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RESEARCH PAPER

Effects of post-shooting sprays and bunch covering on yield attributes of Willium banana (*Musa paradisiaca* L.)

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Abstract : This research investigates the synergistic effects of post-shooting sprays and bunch covering materials on the growth, development, and yield of Willium banana (*Musa paradisiaca* L.). Gibberellic acid (GA3) at 100 mg/l emerges as a potent post-shooting spray, significantly enhancing bunch length, finger length, girth of finger, bunch weight, and overall fruit yield. The study highlights the pivotal role of GA3 in promoting both cell division and elongation, contributing to increased fruit size and weight. Non-woven material bag covering proves superior in creating an optimal microclimate, fostering enhanced air circulation, temperature control, and light interception. This material significantly boosts finger length, girth, bunch weight, and fruit yield. These findings provide valuable insights for banana cultivation, emphasizing the strategic use of GA3 and appropriate covering materials to optimize environmental conditions and hormonal balance for improved crop outcomes. The study contributes to the evolving field of banana cultivation practices and offers practical implications for enhancing fruit quality and yield.

Key Words : Post-shooting spray, Bunch covering material, Gibberellic acid

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INTRODUCTION

India has consistently held the distinction of being the foremost global producer of bananas for the past decade. The cultivation of bananas in India has achieved wide spread adaptation, spanning regions ranging from humid tropics to humid subtropics and semiarid subtropics, extending up to elevations of 2,000 meters above mean sea level. Within the Indian agricultural landscape, bananas rank as the fourth most significant crop in terms of gross value, surpassed only by paddy, wheat, and milk products. Beyond serving as a staple food due to its rich and easily digestible carbohydrates, with a calorific value ranging from 67 to 137 per 100 grams of fruit, bananas also function as a dessert fruit for millions. Notably, bananas constitute an essential dietary source of Vitamin A (190 IU per 100 grams of edible portion) and Vitamin C (100 mg/100g), and they serve as a fair source of Vitamin B1 and B2. In addition to their nutritional value, bananas emerge as a rich source of minerals such as magnesium, sodium, potassium, phosphorus, and a fair source of calcium and iron. Their contribution to a healthy and salt-free balanced diet surpasses that of many other

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fruits.

Gibberellins play a pivotal role in the growth and development of fruits. Numerous physiological responses to Gibberellic Acid (GA) involve both cell division and an augmentation in cell size, with the application of GA resulting in the increased size of certain fruits. Furthermore, GA induces parthenocarpic fruit set in various plant species. The utilization of fruit protection bags, available in diverse colors and with perforated and non-perforated options, has become widespread in both tropical and subtropical banana-growing countries. These bags have proven instrumental in enhancing yield and quality, impacting parameters such as acceptable skin appearance and colour, increased finger length and bunch weight, and a reduction in fruit defects such as sunburn and fruit splitting (Amarante *et al.*, 2002 and Stover and Simmonds, 1987). With this background, this investigation was conducted to explore the response of post-shooting spray and covering materials on bunches, with a specific focus on the interaction effects on yield and yield attributes of bananas (*Musa paradisiaca* L.) cv. Willium.

MATERIAL AND METHODS

The experimental investigation was carried out at the Horticultural Research Farm, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand, spanning the agricultural years 2017-18 and 2018-19. The soil composition at the experimental site was identified as loamy sand. The experimental design employed was a Completely Randomized Design (Factorial) with three repetitions to ensure robust statistical analysis. Prior to planting, the experimental plot underwent meticulous preparation, involving deep ploughing, harrowing, and leveling.

The pits, each measuring 30 x 30 x 30 cm, were strategically dug at a spacing of 1.8 x 1.8 m^2. To augment soil fertility and provide a conducive environment for plant growth, well-decomposed fine-textured Farm Yard Manure (FYM) was applied at a rate of 10 kg per pit during planting. The choice of planting material comprised well-hardened, healthy, and uniformly tissue-cultured banana plants of the Willium variety, each possessing 5-6 leaves.

