172	0.166	0.169
T_4	3.40	3.37	3.39	21.91	21.53	21.72	0.162	0.157	0.160
T_5	3.35	3.33	3.34	21.54	22.79	22.17	0.164	0.162	0.163
T_6	2.94	3.11	3.02	21.01	20.27	20.64	0.173	0.176	0.175
T_7	3.18	3.31	3.25	21.67	21.02	21.34	0.168	0.166	0.167
T_8	3.04	3.01	3.04	21.03	20.77	20.90	0.176	0.171	0.174
T_9	3.15	3.27	3.21	21.19	20.85	21.02	0.171	0.173	0.172
Mean	3.12	3.14		21.22	21.04		0.172	0.170	
S.Em ±	0.044	0.081	0.033	0.334	0.287	0.156	0.003	0.003	0.001
C.D. at 5 %	0.132	NS	0.094	NS	0.859	0.448	NS	NS	0.004
Interaction (Y × T)				Interaction (Y × T)			Interaction (Y × T)		
S.Em ±			0.065			0.311			0.003
C.D. at 5 %			NS			NS			NS
CV%	4.23	7.80	4.72	4.72	4.09	4.42	4.48	5.01	4.75

Table 2: Effect of potash fertilizers and magnesium on ascorbic acid content, reducing sugar and total sugars in banana cv. Grand Naine

Treatments	Ascorbic acid content (mg/100g)			Reducing sugar (%)			Total sugars content (%)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	4.90	4.65	4.78	6.88	6.71	6.80	14.64	15.18	14.91
T_2	4.87	4.75	4.81	7.35	6.58	6.97	14.58	15.01	14.80
T_3	5.01	5.14	5.07	7.61	7.40	7.51	16.02	15.43	15.72
T_4	4.97	5.36	5.17	7.73	7.78	7.75	17.56	17.81	17.69
T_5	4.96	4.99	4.97	7.71	7.49	7.60	17.85	17.45	17.65
T_6	4.92	4.72	4.82	7.54	7.67	7.61	16.24	15.54	15.89
T_7	4.95	5.08	5.01	7.58	7.39	7.49	15.88	15.97	15.92
T_8	4.89	4.92	4.91	7.56	7.20	7.38	15.57	15.27	15.42
T_9	4.94	4.81	4.88	7.47	7.27	7.37	15.16	15.28	15.22
Mean	4.93	4.94		7.49	7.28		15.94	15.88	
S.Em ±	0.065	0.067	0.033	0.118	0.144	0.066	0.322	0.197	0.133
C.D. at 5 %	NS	0.202	0.095	NS	0.432	0.190	0.964	0.590	0.384
Interaction (Y × T)				Interaction (Y × T)			Interaction (Y × T)		
S.Em ±			0.066			0.132			0.267
C.D. at 5 %			NS			NS			NS
CV%	3.92	4.09	4.01	4.74	5.94	5.35	6.05	3.72	5.03

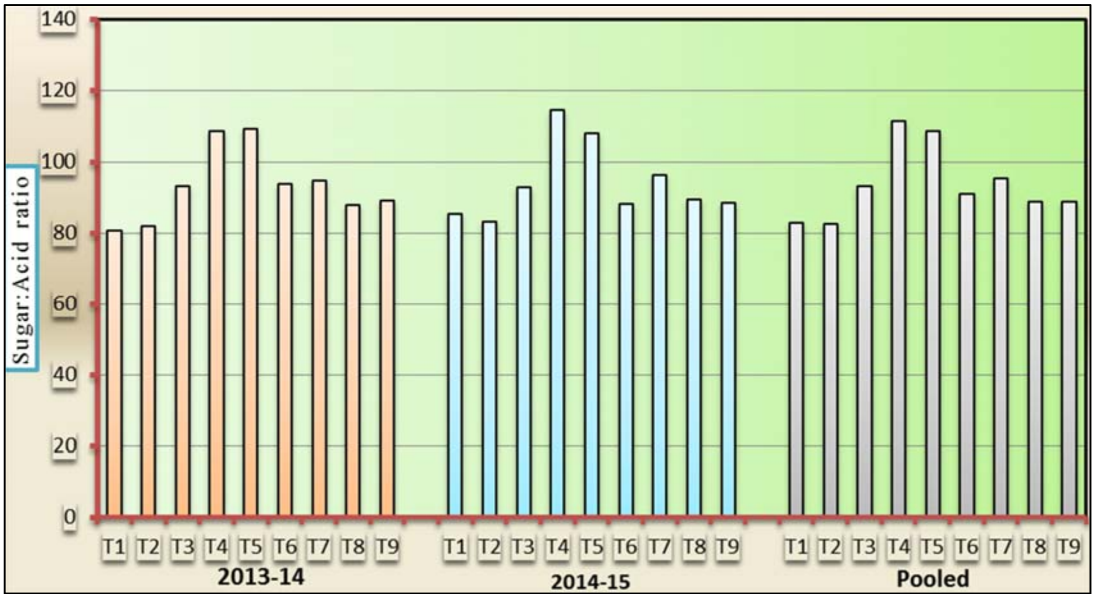

Fig 1: Effect of potash fertilizers and magnesium on Sugar: Acid ratio and shelf life in banana cv. Grand Naine

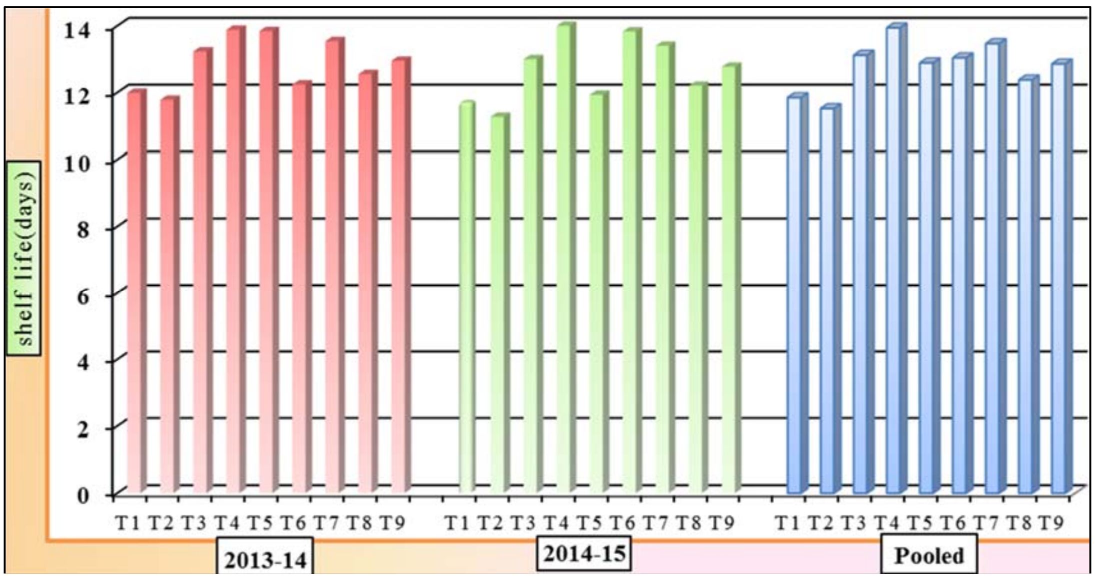

Fig 2: Effect of potash fertilizers and magnesium on shelf life in banana cv. Grand Naine

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