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INFLUENCE OF POST-SHOOTING SPRAYS OF SULPHATE OF POTASH AND CERTAIN GROWTH REGULATORS ON BUNCH CHARACTERS AND FRUIT YIELD OF BANANA CV. NENDRAN (FRENCH PLANTAIN *MUSA* AAB)

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ABSTRACT
An investigation was carried out in Banana cv. Nendran with aiming to improve the bunch and fruit yield characters. The investigation consist of post-shoot application of SOP (2 %) as a main plot treatment and growth regulators (50 ppm GA_3, 25 ppm 2, 4-D, CPPU and Brassinostroid @ 2 ppm) as a subplot treatments under split plot design. The combined foliar sprays of 2 per cent SOP and 2 ppm Brassinosteroid significantly increased the bunch characters *viz*., bunch weight (11.35 kg), finger weight (215.40 g), finger length (29.10 cm), pulp weight (180.22 g), pulp to peel ratio (5.13) and total bunch yield (29.38 tonnes/ ha) with relatively higher benefit: cost ratio (2.87). Thus, the study clearly indicates that combined post-shoot application of SOP (2%) with 2 ppm Brassinosteroid improves the bunch characters and fruit yield with economically cost viable.

INTRODUCTION

Banana (*Musa* spp) is one of the major commercial fruit crop grown in tropics, subtropics and plays a key role in the economy of developing countries. India leads the world in banana production and accounts for about 25.6 % among fruit crops and occupies about 0.796 million hectare with an annual production of 28.45 million tonnes (NHB, 2013). Among the banana varieties grown in India, the French Plantain cultivar 'Nendran' belonging to the 'Plantain' group (*Musa* AAB) is the most popular variety among growers and consumers, particularly in Tamil Nadu and Kerala for domestic and export markets. Since large quantity of photosynthates are move from the source to the sink *i.e.* leaves to developing bunches, any limitations in the supply of photosynthates at this crucial stage affect the bunch size and quality. Because of this problem, poor filling and development of fingers is often reported in almost all cultivars of commercial importance (Jeyakumar *et al*., 2010). Many reports have indicated the usefulness of post shooting spray of various SOP during fruit development in influencing the fruit yield, shelf life and quality Algarsamy Ramesh Kumar and Neelakandan (2008) in Robusta, Madhu in banana cv. Grand Naine (2013), Ramesh Kumar and Kumar (2007 and 2010) in cv. Ney Poovan and Ramesh Kumar *et al*. (2008) in cv. Robusta and Madhu (2013) in banana cv. Grand Naine. Beneficial effect of various plant growth regulators have been studied in several banana cultivars after the last hand opening stage of a bunch. Among the PGR's, Gibberellic acid , 2,4-D, CPPU and BR are commonly used in banana, which have been shown to regulate several physiological processes (Athani *et al*., 1999; Jayakumar *et al*., 2010). With this background, the present investigation was carried out with an objective to find out the possibility to improve the bunch development and yield attributes of Nendran bananas by pre-harvest application of SOP and certain growth regulators.

MATERIALS AND METHODS

The experiment was laid out University Orchard and Former Field in banana cv. Nendran (AAB) under two locations in split plot design with ten pre-harvest treatment (as indicated in the Table 1) combinations as bunch spray and replicated three times as detailed below:

Main plot treatments	**Sub plot treatments**
S_1 - Without SOP	G_0 - Without growth regulator
S_2 – With SOP (2%)	G_1 - GA_3 (50 ppm)
	G_2 - 2, 4, D (25 ppm)
	G_3 - CPPU (2 ppm)
	G_4 - Brassinosteriod (BR) (2 ppm)

The spraying was done twice, first immediately after last hand opening and second, twice after first spray at 15 days interval.

Weight of the bunch was recorded including the peduncle up to first bract leaf node above the first hand and expressed in kilogram (kg). The middle fingers in the top and bottom rows of the second hand were selected as representative fingers (Gottreich *et al.*, 1964) to record average weight of the finger and expressed in gram (Lahav and Mustaffa, 1987). Fully ripe fruit was weighed and peeled. The peel was weighed and pulp weight was arrived by the difference between the two (Baruah and Mohan, 1991). The pulp-peel ratio was computed. The benefit – cost ratio for the different treatments was worked out based on the expenditure and returns in order to study the economics in the present study.

