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EFFECT OF SILICON BUNCH SPRAYING AND BUNCH BAGGING ON FRUIT YIELD, QUALITY AND SHELF LIFE OF 'NEYPOOVAN' BANANA

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ABSTRACT : An experiment was conducted to know the effect of bunch spraying of silicon and bunch bagging on fruit yield, quality and shelf life of banana cv. Neypoovan. Potassium silicate was applied as three sprays at 30 days interval after emergence of inflorescence followed of bagging of bunches. Sprays were given at concentration of 2.0, 4.0 and 6.0 ml/lit per bunch 30 days interval then followed by bagging of bunches with polyethylene sleeves after spraying till harvest of fruits. Fruit characters like fruit weight, fruit length, fruit diameter, bunch weight and maximum shelf life (7.33 days) was recorded in treatment applied with bunch spraying of potassium silicate 6 ml/l per bunch bagging. The quality parameters viz., total sugars, acidity, total soluble solids, starch content of the fruit were also significantly influenced by same treatment.

Keywords : *Banana, silicon, bagging, quality, total soluble solids.*

Banana *(Musa* spp.) is considered as a queen of tropical fruit cultivated by man since prehistoric times. Banana provides nutrition and well-balanced diet to millions of people around the globe and also contributes to livelihood through crop production, processing and marketing (Singh, 20). It grows well in humid tropical low lands and is predominantly distributed between 30° N and 30° S of equator.

Banana provides dessert fruit or starch staple to millions of people in the world. It is easy to digest, nearly fat free with high nutritive value and relatively cheaper than other fruits. The total energy provided by 100g edible ripe pulp is 116 K calories, 1.2 g protein, 0.3 g fat, 27.2 g carbohydrates, 0.4 g fibre, 7 mg vitamin C and 0.8 g of minerals (Gopalan *et al.,* 7).

Neypoovan, (Elakkibale) once a delicate backyard cultivar of choice, now assumes commercial monoclonal cultivation. It is a slender, medium tall cultivar taking 12-13 months for its crop cycle and occupies large area in Karnataka. Average bunch weight is 18-20 Kg with small fruits packed closely having a wind-blown appearance. Pulp is ivory coloured, firm sweet, with good aroma and conspicuous ovules. Fruits attain yellow colour after ripening and are bequeathed with good-keeping quality and flavor.

Silicon is the most abundant element in the earth's crust region next to oxygen and comprises 28% of its weight, 3-17% in soil solution (Epstein, 5). It is most commonly found in soils in the form of solution as silicic acid (H_4SiO_4) and is taken up directly as silicic acid (Ma *et al.,* 11). Being a dominant component of soil minerals, it has many important functions in environment, although silicon is not considered as an essential plant nutrient because of its ubiquitous presence in the biosphere and most plants can be grown from seed to seed without its presence. Many plants can accumulate Si concentrations higher than essential macronutrients (Epstein, 5).

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Silicon deposited in the walls of epidermal cells after absorption by plants, contributes considerably to stem strength. Silicon is not much mobile element in plants (Savant *et al.,* 17). The role of silicon in plant biology is to reduce multiple stresses including biotic and abiotic stresses. It is also known to increase drought tolerance in plants by maintaining plant water balance, photosynthetic activity, erectness of leaves and structure of xylem vessels under high transpiration rates (Melo *et al.,* 14). Gong *et al.* (6) observed improved water economy and dry matter yield by silicon application and it enhanced leaf water potential under water stress conditions, reduced incidence of micronutrient and metal toxicity (Matoh *et al.,* 13). It is most commonly applied as foliar spray to correct the deficiency of specific element rather than complete requirement of that element. They are essential for many enzymatic reactions.

