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Effect of paclobutrazol application and bunch covering on productivity and quality of banana

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ABSTRACT

Purpose: The experiment aimed to evaluate the effect and optimal dose of paclobutrazol, and appropriacy of bunch covering materials on productivity and quality of banana. **Research method**: This study was laid out following a randomized complete block design with four replications. The experiment consisted of two factors namely Factor A: Different doses of paclobutrazol i.e. no paclobutrazol, 1 g/L paclobutrazol and 2 g/L palobutrazol and Factor B: bunch covering i.e. control (no polythene covering), white polythene covering and blue polythene covering. Paclobutrazol was sprayed 2 times; firstly, at fruit set stage and secondly, one month after 1st spray. **Findings**: The treatments showed significant effect on the yield as well as qualitative traits of banana. Paclobutrazol sprayed plants performed better than non-paclobutrazol treated plants. Application of paclobutrazol (2 g/L) and blue bunch covering banana contained higher amount of sugar. However, blue and white polythene had no significant effect on color measurement of banana peel. Paclobutrazol (1g/L) and white polythene treated bunch produced the highest bunch weight (24.91 kg), pulp:peel ratio (3.57), fibre content (4.20%) while no polythene treated with no paclobutrazol produced the lowest bunch weight (16.77 kg), pulp:peel ratio (1.89), fibre content (2.60%) of banana. These results generally prove that paclobutrazol application could potentially be used to improve crop productivity and their quality value. **Research limitations**: There were no limitations identified. **Originality/Value:** Paclobutrazol (1mg/L) with white polythene as bunch covering resulted in the maximum banana production and quality when compared to other treatment combinations, without compromising of human health and environmental sustainability.

INTRODUCTION

Banana (*Musa paradisiaca* L.) is a prominent fruit crop that belongs to the Musaceae family. It is the world's most nutritious fruit crop, grown in over 130 nations in the tropical and subtropical areas and used as a staple food as well as dietary supplements (Al-Dairi et al., 2023). On 11590.30 ha of land, Bangladesh produces 183438.79 metric tons of bananas (BBS, 2022). It has ascorbic acid, riboflavin, niacin, protein, fat, ash, phosphorus, calcium, iron, β-carotene, and crude fiber (Sule et al., 2019). Majority of banana fruits are blemished by dust, bird droppings, leaf scars, and mechanical injuries sustained during postharvest processing.

To improve the growth, maturity, yield, and quality of banana fruits, bunch management techniques, pesticides, and plant growth regulators are applied. Paclobutrazol (PBZ) is a triazole derivative that is crucial for controlling excessive vegetative growth, encouraging flowering, causing early bearing, and boosting fruit crop productivity and quality (Gollagi et al., 2019). According to Carreno et al. (2007), fruit set was increased when paclobutrazol was applied prior to blooming. Increased dry matter partitioning to fruits may be the cause of the enhanced fruit set following paclobutrazol treatment. Because bananas are climacteric and highly perishable (Alhassan & Ndomakaah, 2024), pre-harvest chemical and growth regulator applications are required to increase shelf life while maintaining quality and minimizing post-harvest losses.

Bunch covering has also been linked to decreased fruit defects like sunburn and fruit splitting, as well as an increase in finger length and bunch weight and acceptable skin appearance and color (Rubel et al., 2019). According to Ali et al. (2021), bagging is a highly successful method for altering the fruit's microclimate, which prevents various stresses and preserves or enhances the fruit's overall quality. Covering the plantain or banana bunch soon after pollination can significantly reduce insect pest damage. Additionally, it has been demonstrated that fruit from sleeved bunches has a substantially lower incidence of postharvest anthracnose disease (Buthelezi et al., 2021). Using bunch cover enhances fruit quality and increases marketable product. Bunch coverings of various colors and conditions have been widely utilized in banana-growing countries for enhanced output and quality (Ali et al., 2018). Furthermore, bunches were protected from pests and diseases such as thrips, beetles, pitting, anthracnose, tip end rot, cigar end rot, brown spot, and diamond spot via bunch covering (Amani & Avagyan, 2014).