The experimental matrix encompassed six distinct levels of post-shooting sprays, including a control group. The specific treatments investigated were humic acid 2%, 2,4-D 30 mg/l, gibberellic acid (GA3) 100 mg/l, CPPU 4 mg/l, and sulphate of potash (SOP) 2%. Additionally, two levels of bunch covering materials were studied: non-woven material bag covering and blue-colored polyethylene sleeve (6% perforated) bag covering. The post-shooting sprays were administered twice, with the first spray occurring after the complete opening of the inflorescence and the second spray following 30 days after the initial spray. Bunches were immediately covered after the second spray.

Daily observations were diligently recorded for various bunch and yield characters, including bunch length (cm), length of finger (cm), girth of finger (cm), bunch weight (kg), and fruit yield (t/ha). These observations were conducted at the harvest stage when the fruits reached the full growth stage. Bunch characteristics were counted for each bunch, and the mean values were subsequently calculated. For the purpose of data analysis, the collected experimental data pertaining to different parameters underwent rigorous statistical scrutiny in accordance with the methodology outlined by Gomez and Gomez (1984). This approach ensured a robust and reliable interpretation of the experimental results.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads :

Harvest days :

The investigation revealed that the impact of post-shooting sprays, bunch covering materials, and their interaction effects on harvest days was found to be non-significant throughout the experimental period spanning 2017-18, 2018-19, as well as in the pooled data, as presented in Table 1.

Bunch length at harvest (cm) :

In terms of the effect of post-shooting sprays, it was observed that the bunch length at harvest was significantly maximized with S4 (GA3 100 mg/l), reaching 91.72 cm. This result was on par with S6 (SOP 2%) at 90.08 cm, S3 (2,4-D 30 mg/l) at 88.69 cm, S5 (CPPU 4mg/l) at 88.68 cm, and S2 (Humic acid 2%) at 88.68 cm during the years 2017-18. Similarly, in 2018-19, the significantly maximum bunch length was observed with S4 (GA3 100 mg/l) at 86.98 cm, and it was on par with S6 (SOP 2%) at 85.63 cm and 87.86 cm, S3 (2,4-D 30 mg/l) at 84.75 cm, and 86.72 cm. In the pooled data, a consistent trend was observed.

The superior performance associated with GA3 (S4) in promoting bunch length might be attributed to its role in cell enlargement through the synthesis of enzymes that weaken the cell wall, allowing for increased cell elongation. Additionally, GA3 may contribute to an elevation in auxin content, facilitating their transport to the site of action within the plant (Van Overbeck, 1966). This aligns with findings from previous studies by Patel *et al.* (2011), Biswas and Lemtur (2014), and Kachhadia *et al.* (2017) in banana cultivation.

Analysis of the data revealed that non-woven material bag covering (B1) significantly contributed to higher bunch length at harvest, registering values of 92.66 cm, 87.00 cm, and 89.83 cm compared to blue-colored polyethylene sleeve (B2) at 83.38 cm, 77.10 cm, and 80.24 cm during the years 2017-18, 2018-19, and in pooled data, respectively.

This enhancement in bunch length under non-woven material bag covering (B1) could be attributed to better finger filling, as these covering treatments created a higher temperature environment than open air. The elevated temperature within the bunch covers stimulated nitrate reductase activity in the plants. Nitrate reductase, a pivotal enzyme in the assimilation of exogenous nitrate, contributed to superior fruit development and increased bunch length. Similar outcomes have been reported by Anonymous (2013), Samantaray (2015), Sarkar *et al.* (2016) and Pathak *et al.* (2017) in banana cultivation.

Significantly maximum finger length was recorded with S4 (GA3 100 mg/l), measuring 24.50 cm and 24.36 cm during the years 2017-18 and 2018-19, respectively. This finding was on par with all treatments except the control (S1) during both years. In pooled analysis, S4 (GA3 100 mg/l) demonstrated the highest finger length at 24.43 cm, comparable to S6 (SOP 2%) at 24.15 cm, and S3 (2,4-D 30 mg/l) at 23.91 cm.