The use of bunch covers is widespread throughout the commercial banana growing regions of the world. They are also commonly used to protect export market intended plantain fruit during development. The practice is regarded as essential to improve the market quality and yield of the fruit. Bunch covers provide protection to the fruit surface against wind damage, leaf and petiole scarring, dust, light hail, sunburn, bird feeding and handling damage during harvest and transport. Pre-harvest fruit bagging is a simple, grower-friendly technology which is safe to use and has several beneficial effects on the physical appearance and quality of fruit. Furthermore, it is the safest approach to protect fruit from insect pests, diseases and other disorders. This approach is an integral part of fruit production in some parts of the World (Sharma *et al.,* 19).

In view of possible benefits of silicon and bagging on banana bunches the present study was carried out to know the effect of bunch treatment on yield and quality of banana cv. Neypoovan.

MATERIALS AND METHODS

A field experiment on yield, quality and shelf life of banana cv. Neypoovan as influenced by bunch spraying with potassium silicate and bunch bagging with polyethylene covers was carried out during 2014 at farmers field in Chikmagalur district of Karnataka state.

The experiment was carried on newly planted banana plants spaced at 2 m $\times$ 2 m. The experiment was laid out in a randomized complete block design (RCBD) with eight treatments, replicated thrice. Total number of plants was 5 per each replication. The uniform sized sword suckers from healthy and vigorous banana plants of cv. Neypoovan free from viruses and other diseases were selected for planting. The suckers were trimmed and the rhizome had been applied with carbofuran (3%) granules to prevent the rhizome weevil and other pests. Protective irrigation was given at weekly intervals and the treatments were imposed as per the experiment.

Treatment details

T_1 :	Control (No silicon application + No bagging)
T_2 :	Only bagging (No silicon application)
T_3 :	Bunch spray of Potassium silicate @ 2 ml L^{-1}/bunch at 30 days interval
T_4 :	Bunch spray of Potassium silicate @ 4 ml L^{-1}/ bunch at 30 days interval
T_5 :	Bunch spray of Potassium silicate @ 6 ml L^{-1}/ bunch at 30 days interval
T_6 :	Bunch spray of Potassium silicate @ 2 ml L^{-1}/ bunch at 30 days interval+ polyethylene bagging of bunches
T_7 :	Bunch spray of Potassium silicate @ 4 ml L^{-1}/ bunch at 30 days interval+ polyethylene bagging of bunches
T_8 :	Bunch spray of Potassium silicate @ 6 ml L^{-1}/bunch at 30 days interval + polyethylene bagging of bunches

Pre-harvest sprays as given below were taken up at monthly interval (3 sprays) from the time of emergence of flowers (inflorescence).

The observations like bunch wt/plant, fruit weight, fruit length, fruit diameter, TSS, acidity, total sugars, reducing sugars, instrumental colour readings, physiological loss in weight and shelf life of fruits were recorded.

OBSERVATIONS RECORDED

Bunch weight (kg)

The weight of bunches was recorded using a weighing scale after harvest of fully matured bunches and the bunch weight was expressed in kilogram.

Fruit characters

Fruit characters were recorded at mature stage for characters like fruit weight, fruit length and fruit diameter. Five ripe fingers from third hand were used for recording all the fingers characteristics.

Finger weight (g)

Fingers were weighed by using electronic balance and the mean weight of fingers was recorded and expressed in grams.

Finger length (cm)

Finger length was measured by using foot scale from the top of a finger to the pedicel; the mean length of finger was recorded and expressed in centimeters.

Finger diameter (cm)

Finger diameter was measured at the centre of finger by using vernier calipers and mean diameter of finger was recorded and expressed in centimeters.

Instrumental colour measurement (L*, a*, b*)

The colour of samples was measured using a Lovibond colour meter (Lovibond RT300, Portable spectrophotometer, The Tintometer Limited, Salisbury, UK) fitted with 8mm diameter aperture. The instrument was calibrated using the black and white tiles provided. Colour was expressed in Lovibond units L* (Lightness/ darkness), a* (redness/greenness) and b* (yellowness/ blueness). Banana fruits were directly placed under the aperture of the colour meter and measured on two sides per fruit for colour analysis and the values were averaged.