Knowledge on the effects of paclobutrazol treatment and bunch covering on productivity and quality of banana is scarce or scanty in the agricultural climate of Bangladesh. Therefore, the study aimed to evaluate the effect of paclobutrazol, and appropriate of bunch covering materials on productivity and quality of banana at the Horticulture Farm at Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh.

MATERIALS AND METHODS

Study area

The experiment took place from July 2022 to June 2023 on an open field at Sher-e-Bangla Agricultural University's Horticulture Farm in Bangladesh. The location was 24.09°N and 90.26°E longitude, with an elevation of 8.20 m from sea level. The soil was loamy, and the climate was divided into three seasons: winter (November to February), pre-monsoon (March to April), and monsoon (May to October).

Experimental design, plant materials and growing conditions

This study was laid out a randomized complete block design (RCBD) with four replications for each treatment and five plants in each replicate. Banana sucker (cv. BARI Banana 1) was obtained from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh and planted with spacing (1.5×1.5m). All plants were comparable in terms of age and growth, and they all received the recommended fertilization schedule, as well as all necessary cultural practices and plant protection measures.

Treatments and treatment combination

The experiment consisted of two factors as factor A: different doses of paclobutrazol (PBZ) i.e. No PBZ, 1 g/L PBZ and 2 g/L PBZ and Factor B: bunch covering i.e. control (no polythene), white polythene and blue polythene. There were 9 (3×3) treatments combinations such as: Control, No PBZ + White polythene, No PBZ + blue polythene, PBZ (1g/L) + No polythene, PBZ (1g/L) + white polythene, PBZ (1g/L) + blue polythene, PBZ (2g/L) + No polythene, PBZ (2g/L) + white polythene, PBZ (2g/L) + blue polythene. Afterwards, PBZ was sprayed 2 times, firstly during bunches emergence stage and secondly one month after 1st spray. Once the floral remnants were hardened and the bracts covering the hands and fingers were curling upward, bunches were covered. The bunch covers hung at least 15 cm below the banana's last hand and were left open at the bottom.

Sampling for experimentation

Three plants were chosen at random from each replication for analysis of fruit production, yield, and physiochemical characteristics.

Evaluation of the effect of paclobutrazol (PBZ) and bunch covering on pre-harvest and physical-harvest properties of banana

For all five of the chosen plants in each treatment, the number of days needed from bunch initiation to harvesting, bunch length, and bunch weight were noted. Fruits that attained harvestable ripeness were counted to determine the number of hands/bunch and fingers/hand. An electronic top pan balance was used to remove the pulp and peel from each chosen hand.

Evaluation of the effect of paclobutrazol (PBZ) and bunch covering on biochemical properties of banana *α-amylase activity assay*

The third hand of each bunch was used to conduct chemical analysis. The hand at the top of the bunch is the first to be initiated, and hands are generally numbered from this point down.

Total soluble solids content

A digital refractometer (MA871; Romania) was used to measure the TSS concentration of bananas. Using a dropper, a drop of banana juice was collected and put on the refractometer prism. The total soluble solids reading were displayed by the refractometer. Results were expressed as degree Brix (°Brix).

Titratable acidity (TA %)

In order to determine the TA, the 5g of fruit samples were macerated using a mortar and pestle. Following maceration, the samples were filtered and 100 milliliters of water were added. Two drops of phenolphthalein were then added to ten milliliters of stock solution in a conical flask. 1N NaOH was used to titrate the solution three times. Until the pink hue emerged, the titration was stopped.

Vitamin C determination

A 5 g sample of banana fruit was mixed, and filter paper (Whatman No. 1) was used to sieve the liquid. A solution of 5% oxalic acid was added to get the volume up to 100 milliliters. The dye solution 2, 6-dichlorophenol indophenol, was used for the titration. Using the L-ascorbic acid standard, the mean observations yielded the quantity of dye needed to oxidize a specific amount of L-ascorbic acid solution at an unknown concentration. Each time, a 5 ml solution was used for titration, and the final point of titration was identified by the pink color, which persisted for 10 seconds. Vitamin C contents in fruit samples were recorded as mg of Vitamin C per 100 gram of fruit pulp.