The exogenous application of GA3 in the present study likely kept protein synthesis in an active state, allowing for prolonged fruit growth. This increase in length is attributed to cell division and elongation, indicating GA3's role in enhancing fruit size. The positive impact of GA3 on Seedless fruit size has been well-established

Table 1 : Effect of post shooting sprays and bunch covering materials on harvest days and bunch length at harvest

Treatments	Harvest days			Bunch length at harvest (cm)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Post shooting spray (S)						
S_1 : Control	432.58	438.37	435.47	80.26	73.35	76.80
S_2 :Humic acid @ 2%	426.52	435.72	431.12	88.68	80.95	84.82
S_3 : 2,4-D @ 30 mg/l	423.19	430.60	426.90	88.69	84.75	86.72
S_4 : GA3 @ 100 mg/l	424.57	433.45	429.01	91.72	86.98	89.35
S_5 : CPPU @ 4 mg/l	421.66	430.60	426.13	88.68	80.63	84.65
S_6 : SOP @ 2%	420.96	427.13	424.05	90.08	85.63	87.86
S.E. ±	6.11	6.98	4.64	2.15	1.57	1.33
C.D. (P=0.05)	NS	NS	NS	6.28	4.58	3.79
Bunch covering material (B)						
B_1: Non- woven material bag covering	421.20	429.58	425.39	92.66	87.00	89.83
B_2: Blue colour polyethylene sleeve	428.63	435.71	432.17	83.38	77.10	80.24
S.E. ±	3.53	4.03	2.68	1.24	0.91	0.77
C.D. (P=0.05)	NS	NS	NS	3.63	2.65	3.79
Interaction effect (S X B)						
S.E. ±	8.64	9.88	1.12	3.04	2.22	2.06
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Pooled interaction						
Source	Y x S	Y x B	YxSxB	Y x S	Y x B	YxSxB
S.E. ±	6.56	3.79	9.28	1.88	1.09	2.66
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
CV %	3.52	3.95	3.75	5.99	4.69	5.43

NS= Non-significant

(Weaver, 1972), aligning with the findings of Athani and Hulamani (2001), Patel *et al*. (2011), Biswas and Lemtur (2014), and Kachhadia et al. (2017) in banana cultivation.

Non-woven material bag covering (B1) significantly contributed to higher finger length, measuring 24.30 cm, 24.12 cm, and 24.21 cm during the years 2017-18, 2018-19, and in pooled data, respectively. This can be attributed to the favorable microclimate conditions created by non-woven material, allowing free air, temperature, moisture circulation, and optimal exposure to photosynthetically active radiation. The higher temperature within the bunch cover stimulated nitrate reductase activity, contributing to better fruit development. This finding aligns with results reported by Cuneen and Entyre (1998), Choudhury (1994), Anonymous (2013), and Pathak *et al.* (2017) in banana cultivation.

Girth of finger (cm) :

The girth of the finger was significantly maximum with S4 (GA3 100 mg/l), measuring 13.50 cm and 13.35 cm during the years 2017-18 and 2018-19, respectively. In pooled analysis, S4 (GA3 100 mg/l) demonstrated the highest girth at 13.42 cm, comparable to S6 (SOP 2%) at 13.27 cm and S3 (2,4-D 30 mg/l) at 13.14 cm.

For bunch covering materials, non-woven material bag covering (B1) showed significantly better finger girth, measuring 13.39 cm, 13.22 cm, and 13.30 cm during the years 2017-18, 2018-19, and in pooled data, respectively. This result indicates that non-woven material is more effective in promoting optimal finger growth and development.