Physiological loss in weight (PLW %)

The fruits in each replication of respective treatment were weighed at the beginning of storage which was recorded as initial weight at mature green stage and later at ripe stage or senescence stage as final weight. Per cent physiological loss in weight was calculated using the formula given below.

$$\text{Physiological loss in weight (\%)} = \frac{P_0 - P_1}{P_0} \times 100$$

Where,

P_0 - initial weight

P_1 - Fruit weight at ripe stage

Shelf life (days)

The shelf life of fruits was determined by counting the number of days from ripening till the fruits remained edible without spoilage.

Total soluble solids (°B)

The juice extracted by squeezing the homogenized fruit pulp through muslin cloth was used to measure the TSS. It was determined by using ERMA hand refractometer, replicated three times and the mean was expressed in °B.

Titratable acidity (%)

A known weight of fruit pulp (5g) was homogenized with distilled water and filtered using muslin cloth followed by Whatman No. 1 filter paper. An aliquot of 10 ml was taken and titrated against standard 0.1N NaOH using phenolphthalein indicator. The appearance of light pink colour was marked as the end point. The value was expressed in terms of malic acid as per cent titratable acidity of juice.

Total sugars (%)

Non-reducing sugars were first hydrolyzed with hydrochloric acid to reducing sugars. Then, the total sugar was estimated using Dinitrosalicylic acid (DNSA) method and values were expressed as per cent.

Reducing sugar (%)

Reducing sugars in the samples were estimated as per the Dinitrosalicylic acid method. The values obtained were expressed as per cent.

Non-reducing sugar (%)

The per cent non-reducing sugars were obtained by subtracting the value of reducing sugars from that of total sugars. The resultant value was multiplied by the factor 0.95.

Non-reducing sugar (%) = [Total sugar (%) – reducing sugar (%)] × 0.95

RESULTS AND DISCUSSION

The maximum bunch weight (26.80 kg/ plant) was recorded in the treatment (T_8) with application of potassium silicate at 6ml/l + bagging of bunches at 30 days interval and lowest was recorded in the control T_1 (Table 1). The increase in bunch weight could be the result of an increase in bunch size and finger size and numbers. The increase in finger size can be a major factor contributing to the bunch weight. The similar observation was recorded by Bhavya (4) in Bangalore Blue grapes. Silicon helps in cell division; Si improves the structural stability of cell walls during cell elongation and division and thereby maintains cell shape, which may be important for the function and survival of cells (Sivanesan and Park, 21), Silicon in plants can stimulate nutrient uptake and plant photosynthesis (Smith, 22). As silicon helps in cell division, may result in production of more number of fruits. Similar observations were made by Gorecki and Danielskibusch (8) in green house cucumber where results revealed that, increased yield was attributed on the number of fruits. Nesreen *et al.* (15) noticed application of silicon increased the number of pods per plant in beans. Stamatakis *et al.* (23) reported that, silicon application increased fruit retention and increased number of fruits per plant and similar results were observed by Bhavya (4) in Bangalore Blue grapes.

Results indicated profound influence of application of silicon and bagging treatments on finger characters *viz.,* finger weight, finger length and finger diameter (Table 1). These parameters recorded significantly maximum values in silicon and bagging treatments than in untreated control. The increase in finger size might be due to higher photosynthetic activity and biomass production in the plant which might have resulted in more metabolites in the fruits (Young *et al.,* 27). As the growth and development of the fingers advances, large amount of water and other metabolites moves in to the fingers resulting in higher fruit weight, length and diameter. The increase length, diameter and weight of finger could also be due to the effect of skirting materials. The growth and development of a plant organ follows a rhythm and log phase contributes maximum to increase in size. Covering fruits with a bag at a particular developmental stage may influence their growth and size. According to Xu *et al.* (26) bagging with plastic bags increased fruit weight in carambola when applied 10 days after full bloom.