Total sugar

After chopping the fruit pulps into small bits, they were added to ethyl alcohol that was just starting to boil and left for ten minutes. For every gram of pulp, 10 milliliters of alcohol are needed. The extract was re-extracted for three minutes in 80% hot alcohols with two to three milliliters of alcohol per gram of tissue after being screened through two layers of cotton. The extract was cooled and then passed through two cotton layers. To purify both extracts, Whatman No. 41 filter paper was used. Before being cooled, the extract was evaporated over a steam bath to a quarter of its initial volume. After that, distilled water was added to a 100 ml volumetric flask until the appropriate amount was reached, and the concentrated extract was placed inside (1).

$$\text{Total sugar (mg/100g)} = \text{Amount of sugar obtained/ Weight of sample} \times 100 \quad (1)$$

Reducing sugar

The phenol-sulfuric acid method was used to determine the reducing sugars. The extract was filtered after 0.2 grams of fresh leaf were homogenized with deionized water. Two milliliters of the solution were mixed with 0.4 milliliters of 5% phenol. 2 cc of 98% sulfuric acid was then rapidly added to the liquid. To allow the color to develop, the test tubes were placed in a water bath that was set at thirty degrees Celsius for twenty minutes after being left at room temperature for ten minutes. The spectrophotometer was then used to detect the light absorption at 540 nm. The blank solution, which is distilled water, was made using the same procedure. In mg/100g FW, the reducing sugar content was reported.

Non-reducing sugar

The non-reducing sugar content of banana pulp was determined using the following formula (2):

$$\text{Non-reducing sugar (mg/100g)} = \text{Total sugar - reducing sugar} \quad (2)$$

Evaluation of the effect of paclobutrazol (PBZ) and bunch covering on proximate composition of banana

Ash content (%)

For calculating the ash content of banana, use the dry ash method, AOAC (1995) method no. 942.05. By precisely measuring one gram of each sample into a crucible, setting the crucible on a clay pipe triangle, heating the material over a low flame until it was completely charred, and then heating the material in a muffle furnace for roughly six hours at 600°C, it was possible to calculate the total amount of ash in banana. After cooling, it was weighed in desiccators. To determine the total amount of ash, apply the equation below (3) (Raghuramulu et al., 2003).

Ash content (%) = sampled weight of banana divided by weight of ash (3)

Lipid content (%)

The AOAC (1995) technique was used to determine lipid. The mixture of 50 ml of chloroform, methanol (2:1 v/v), and five grams of ground banana was carefully mixed before being allowed to stand for three days. A table centrifuge was used to filter the solution and centrifuge it at 1000g. The Pasteur pipette was used to remove the top layer of the methanol, and heating caused the chloroform to evaporate, thus crude lipid is remained.

Fiber content (%)

The AOAC method no. 962.03 was used to determine the banana fiber content. 200 ml of boiling 0.255 N H_2SO_4 was added to a beaker containing five grams of moisture- and fat-free substance. Five grams of the sample, which was free of moisture and fat, were put in a beaker, and 200 ml of boiling 0.255 N H_2SO_4 were added. The volume was maintained constant throughout the 30-minute boiling process by adding water at regular intervals. After filtering the mixture through a muslin cloth, the remaining material was thoroughly washed with hot water to remove any remaining acids. 200 ml of boiling 0.313 N NaOH was then added to the mixture in the same beaker. After boiling for 30 minutes (at the same volume), the mixture was filtered through a muslin cloth. The remaining substance was then washed in ether and alcohol before being rinsed with hot water to remove any remaining alkali. After spending the night in a crucible drying at 80 to 100 °C, it was then weighed using an electric balance. The crucible was heated in a muffle furnace at 600°C for 5–6 hours before being cooled, weighed, and calculated (Raghuramulu et al., 2003)

Moisture content (%)

The moisture content of banana powder was determined using an electric moisture meter and expressed as a percentage.