RESULTS

The bunch characters and fruit characters like bunch weight, finger weight, finger length, pulp weight and peel weight, pulp to peel ratio, total bunch yield and benefit: cost ratio were recorded after the harvest and the results are as follows.

Bunch weight (kg)

The mean data on bunch weight at both locations are represented in Table 2. Among the SOP treatments, the S_2 treatment (SOP @ 2%) recorded the highest mean bunch weight (11.07 kg) and highly significant from S_1 (Without SOP) of 10.29 kg in location II. Spraying of growth regulators significantly influenced the mean bunch weight at both locations. However, application of brassinosteroid (G_5) registered significantly maximum bunch weight (11.24 kg) followed by 2, 4-D (10.95 kg) and minimum bunch weight was recorded in SOP alone (9.80 kg).

Table 1: Details of the treatment combinations imposed during the experiment

Treatment	Components / materials
$T_1 (S_1G_1)$	Control
$T_2 (S_1G_2)$	Spray GA_3 at 50 ppm without SOP
$T_3 (S_1G_3)$	Spray 2,4,D at 25 ppm without SOP
$T_4 (S_1G_4)$	Spray CPPU at 2 ppm without SOP
$T_5 (S_1G_5)$	Spray BR at 2 ppm without SOP
$T_6 (S_2G_1)$	Spray with 2% SOP alone
$T_7 (S_2G_2)$	Spray with 2% SOP + GA_3 at 50 ppm
$T_8 (S_2G_3)$	Spray with 2% SOP + 2,4,D at 25 ppm
$T_9 (S_2G_4)$	Spray with 2% SOP + CPPU at 2 ppm
$T_{10} (S_2G_5)$	Spray with 2% SOP + BR at 2 ppm

Bunch weight was significantly influenced by the interaction of SOP and growth regulators at both locations. SOP @ 2% + brassinosteroid combination (S_2G_5) recorded the higher mean bunch weight (11.35 kg) in location II than all other treatments. The lowest mean bunch weight (9.75 kg) was recorded in control at location I.

Finger weight (g)

The finger weight was significantly influenced by various pre harvest treatments in both locations (Table 3). The location II recorded the higher finger weight (189.94 g) and significantly different from Location I (185.95g). Among main effects, S_2 (with SOP @ 2%) recorded the highest finger weight (197.51g) and highly significant from S_1 (178.38 g) in location II. Whereas G_5 (Brassinosteroid @ 2 ppm) higher finger weight (202.45 g) followed by 2, 4-D (194.20 g) compared to control (167.09 g). Among the interactions, SOP @ 2% + brassinosteroid combination (S_2G_5) recorded the maximum bunch weight (215.40 g) in location II than all other treatments. The minimum bunch weight (162.62 g) was recorded in treatment combination of SOP @ 2 % alone + no growth regulator spray in location I.

Finger length (cm)

The higher finger length (26.38 cm) was recorded in Location II and significantly different from location I (25.92 cm) (Table 4). Among main effects, S_2 recorded significantly higher finger length (26.97 cm) compared to S_1 (25.33 cm) in II location. Finger length varied significantly due to application of growth regulators at both locations. The G_5 (Brassinosteroid @ 2 ppm) resulted in higher finger length (27.74 cm) followed by 2, 4-D (26.43 cm) and lowest finger length was recorded with treatment sprayed with SOP alone (24.12 cm).among interaction effects, SOP @ 2% + Brassinosteroid (S_2G_5) combination recorded higher finger length (29.10 cm) in location II. However, the lowest finger length (24.00 cm) was recorded in S_1G_1 combination (SOP @ 2 % alone + no growth regulator) at location I.