Weight of bunch (kg) :

The weight of the bunch at harvest was significantly maximum with S4 (GA3 100 mg/l) during the years 2017-18 and 2018-19. In pooled analysis, S4 (GA3 100 mg/l) maintained its superiority, with significantly higher bunch weight compared to other treatments. This increase in fruit size and bunch weight with gibberellin aligns with the positive correlation between fruit growth and gibberellin levels. GA3 induces metabolic changes that lead to the accumulation of food constituents in the fruit,

Table 2 : Effect of post shooting sprays and bunch covering materials on length of finger and girth of finger (cm)

Treatments	Length of finger (cm)			Girth of finger (cm)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Post shooting spray (S)						
S_1 : Control	21.05	20.82	20.93	11.60	11.41	11.50
S_2 : Humic acid @ 2%	23.45	23.37	23.41	12.92	12.81	12.87
S_3 : 2,4-D @ 30 mg/l	23.95	23.88	23.91	13.19	13.09	13.14
S_4 : GA3 @ 100 mg/l	24.50	24.36	24.43	13.50	13.35	13.42
S_5 : CPPU @ 4 mg/l	23.47	23.65	23.56	12.93	12.96	12.94
S_6 : SOP @ 2%	24.11	24.19	24.15	13.28	13.26	13.27
S.E. ±	0.40	0.35	0.27	0.20	0.18	0.14
C.D. (P=0.05)	1.18	1.03	0.76	0.58	0.54	0.39
Bunch covering material (B)						
B_1: Non- woven material bag covering	24.30	24.12	24.21	13.39	13.22	13.30
B_2: Blue colour polyethylene sleeve	22.55	22.63	22.59	12.42	12.40	12.41
S.E. ±	0.23	0.20	0.15	0.11	0.11	0.08
C.D. (P=0.05)	0.68	0.59	0.76	0.33	0.31	0.39
Interaction effect (S X B)						
S.E. ±	0.57	0.50	0.46	0.28	0.26	0.25
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Pooled interaction						
Source	Y x S	Y x B	YxSxB	Y x S	Y x B	YxSxB
S.E. ±	0.38	0.22	0.54	0.19	0.11	0.27
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
CV %	4.23	3.68	3.97	3.75	3.53	3.65

NS=Non-significant

resulting in increased weight. These findings are consistent with studies by Kumar and Reddy (1998), Athani and Hulamani (2001), Patel *et al*. (2011), Biswas and Lemtur (2014) and Kachhadia *et al.* (2017) in banana cultivation.

Effect of bunch covering material on bunch weight:

The data presented in Table 3 highlight the significant impact of different bunch covering materials on bunch weight. Non-woven material bag covering (B1) demonstrated a significantly higher bunch weight at harvest, measuring 27.10 kg, 25.31 kg, and 26.20 kg compared to blue-colored polythene sleeve (B2) at 24.80 kg, 23.13 kg, and 23.97 kg during 2017-18, 2018-19, and in pooled analysis, respectively.

The increase in bunch weight attributed to non-woven bag covering may be attributed to the elevated temperature, increased photosynthetically active radiation, and enhanced light interception within the bunch cover. A positive correlation between temperature from shooting to harvest and an increased trend in bunch weight has been observed, as noted by Robinson and Nel (1985) and Singh (1988) in banana cultivation. Additionally, the larger size, volume, and weight of individual fingers likely influenced the overall augmentation of bunch weight. These results align with the findings of Choudhury (1994), Mukherjee (2006), and Pathak *et al*. (2017) in banana cultivation.

Yield (t/ha) :

Fruit yield was significantly maximum with S4 (GA3 100 mg/l), recording 85.45 t/ha and 79.41 t/ha during the years 2017-18 and 2018-19, respectively. This was on par with S6 (SOP 2%) at 83.30 t/ha and 78.13 t/ha, S3 (2,4-D 30 mg/l) at 82.52 t/ha and 77.21 t/ha, and S5 (CPPU 4mg/l) at 79.99 t/ha and 74.46 t/ha during the respective years. In the pooled analysis, S4 (GA3 100 mg/l) maintained its significantly maximum fruit yield at 82.43 t/ha, on par with S6 (SOP 2%) at 80.71 t/ha and S3 (2,4-D 30 mg/l) at 79.87 t/ha.