Colour and appearance is one of the important attributes that determine the edibility of a fruit. Colour change in a ripening banana fruit results from various

Table 1: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bunch bagging on bunch weight, fruit characters and on instrumental colour values of banana fruits cv. 'Neypoovan'.

Treatments	Bunch weight (kg)	Finger characters			Instrumental colour values				
		Finger weight (g)	Finger length (cm)	Finger diameter (cm)	L* (Lightness)	a* (Redness)	b* (Yellowness)	C* (Chroma)	h^0 (Hue angle)
T_1	8.30d	65.53f	10.73h	2.35d	57.07f	2.93d	36.44g	33.94g	97.90a
T_2	9.11cd	69.14e	11.27g	2.30e	63.02de	5.39b	42.32d	37.65d	96.77b
T_3	9.40cd	71.48d	11.43f	2.32de	61.29e	3.34d	40.34f	36.03f	96.60b
T_4	10.04bc	73.45c	12.30d	2.44c	63.78cd	3.93c	41.71e	36.87e	96.21b
T_5	11.14b	75.98b	13.47b	2.67b	63.93cd	5.41b	42.02de	37.55d	91.19c
T_6	9.98bc	73.18c	11.73e	2.48c	65.13bc	5.80b	42.91c	38.74c	88.65d
T_7	10.90b	74.13c	12.87c	2.70b	65.91b	6.62a	44.10b	40.04b	86.02e
T_8	12.62a	78.55a	13.93a	2.78a	68.02a	6.73a	45.13	40.76a	85.59e
C.D (P = 0.05)	1.46	1.31	0.14	0.04	1.93	0.54	0.36	0.52	0.98

Note : Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$

physico-chemical changes that a fruit undergoes during ripening leading to characteristic appealing yellow skin colour.

The peel colour of banana fruits changes from green (chloroplasts) to yellow colour (chromoplasts) during ripening (Seymour *et al.,* 18; Stover and Simmonds, 24). L* (brightness) values of peel colour were significantly higher in the fruits sprayed with potassium silicates followed by bunch bagging (T_8-68.02, T_7-65.91, and T_6-65.13). The values for a* (redness) and b* (yellowness) were positive and maximum in fruits of the same treatments. As a result chroma (C*), the index or purity of the hue (ho) that correlates between a* and b* were also significantly higher in fruits under those treatments in comparison to unbagged treatments (Table 2). This indicates the role of potassium silicate and bagging in conversion of peel pigments leading to improved peel colour of banana fruits. Some reports revealed that the pre-harvest sprays of silicon and potassium influenced the colour of the crops *viz.,* rose (Saeed *et al.,* 9) and banana (Kumar *et al.,* 16). In this study all the colour coordinates were significantly influenced by the potassium silicate application and bagging of bunches. Saeed *et al.* (16) observed the role of silicon sprays in improving colour and appearance of Rosa hybrida var. Hot lady and A-Shiarn *et al.* (1) noticed increased chroma and lightness in grapes bagged with black paper. On the other hand, L* (57.07), b* (36.44), C* (33.94) were lower for the peel colour of control fruits indicating dullness of skin colour.

The significant difference was noticed in the total soluble solids with bunch spraying of silicon on banana cv. Neypoovan. The maximum total soluble solids (26.80 0 Brix) was found in the treatment T_8 (bunch spraying of potassium silicate @ 6 ml/l/plant at 30 days interval+bagging). Whereas, the lowest total soluble solid (22.57° Brix) content was recorded in control (T_1). Silicon and potassium helped in synthesis of more sugars in the fruit and thus helped in increasing total soluble solids the results are in accordance with Bhavya (4) in Bangalore bluegrapes.

The titratable acidity was less (0.30 per cent) in bunch spraying of potassium silicate @ 6 ml/l/plant at 30 days interval+bagging (T_8) and highest was found in control (0.39). The decrease in acidity might be due to increase in the total soluble solids and it may be also because of potassium which might have either involved in fast conversion of metabolites into sugar and their derivatives.