Color measurement

The colors of the banana peel were measured nondestructively using a Minolta Chroma meter (Model CR400) that was configured with a D65 illuminant and a 10° observer angle. The color values were represented by the letters L*, a*, b*, and C*. For every fruit, the reading was set to require an average of six random points. The colorimeter must be completely in contact with the fruits to stop light from leaking from it.

Statistical analyses

The Statistical Analysis System (SAS), version 9.4 (SAS Institute, Cary, NC, USA), was used for statistical analyses. Statistical significance was reached when the mean value of the treatments was $p = 0.05$.

RESULTS AND DISCUSSION

Time (days) to harvest from fruit set

Days to harvest from set were significantly influenced by paclobutrazol and bagging materials. The lowest number of days (110) required for harvesting was observed from the treatment combination of paclobutrazol (1g/L) and white polythene and the highest days (151 days) required for harvesting was recorded from control which was significantly highest from other treatment combinations (Table 1). It was observed that exogenous application of paclobutrazol at 1g/L and bunch covering with white polythene influenced some physiological attributes of banana and this treatment took the lowest number of days to harvesting. Singh and Ranganath (2006) observed that paclobutrazol exhibited earlier harvest than that of the control. Fruits harvesting occurred 18 days earlier in plants treated with paclobutrazol due to early fruit maturity (Rahman et al., 2023). Ruiz et al. (2005) stated that Paclobutrazol reduces days to harvesting from flowering by accelerating the ovule maturity in flower. Santosh et al. (2017) observed the maintenance of fruit quality with bunch covering. Rajan et al. (2020) proved that the white perforated bags create a microclimate inside the bunch which helps the bunch in early maturity by increasing the temperature around the developing bunch.

Bunch weight (kg)

The maximum bunch weight (24.91 kg) was observed when Paclobutrazol (1 g/L) was applied and bunch was covered with white polythene which was statistically similar to the treatment combination of same rate of paclobutrazol application with blue bunch covering (24.36 kg). The minimum bunch weight (16.77 kg) was recorded in untreated plants (Table 1). According to Ashraf and Ashraf (2020), paclobutrazol increases bunch weight by reallocating carbohydrates from the sources to the sinks as it were in the case of transport of photosynthates to developing fruits. Maximum fruit weight was obtained from bagging with white polythene and might be due to the protection of fruit from ultra violet rays which helps in increasing cell division and proper availability of photosynthates in the growing regions e.g. fruits of the plant (Rahman et al., 2017).

Number of hands bunch^{-1}

The highest number of hands bunch^{-1} (9.33) was observed from the treatment combination of paclobutrazol (1 g/L) and white polythene. The lowest number of hands bunch^{-1} (7.66) was recorded from the control which was statistically similar to the treatment combination of no paclobutrazol with white polythene and blue polythene respectively (Table 1). The application of paclobutrazol resulted in a larger number of hands per bunch, but bagging did not significantly alter the number of hands per bunch. Amani and Avagyan (2014) reported that there was no significant difference on number of hand with the treatment of bagging material and control. Paclobutrazol inhibits gibberellin, which lowers the level of vegetative promoter and raises the level of florigenic promoter, which may be responsible for the induction of the number of hands per bunch (Desta et al., 2021).

Number of fingers bunch^{-1}

The highest number of fingers bunch^{-1} (151.00) was observed from the treatment combination of Paclobutrazol (1 g/L) and bunch covering with white polythene. The result was statistically similar for the same rate of paclobutrazol application with blue bunch covering (152.33). The lowest result (111.67) was found from control (Table 1). Paclobutrazol improves flowering by modifying assimilate partitioning and nutrient delivery patterns for new growth, which supports increasing the number of flushes per plant (Meena et al., 2014).