The application of GA3 was found to enhance finger length, girth, and bunch weight, directly contributing to

Table 3 : Effect of post shooting sprays and bunch covering materials on weight of bunch and yield

Treatments	Weight of bunch (kg)			Yield (t/ha)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Post shooting spray (S)						
S_1 : Control	22.82	21.21	22.01	70.42	65.44	67.93
S_2 :Humic acid @ 2%	25.52	23.92	24.72	78.75	73.81	76.28
S_3 : 2,4-D @ 30 mg/l	26.74	25.02	25.88	82.52	77.21	79.87
S_4 : GA3 @ 100 mg/l	27.69	25.73	26.71	85.45	79.41	82.43
S_5 : CPPU @ 4 mg/l	25.92	24.13	25.02	79.99	74.46	77.23
S_6 : SOP @ 2%	26.99	25.32	26.15	83.30	78.13	80.71
S.E. ±	0.62	0.57	0.42	1.90	1.77	1.30
C.D. (P=0.05)	1.80	1.67	1.20	5.56	5.15	3.69
Bunch covering material (B)						
B_1: Non- woven material bag covering	27.10	25.31	26.20	83.62	78.10	80.86
B_2: Blue colour polyethylene sleeve	24.80	23.13	23.97	76.52	71.39	73.96
S.E. ±	0.36	0.33	0.24	1.10	1.02	0.75
C.D. (P=0.05)	1.04	0.96	1.20	3.21	2.97	3.69
Interaction effect (S X B)						
S.E. ±	0.87	0.81	0.48	2.69	2.50	1.47
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Pooled interaction						
Source	Y x S	Y x B	YxSxB	Y x S	Y x B	YxSxB
S.E. ±	0.59	0.34	0.84	1.84	1.06	2.60
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
CV %	5.82	5.78	5.81	5.82	5.78	5.81

NS= Non-significant

increased fruit yield. Gibberellins, being phytohormones, play a pivotal role in growth through both cell division and cell elongation. These results are in agreement with previous studies in banana by Kumar and Reddy (1998), Athani and Hulamani (2001), Patel *et al.* (2011), Biswas and Lemtur (2014), and Kachhadia *et al*. (2017).

The examination of data indicates that non-woven material bag covering (B1) significantly contributed to estimated fruit yield at harvest, measuring 83.62 t/ha, 78.10 t/ha, and 80.86 t/ha compared to blue-colored polythene sleeve (B2) at 76.52 t/ha, 71.39 t/ha, and 73.96 t/ha during 2017-18, 2018-19, and in pooled analysis, respectively. The observed increase in finger length, girth, and bunch weight under non-woven material bag covering likely influenced the overall yield per hectare. These findings align with studies conducted by Choudhury (1994), Mukherjee (2006), and Pathak *et al*. (2017) in the realm of banana cultivation.

Conclusion :

The experimental investigation into the cultivation of Willium banana revealed that post-shooting sprays, particularly Gibberellic acid (GA3) at 100 mg/l, significantly influenced fruit characteristics, including bunch length, finger length, girth of finger, bunch weight, and overall fruit yield. The positive impact of GA3 on cell division and elongation underscored its role in enhancing fruit size and weight. Moreover, the study identified non-woven material bag covering as a superior option, creating favorable microclimate conditions with enhanced air circulation, temperature control, and light interception. This material substantially increased finger length, girth, bunch weight, and fruit yield. The observed positive correlation between temperature, especially within bunch covers, and increased bunch weight highlighted the crucial role of temperature in banana growth. These findings, consistent with previous research, offer valuable insights into optimizing banana cultivation practices, emphasizing the importance of strategic interventions such as GA3 application and the use of suitable covering materials for improved crop outcomes.

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