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Quality Characters and Shelf Life of Banana (*Musa* spp.) cv. Barjahaji as Influenced by Bunch Feeding of Nitrogen (N) and Potassium (K)

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Authors' contributions

This work was carried out in collaboration between all authors. Authors TTM and KB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TTM and VK managed the analyses of the study. Authors VK and NB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during March 2015 to June 2016 to study the impact of denavelling (removal of male bud) and stalk-end nutrient application (bunch feeding) on the improvement of bunch quality of banana cultivar cv. Barjahaji. The experiment was conducted with nine (09) treatments and three (03) replication in a randomized block design (RBD). Nitrogen and Potassium were applied (at stalk-end after removal of male bud) in the form of different chemicals along with cow dung and compared with control. Among the treatments less acidity (0.23%), the highest total soluble solids (29.23 ^{o}Brix), total sugars (17.42%), reducing sugar (9.09%), non-reducing sugar (8.33%) and Sugar acid ratio (75.74 %) were observed in the treatment T_7 (500 g fresh cow dung + 7.5 g Urea + 7.5g K_2SO_4). In respect to shelf life, bunch feeding with 500 g fresh cow dung + 7.5 g Urea + 7.5g K_2SO_4 (T_7) had attained the highest shelf life (7.67 days). It is

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evident from the study that there is a positive effect of bunch feeding on quality attributes and shelf life of banana. Hence bunch feeding of 500 g fresh cow dung + 7.5 g Urea + 7.5 g K_2SO_4 can be recommended for banana cv. Barjahaji (AAA) for getting best quality fruits of higher shelf life.

Keywords: Bunch feeding; TSS; total sugars; shelf-life; quality.

1. INTRODUCTION

Banana is one of the major commercial fruits crops grown in tropics, subtropics and considered as one of the most economical sources of food. It contains about 71.3 g moisture, 26.56 g carbohydrate, 1.08 g protein, 0.11 g fiber, 5 mg calcium, 0.49 mg iron, 18 mg phosphorus, 494 mg potassium, 5.1 mg ascorbic acid, 0.044 mg thiamine 0.045 mg riboflavin and 88 IU Vitamin A per 100 g edible portion [1]. In view of its nutritive value and fruit value, banana could be considered as "Apple of paradise" and it is cheaper than any other fruits and yet nutritionally delicious liked by people of all social strata. Banana is also used as dessert fruit for millions of people and can be used as staple food due to it's rich and easily digestible carbohydrates. Owing to its multifaceted uses and high economics returns, banana is referred as" Kalpataru" (a plant of virtue) in India [2]. At present banana production in India is 30.0 million tonnes from an area of 0.88 million hectares and the productivity is 34.1 tonnes [3].

Nutrients play a significant role in the production of high yield of good quality fruits. Providing appropriate quantities of nutrients at the right proportion when needed most is the essence of management of nutrients in successful banana cultivation. Banana takes up major nutrients in great quantities during peak growth phase and after shooting the rate of nutrient uptake slows down [4]. Nitrogen and Potassium are the most used nutrient elements in plant growth and development which play an essential role in high yields and fruit quality. Potassium is the key element in banana nutrition. Potassium is known to influence fruit yield in general and fruit quality in particular [5]. Bunch is the most drastically affected organ if potassium is insufficiently supplied.

In the traditional system of banana cultivation nutrient applied directly in the soil. Nutrient absorption by the plant from the soil and its utilization depend on a number of factors. Any limitation of nutrient supply at the time of bunch development can cause a serious problem like poor filling of the bunch with low-quality fingers and it was reported in almost all cultivar grown in India. Yield and quality of banana improved by combined application of nitrogen and potassium as reported by Kumar et al. [6] and Swati et al. [7]. Many reporters indicated that several crop along with banana responded well to the supplemental application of these nutrients at the time of bunch development. Hence an additional dose of fertilizer after shooting becomes imperative [8]. However, it is not wise to go for soil application of fertilizers at finger development stage, since the uptake is slow and low [9]. Many reports have indicated the usefulness of the external application of various nutrients during fruit development in influencing the fruit yield, shelf life and quality [7,8,10]. Banana has been found to respond well to urea and potash application. However, a very few work has been done on the combined effect of urea with the different form of potash along with cow dung as bunch feeding through the distal end in banana. Therefore, the present investigation was taken to study the potential impact of these nutrient placements at the cut stalk end on quality attributes and shelf life in banana cv. Barjahaji which is one of the commercial variety in the state of Assam.