Pulp-peel ratio

The maximum pulp-peel ratio (3.57) was observed when the foliar application of paclobutrazol (1 g/L) with white bunch covering was executed and was statistically similar to results was found from the treatment combination of palclobutrazol (1 g/L) with blue polythene (3.17). The minimum pulp-peel ratio (1.89) was recorded from the plants without paclobutrazol and bagging treatments (Table 1). Increase in pulp weight in paclobutrazol treated fruits may be due to increase in sugars all the sinks (Prasana et al., 2018). Lobo et al. (2020) observed that paclobutrazol creates a strong correlation in pulp to peel ratio where pulp increases and peel decreases. According to Rubel et al. (2019) bunch covering of banana facilitates higher pulp thickness than that of the control treatment. This decrease in peel thickness may be due to the movement of moisture from the peel to the pulp during ripening and as well contributes to the ease with which the peel can be separated from the pulp. This is because as bananas and plantains ripen the ratio of the pulp mass: peel mass increases and the peel becomes progressively easier to separate (Rubel et al., 2019).

Total soluble solids (°Brix)

The maximum amount of Total soluble solid (TSS) (24.63 °Brix) was observed from the treatment combination of paclobutrazol (1 g/L) and white polythene which was statistically similar to the same rate of paclobutrazol with blue polythene (21.23 °Brix). The minimum TSS (17.03 °Brix) was recorded from the control (Table 2). The amount of TSS was not influenced largely with bunch covering but paclobutrazol has a great impact. Pre-harvest bagging can reduce titratable acids due to rapid maturity and ripening (Sharma et al., 2014) and increase respiration and ethylene production rates, which can greatly increase the concentration of total soluble solids (Islam et al., 2017). According to Khodair et al. (2018) and Reddy et al. (2013), TSS (°Brix) is increased due to spray of paclobutrazol which is capable of inducing ripening, however through ethylene synthesis than that of control.

Table 1. Effect of paclobutrazol (PBZ) and bunch covering on pre-harvest and physical harvest properties of banana.

Treatments	Time (days) from fruit set to harvest	Bunch weight (kg)	Number of hands/bunch	Number of fingers/bunch	Pulp: Peel ratio
Control	150.33a	16.77d	7.66d	111.67e	1.89e
No PBZ + White polythene	127.00de	19.36c	7.66d	120.00d	2.36cd
No PBZ + blue polythene	139.33b	18.11cd	7.66d	119.00d	2.27de
PBZ (1g/L) + No polythene	122.33e	22.29b	8.33cd	144.33b	3.16ab
PBZ l(1g/L) + white polythene	110f	24.91a	9.33a	152.33a	3.57a
PBZ (1g/L) + blue polythene	122.67e	24.36a	8.89b	151.00a	3.17ab
PBZ (2g/L) + No polythene	134.00bc	22.29b	8.66bc	138.67c	2.55cd
PBZ (2g/L) + white polythene	129.33cd	21.44b	8.66bc	136.33c	2.79bc
PBZ (2g/L) + blue polythene	131.67cd	21.18b	8.66bc	140.33bc	2.76bc
CV%	2.82	5.31	6.28	2.34	9.80
$LSD_{0.05}$	6.325	1.95	0.94	5.46	0.46

Means within each column with different letters are different significantly ($p<0.05$).

Table 2. Effect of paclobutrazol and bunch covering on biochemical properties of banana.

Treatments	TSS (°Brix)	Vitamin C (mg/100g)	TA (%)	Reducing sugar (mg/100g)	Non reducing sugar (mg/100g)	Total sugar (mg/100g)
Control	17.03c	3.84d	0.57a	4.12g	0.48d	4.60i
No PBZ + White polythene	18.66abc	5.76abc	0.17cd	4.13g	0.50d	4.63h
No PBZ + blue polythene	17.80bc	5.12bcd	0.23b	4.41f	1.09b	5.50g
PBZ (1g/L) + No polythene	19.43abc	5.76abc	0.19bc	4.69e	1.11b	5.80f
PBZ l(1g/L) + white polythene	24.63a	7.04a	0.06f	4.73d	1.13b	5.86e
PBZ (1g/L) + blue polythene	24.50ab	6.40ab	0.12de	4.86c	1.13b	5.99d
PBZ (2g/L) + No polythene	18.66abc	4.48bcd	0.10ef	5.11b	1.14b	6.25b
PBZ (2g/L) + white polythene	21.23abc	5.76abc	0.06f	5.20a	1.29a	6.51a
PBZ (2g/L) + blue polythene	21.23abc	6.40ab	0.08ef	5.10b	0.90c	6.02c
CV%	19.48	15.43	16.99	0.01	7.48	0.18
$LSD_{0.05}$	6.75	1.49	0.05	0.27	0.07	0.01

Means within each column with different letters are different significantly ($p<0.05$).