However at optimum ripe stage, the total sugar content (23.46 %) and reducing sugar content (17.84 %) was more in fruits treated with bunch spraying of potassium silicate at 6 ml/l and bagging while minimum total sugar (18.18 %) and reducing sugar (11.32 %) were noticed in untreated control (T_1). This progressive increase could be related to increase in total soluble solids content of fruits. The similar results obtained by Bhavya (4) in Bangalore Blue grapes and Stamatakis *et al.* (23) in tomato. The increase in sugar content could

Table 2: Influence of pre-harvest bunch treatments (bunch spraying of nutrients) and bunch bagging on physiological loss in weight, shelf life and quality parameters of banana fruits var. 'Neypoovan'.

Treatments	Quality parameters					Physiological loss in weight (%)	Shelf life (Days)
	TSS (^{0}B)	Acidity (%)	Total sugars (%)	Reducing sugars (%)	Non Reducing sugars (%)		
T_1	22.57f	0.390a	18.18h	11.32h	6.51b	10.97a	4.33e
T_2	23.47e	0.353b	19.10f	11.98f	6.76b	9.33b	5.33cd
T_3	23.03e	0.377a	18.47g	11.49g	6.63b	9.74b	4.67de
T_4	24.47d	0.337bc	19.94e	12.20e	7.35a	8.44c	6.00bc
T_5	25.47c	0.323cd	20.31d	13.90d	6.09c	8.48c	6.33b
T_6	24.90d	0.337bc	21.60c	15.40c	5.89c	8.15c	5.00de
T_7	26.20b	0.313de	22.80b	16.93b	5.59d	5.49d	5.33cd
T_8	26.80a	0.303e	23.46a	17.84a	5.34d	4.39e	7.33a
C.D (P = 0.05)	0.45	0.017	0.31	0.22	0.26	0.66	0.93

Note : Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at P = 0.05

be attributed to enzymatic conversion of starch to reducing sugars.

The weight loss is an important index of post harvest storage life in the fresh produce. It is mainly attributed to loss of water during metabolic process like respiration and transpiration. Transpiration that occurs in banana fruits through stomata present on the skin leads to direct loss of moisture resulting in loss of weight. The transpiration rate is accelerated by cellular breakdown (Woods, 25). Respiration which is a catabolic process, results in utilization of reserved foods. It causes weight reduction because a carbon atom is lost from the fruit each time a carbon dioxide molecule is produced from an absorbed oxygen molecule and evolved into the atmosphere. Thus physiological loss in weight progressively increased during the storage of banana fruit at ambient condition.

Pre-harvest treatment with potassium silicate and subsequent bagging in polyethylene sleeves showed the minimum physiological loss in weight (4.39 %) in treatment T_8 as compared to control (10.97 %). Reduced PLW in T_8 could be corroborated by reduced respiration rate. Minimum respiration rate in potassium silicate treated fruits is thought to be due to its antisenescence properties, inhibition of ethylene biosynthesis or reduced rate of metabolism (Stamatakis *et al.,* 23). Bagging in the present experiment provided protection to the fruits against possible mechanical damage on fruits by insects, birds or atmospheric events (Sharma *et al.,* 19) which would have otherwise led to rapid loss of moisture. The results are in conformity with reports of Barbang *et al.,* (3) in banana; Kaluwa *et al.* (9) and Stamatakis *et al.* (23) in avocado, Babak and Majid (2) in cut carnations and Mathooko *et al.* (11) in mango.

Due to antisenescence properties, inhibition of ethylene biosynthesis or reduced metabolic rate, banana fruits treated with potassium silicate had higher shelf life compared to control fruits. Maximum shelf life (7.33) was observed in fruits of treatment T_8. The results are in conformity with report of Barbang *et al.* (3) in banana; Kaluwa *et al.* (9) and Stamatakis *et al.* (23) in avocado and Babak and Majid (2) in cut carnations.

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