2. MATERIALS AND METHODS

2.1 Study Area

The field experiment was carried out during the year 2015-2016 in the Horticultural orchard/ Experimental Farm, Department of Horticulture, College of Agriculture, Assam Agricultural University, Jorhat. The experimental site is located at 26^{o}47'N latitude and 94^{o}12'E longitude and at an altitude of 86.8 m above sea level. The climatic condition of Jorhat city located within the Upper Brahmaputra Valley Agro climatic Zone of Assam is characterized by a subtropical environment with hot humid summer and relatively dry and cool winter. The average rainfall is about 1875 mm to 2146 mm which is unevenly distributed throughout the year. The soil of the experiment site belonged to the order inceptisol and derived from the alluvial deposits of the river Brahmaputra. The soil of the experimental field is acidic, well drained and sandy loam in texture. The results of physico- chemical characterization and available nutrients of the soil of experimental site are presented in the Table 1 and Table 2.

Table 1. Physical properties of soil

Particulars	Values	Textual class
Course sand (%)	10.95	Sandy loam
Fine sand (%)	53.55	
Silt (%)	13.03	
Clay (%)	17.90	

Table 2. Chemical properties of soil

Particulars	Values
pH	4.60
Organic carbon (%)	0.52
Available Nitrogen (kg/ha)	216.50
Available Phosphorous (kg/ha)	41.35
Available Potassium (kg/ha)	86.09

2.2 Treatment and Design

The experiment was laid out in Randomized Block Design (RBD) with three replications comprising nine treatments (Table 3). There were twenty-seven plots each having eight numbers of plants with the spacing of 1.8 m x 1.8 m. Individual plot size was 25.92 m^2 and the total area of the experimental site was 699.84 m^2.

2.3 Data Collection

Uniform cultural practices were followed for all the treatments. Immediately after the fruit set or bunch formation and shedding of 7 - 8 flower petals (spathes), the male bud was denavelled at the stalk end of the bunch by cutting with a sharp knife at 60^0 angles in such a way that about 10-15 cm long rachis/stalk end was available after the last hand of the bunch. A fresh cow dung of 500 g is blended with the fertilizers (7.5 g each Urea, KCl, K_2SO_4, and KNO_3) dissolved in 100 ml of water to form a slurry for imposing to Barjahaji banana bunches after denavelling. This slurry was placed in a 200 gauge 15 cm × 25 cm plastic bag and tied the bag with a strong thread such that about 8 – 10 cm of the distal end of the rachis was immersed in the slurry and the remaining part above the tied portion is visible. Harvesting was done uniformly at three fourth maturity stages when the ridges of the fingers had disappeared and color turned from dark green to light green. The peduncle was cut at 22.5 cm above the first hand along with the bended poly bag. In control treatment, the male bud was allowed to grow naturally without removing from the bunch till harvest. After harvesting the bunch were allowed for natural and uniform repining and these fruits were utilized for determining different quality parameters and shelf life. TSS of the fruit was determined by the Zeiss Hand Juice Brix Refractometer and the result was expressed in ˚Brix [11]. The sugar to acid ratio was calculated by dividing the mean of total sugar by the mean titrable acidity of the respective fruit sample.

$$\text{Sugar-acid ratio} = \frac{\text{Total sugar (\%)}}{\text{Titrable acidity (\%)}}$$

Total sugar was estimated by adopting the procedure suggested by AOAC [12] and the result was expressed in percentage. Reducing sugars was also estimated by the standard method of Lane and Eyon [12] and the result was expressed in percentage. Non-reducing sugars were estimated by subtracting reducing sugars from total sugars and expressed as per cent. The titrable acidity was estimated by using the standard method of A.O.A.C. [12] and the result was expressed in percentage. Storage life or shelf life of fruits was decided based on the appearance and marketability of the fruits.