Ascorbic acid (mg/100g FW)

The maximum Vit C Content (7.04 mg/100g) was observed from the treatment combination of Paclobutrazol (1 g/L) and white polythene and minimum Vit C Content (3.84) was recorded from the control (Table 2). Ascorbic acid content was higher under this paclobutrazol application with white bunch covering. Jungklang et al. (2017) stated that PBZ treated plants showed the highest levels of ascorbic acid compared to other treatments. This might be due to paclobutrazol having the mechanism to protect the plant from oxidative damage which was ensured by the high level of endogenous ascorbic acid. This finding is consistent with Jangid et al. (2021), who observed that bunch covering enhanced vitamin C content. This could be due to the bags' selective solar permeability and the microenvironment (temperature, humidity, and moisture) around the fruit (Srivasta et al., 2023).

Titratable acidity (%)

Titratable acidity (TA) content of banana was varied significantly due to combined effect of paclobutrazol and bagging materials (Table 2). The maximum TA (0.57%) was observed from the treatment combination of no paclobutrazol and no bunch covering and the minimum TA (%) was recorded from the treatment combination of paclobutrazol (1 g/L) with white covering which was statistically similar with paclobutrazol (2 g/L) with blue bagging, both had (0.06%) (Table 2). Titratable acidity (TA) represents the organic acids that greatly affect overall eating quality and flavor of fruit. Moscoso-RamÃrez and Peña-Peña (2020) observed less TA percentage was present in fruit under bagging treatment than that of control. According to Trad et al. (2013), titratable acids can be decreased by pre-harvest bagging since it raises the interior temperature.

Reducing sugar, non-reducing sugar and total sugar (mg/100g)

The maximum reducing sugar (5.20), non-reducing sugar (1.29) and total sugar (6.51) was recorded in paclobutrazol (2 g/L) with white polythene and the minimum reducing sugar (4.12), non-reducing sugar (0.48) and total sugar (4.60) was recorded in no paclobutrazol and no polythene (Table 2). Paclobutrazol application (2 g/L) with white bunch covering showed higher amount of sugar content compared to other treatment. Suman et al. (2017) found that the highest value of the reducing sugar was exhibited when paclobutrazol was applied to the plant whereas the lowest value appeared in the control. Sarker et al. (2018) found similar result that paclobutrazol helps to increase total sugar. Jaya et al. (2016) reported that this rapid increase in sugar content under covering materials is believed to occur due to hydrolysis of starch into simple sugars and also due to the polymerization of tannins (perhaps the most important phenolic from the point of view of fruit utilization) to insoluble compounds resulting in a reduction of astringency (sharp/acidic taste) during ripening.

Moisture content (%)

The maximum moisture content (26.29%) was observed from the treatment combination of paclobutrazol (1 g/L) and white polythene cover which was statistically similar to the treatment combination of paclobutrazol (1 g/L) with blue polythene cover (25.98%). The minimum moisture content (14.62%) was recorded from control (Table 3). Application of Paclobutrazol exhibited maximum dry matter by accumulation of biomass which leads to minimum moisture content compared to control. Campbell et al. (2018) concluded that the microclimate under the polythene resulted higher relative humidity that facilitate higher moisture content on ripened fruit.

Ash, lipid and fibre content (%)

The maximum ash content (2.96%) was noticed from the treatment combination of paclobutrazol (1 g/L) and white polythene cover. The minimum ash content (1.72%) was recorded from the control which was statistically similar (1.77%) to that under blue bunch covering without paclobutrazol application (Table 3). Applying paclobutrazol to the fruit crops increases its ash content by absorbing mineral elements (Wang et al., 2019). Haryanto et al. (2021) carried out an experiment and observed that ash percentage increases by the influence of the covering material.

The maximum Lipid (5.33%) was observed from the treatment combination of paclobutrazol (1 g/L) and white polythene and the minimum Lipid (2.40%) was recorded from the control which was significantly different from other treatment combinations (Table 3). It has been demonstrated that hydrogen peroxide, which is produced as a result of the oxidative damage caused by paclobutrazol, promotes the accumulation of neutral lipids (Yang et al., 2023).

The maximum fiber content (4.20) was observed from the treatment combination of paclobutrazol (1 g/L) and white polythene which was statistically similar to the treatment combination of paclobutrazol (1 g/L) with blue polythene (4.00). The minimum fibre content (2.60%) was recorded in the untreated plant which was similar to the application of paclobutrazol (1 g/L) with no bagging (2.70) (Table 3). According to Kumar et al. (2021) fruit bagging has been shown to improve the quality attributes hence, the amount of fibre may increase under bagging conditions.

Table 3. Effect of paclobutrazol (PBZ) and bunch covering on proximate composition of banana.

Treatments	Moisture content (%)	Ash (%)	Lipid (%)	Fiber (%)	L*	a*	b*
Control	14.62d	1.72g	2.40e	2.60f	53.00e	3.84c	11.97c
No PBZ + White polythene	23.47bc	1.91f	3.33d	2.70ef	66.33cd	3.84c	25.14b
No PBZ + blue polythene	21.20c	1.77g	3.40cd	2.90de	61.41d	6.16ab	35.50a
PBZ (1g/L) + No polythene	24.04ab	2.30d	4.30b	3.80b	54.64e	6.66a	25.14b
PBZ l(1g/L) + white polythene	26.29a	2.96a	5.33a	4.20a	80.20a	6.40ab	41.70a
PBZ (1g/L) + blue polythene	25.98ab	2.76b	4.60b	4.00ab	76.10ab	5.77a	37.11a
PBZ (2g/L) + No polythene	23.45bc	2.02e	3.80c	3.30c	72.87bc	5.54ab	33.68ab
PBZ (2g/L) + white polythene	24.96ab	2.81b	4.33b	3.50c	76.96ab	5.45ab	33.22ab
PBZ (2g/L) + blue polythene	25.11ab	2.66c	4.23b	3.00d	71.84bc	5.40b	33.15ab
CV%	3.00	1.89	5.97	5.15	5.60	12.67	17.63
$LSD_{0.05}$	2.80	0.07	0.41	0.29	6.87	1.22	9.38

Means within each column with different letters are different significantly ($p<0.05$).

Color measurement

Significant changes in color values (L* and b*) during ripening was found in paclobutrazol and bagging materials treatments. The highest lightness value (L* value) (80.20) and the highest yellowness (b* value) (41.70) is found in paclobutrazol (1 g/L) with white bagging treatment whereas the lowest lightness value (L* value) (80.20) and the lowest yellowness (b* value) (53.00) was found in control (Table 3). It can be observed from table 3, that the lightness value (L* value) and yellowness (b* value) increased during ripening and the value was more in fruits treated with paclobutrazol and banana bunch covered with polythene. This could be due to the degradation of chlorophyll, which makes the yellow carotenoid pigments visible (Choudhury et al., 2023). The lower values of L and b may be the result of brown patches and specks developing on the banana's peel as it ripened (Escalante-Minakata et al., 2018).

CONCLUSION

The postharvest treatment of paclobutrazol is the best suited and beneficial for the yield and quality of banana. Fruits grown under bagging condition had substantially more total soluble solids, vitamin C and sugar content. Furthermore, in white polythene bagging, the fruit peel color, yield and all the quality contributing parameters of the banana were higher except sugars. The sugar content was higher in blue polythene covering fruits. From the present investigation, it is concluded that banana can be grown successfully using paclobutrazol (1g/L) and white polythene covering for improved productivity and quality banana produce.

Hence, we recommend this concentration as the optimal choice for achieving the desired improvements in banana productivity and quality.

Conflict of interest

The authors declare that they have no conflict of interest.

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