Table 3. Treatment details (as bunch feeding)

Notations	Treatments
T_1	500 g fresh cow dung
T_2	500 g fresh cow dung + 7.5 g Urea
T_3	500 g fresh cow dung + 7.5 g KCl
T_4	500 g fresh cow dung + 7.5 g K_2SO_4
T_5	500 g fresh cow dung + 7.5 g KNO_3
T_6	500 g fresh cow dung + 7.5 g Urea + 7.5 g KCl
T_7	500 g fresh cow dung + 7.5 g Urea + 7.5 g K_2SO_4
T_8	500 g fresh cow dung + 7.5 g Urea + 7.5 g KNO_3
T_9	Control

**Nitrogen is applied in the form of urea (46 % nitrogen), Potassium is applied in the form of chemical (KCl, K_2SO_4, KNO_3), Cow dung (0.5% N, 0.2% P and 0.5% K)*

The shelf life of fruits was determined by recording the number of days the fruits remained in good condition in storage. The stage where in more than 50 per cent of the stored fruits became unfit for consumption was considered as end of shelf life in that particular treatment and expressed as mean number of days. The shelf life can be defined as the time over which the ripe fruits remain acceptable for consumption [13].

2.4 Data Analysis

Data on all parameters were subjected to analysis of variance (ANOVA) as suggested by Fisher and Yates [14]. When ANOVA showed significant differences, mean separation was carried out using Critical Difference (CD) test at 5% level of significance to draw the valid conclusion.

3. RESULTS AND DISCUSSION

3.1 Total Soluble Solids (TSS)

Analytical data on TSS content on fruits were furnished in Table 4. Differences in TSS in fruit due to treatments were found to be highly significant. T_7 recorded significantly highest TSS (29.23^{0}Brix) followed by T_4 (28.10^{0}Brix). An appreciable increase in total soluble solids (TSS) content was observed with the supplemental application on N and K through bunch feeding accompanied by a higher sugar impact and accumulation. The increase in TSS content of fruits might be due to both nutrients are helpful in photosynthesis which ultimately led the accumulation of carbohydrates which help in increase of TSS content of the fruits. Nandan et al. [15] reported that increase in TSS due to sulphate of potash when supplied exogenously increased the flow of plant assimilates into the developing fruits especially when assimilate flow from other parts of plant becomes limited in banana cv. Nanjangudu Rasabale. The findings were in close conformity Kumar et al. [8] in cv. Robusta.

3.2 Titrable Acidity

The significantly highest titrable acidity (Table 4) was recorded in T_9 (0.36%) which was at par with T_1 (0.34%). In banana, fruit quality is mainly judged by sugar content and acidity in the pulp. Reduced acid content of fruits with potassium application in the present investigation can be explained by an apparent shunting of phosphoenol pyruvate (PEP) into alternate pathways resulting in a shortage of acetyl co-A [16]. Hence, oxaloacetate appeared to be preferentially acid derivative accumulated. Neutralization of organic acids due to high potassium level in tissues could have also resulted in a reduction in acidity [17]. The reason for the decrease in acidity due to additional nutrient supply might be due to increased translocation of carbohydrates and increased metabolism due to conversion of acids to sugars, thus bringing about reduction in acid percentage.

3.3 Total Sugar

Among the treatments, T_7 (500 g fresh cow dung + 7.5 g Urea + 7.5 g K_2SO_4) recorded the significantly highest total sugar of 17.42% (Table 4). Application of K_2SO_4 was found to be good in increasing sugar content as potassium plays a major role in carbohydrate synthesis, breakdown and translocation and synthesis of protein and neutralization of physiologically important organic acids. Further potassium when supplied in the form of sulphate of potash favours conversion of starch into simple sugars during ripening by activating the sucrose synthatase enzyme thus resulting in higher sugar percentage. Potassium 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 synthase [18]. Similar results were found by Kumar and Kumar [19] and [20] in banana cv. Neypoovan, Nandan et al. [15] in cv. Nanjanagudu Rasabale and Kumar et al. [8] in cv. Robusta.

3.4 Reducing Sugar

From the Table 4 it was evident that the significantly highest reducing sugar content was recorded in T_7 (9.09%). The effect of different concentrations of SOP on reducing sugar content of the fruits was studied by Kumar et al. [8] in cv. Robusta. This was 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. Potassium is responsible for energy production in the form of ATP and NADPH in chloroplasts by maintaining balanced electric charges. Post-shoot application of potassium favours the conversion of starch into simple sugars during ripening by activating sucrose synthase enzyme, resulting in high sugar content of the fruits.

Table 4. Effect of bunch feeding on quality characters and self life of banana

Treatments	Total soluble solids TSS (^{o} Brix)	Titrable acidity (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Sugar acid ratio (%)	Storage life (days)
T_1: 500 g fresh cow dung	21.60	0.34	6.03	7.95	13.10	40.94	5.33
T_2: 500 g fresh cow dung + 7.5 g Urea	20.70	0.32	8.33	7.09	15.42	48.19	5.67
T_3: 500 g fresh cow dung + 7.5 g KCl	13.50	0.32	7.03	7.29	14.30	41.87	5.67
T_4: 500 g fresh cow dung + 7.5 g K_2SO_4	28.10	0.26	8.50	7.20	15.70	61.33	6.67
T_5: 500 g fresh cow dung + 7.5 g KNO_3	13.50	0.33	7.04	7.72	14.42	43.03	5.33
T_6: 500 g fresh cow dung + 7.5 g Urea + 7.5 g KCl	21.55	0.32	8.62	6.20	14.82	46.31	5.67
T_7: 500 g fresh cow dung + 7.5 g Urea + 7.5 g K_2SO_4	29.23	0.23	9.09	8.33	17.42	75.74	7.67
T_8: 500 g fresh cow dung + 7.5 g Urea + 7.5 g KNO_3	21.50	0.31	8.33	6.05	14.36	42.24	6.00
T_9: Control	21.35	0.36	7.30	5.63	14.20	42.00	5.33
S.Ed (±)	0.20	0.01	0.17	0.11	0.11	0.46	0.68
$C.D_{0.05}$	0.42	0.02	0.36	0.24	0.22	0.98	1.44

** S.Ed= Standard Error of mean difference, C.D= Critical Difference*

3.5 Non Reducing Sugar

Table 4 revealed that T_7 (500 g fresh cow dung + 7.5 g Urea + 7.5 g K_2SO_4) recorded the significantly highest non-reducing sugar content of 8.33%. Such result might be due to application of cow dung, urea and K_2SO_4 to the cut distal stalk end of the bunch significantly improved the non reducing sugar content of the fruits. Removal of male bud and provision of feeding causes conservation and utilization of energy for finger development which would be otherwise lost for opening of the remainder of the flower and removal of a strong and active competing sink for photosynthates [10,21,22].

3.6 Sugar Acid Ratio

The significantly highest sugar acid ratio of 75.74% was observed in T_7 (500g fresh cow dung + 7.5 g Urea + 7.5 g K_2SO_4) (Table 4). Such result might be due to Potassium supply affects the fruit quality by affecting the reducing sugars, non-reducing sugars and total sugars. As potassium supply increases, the sugar to acid ratio increases because of increase in sugars as well as decrease in acidity [23].

3.7 Shelf Life

The number of days required after fully ripening of fruits in banana until spoilage was the shelf life and the results obtained as influenced by bunch feeding of nitrogen and potassium application of nutrients were presented in the Table 4. The longest shelf life (7.67 days) was observed in T_7 (500 g fresh cow dung + 7.5 g Urea + 7.5 g K_2SO_4). The effects of K on shelf life are predominantly favours, both through slowing senescence and through a decrease of numerous physiological diseases. Potassium increases firmness and strengthens the skin of fruits, thus they are not damaged easily during transport, and resist decay for a longer period and stay fresh longer. Increased K application reduces the postharvest moisture loss by increasing the weight of the harvested organs and maintaining tissue integrity. Potassium also can reduce the incidence of some fungal storage diseases that may cause considerable losses, given that fruits, tubers or roots showing even minor damage must be discarded before marketing. Storage compounds accumulating in the harvested produce during growth and maturation are consumed in the course of metabolic activities during storage. Respiration includes the oxidative breakdown of sugars, starch and organic acids into carbon dioxide and water, with the concurrent production of energy, heat and intermediary compounds to be used in biochemical reactions. Kumar and Kumar [20] reported that extended shelf life of bunch sprayed with sulphate of potash might be due to the lesser physiological loss in weight experienced in fruits. Similarly, the extended shelf life was found in Ney Poovan banana by Kumar and Kumar [19-20] by spraying 1.5% sulphate of potash, Kumar et al. [8] in Robusta, Nandan et al. [15] in cv. Nanjangudu Rasabale and Sateesh and Bangaruswamy [24] in cv. Rasthali by spraying 1% potassium chloride.

4. CONCLUSION

It is evident from the above result that all the quality traits have been improved when the banana bunch fed with different combination of nutrients over control. Also the shelf life of banana has been improved over the control. So it can be concluded that bunch feeding of banana with different nutrients can be integrated with application of recommended dose of fertilizers. Therefore treatment T_7 (500 g fresh cow dung + 7.5 g Urea + 7.5 g K_2SO_4) can be practiced in farmer field for getting high quality banana with longer storage life.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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