Pulp weight (g)

The mean data on pulp weight at both locations were represented in Table 5. The location II recorded the maximum pulp weight (152.91g) and significantly different from Location I (145.85g). The S_2 treatment recorded the highest pulp weight (160.28 g) and highly significant from S_1 (138.48 g) and among

Table 2: Effect of pre harvest sprays of SOP and growth regulators on bunch weight (kg) of banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	9.65	9.75	9.70	9.85	9.98	9.91	9.75	9.91
G_2	10.26	11.15	10.70	10.45	11.38	10.91	10.35	10.91
G_3	10.28	11.42	10.85	10.53	11.60	11.06	10.40	11.06
G_4	10.00	10.90	10.45	10.42	11.10	10.76	10.21	10.76
G_5	10.62	11.65	11.13	10.85	11.85	11.35	10.73	11.35
Interaction Mean	10.16	10.97	10.56	10.42	11.18	10.80		
Mean	S_1(10.29)	S_2(11.07)	G_1(9.80)	G_2(10.81)	G_3(10.95)	G_4(10.60)	G_5 (11.24)	
	L	S	G	L x S	L x G	S x G	L x S x G	
S Ed	0.0116*	0.0317**	0.0502**	0.0338	0.0645	0.0710**	0.0710	
CD(0.05)	0.0520	0.0644	0.1018	NS	NS	0.1440	NS	

L_1 - First Location; L_2 – Second Location; S_1 - Without SOP spray S_2 – With SOP @; G_1 - Without Growth regulator; G_2 - 50 ppm GA_3 G_3-25 ppm 2, 4-D G_4 - 2 ppm CPPU; G_5 - 2 ppm Brassinosteroid

Table 3: Effect of pre harvest sprays of SOP and growth regulators on finger weight (g) of banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	160.36	171.05	165.70	164.88	172.10	168.49	162.62	171.57
G_2	180.56	197.41	188.98	181.80	201.33	191.56	188.18	199.37
G_3	180.00	204.08	192.04	182.44	210.30	196.37	181.22	207.19
G_4	173.65	192.81	183.23	181.11	195.30	188.20	177.38	194.05
G_5	187.41	212.20	199.80	191.60	218.60	205.10	189.50	215.40
Interaction Mean	176.36	195.51	185.95	180.36	199.52	189.94		
Mean	S_1(178.38)	S_2(197.51)	G_1(167.09)	G_2(190.27)	G_3(194.20)	G_4(185.71)	G_5(202.45)	
	L	S	G	L x S	L x G	S x G	L x S x G	
S Ed	0.2240*	0.7326**	1.1583**	0.7661	1.4822	1.6381**	1.6381	
CD(0.05)	0.9642	1.4859	2.3494	NS	NS	3.3226	NS	

L_1 - First Location; L_2 – Second Location; S_1 - Without SOP spray; S_2 – With SOP @;G_1 - Without Growth regulator; G_2 - 50 ppm GA_3 G_3-25 ppm 2,4-D G_4 - 2 ppm CPPU; G_5 - 2 ppm Brassinosteroid

Table 4: Effect of pre harvest spray of SOP and growth regulators on finger length (cm) banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	24.32	24.60	24.46	23.68	24.95	24.31	24.00	24.77
G_2	25.30	27.10	26.20	25.52	27.80	26.66	25.41	27.45
G_3	25.36	26.00	25.68	25.83	27.28	26.55	25.60	26.64
G_4	24.90	26.80	25.85	25.69	27.00	26.34	25.29	26.90
G_5	26.10	28.80	27.45	26.68	29.40	28.04	26.39	29.10
Interaction Mean	25.19	26.66	25.92	25.48	27.28	26.38		
Mean	S_1(25.33)	S_2(26.97)	G_1(24.12)	G_2(26.38)	G_3(26.43)	G_4(26.0995)	G_5(27.74)	
	L	S	G	L x S	L x G	S x G	L x S x G	
S Ed	0.01432 *	0.06594**	0.10426**	0.06748**	0.14377**	0.14745**	0.09326**	
CD(0.05)	0.06159	0.13375	0.21148	0.13266	0.27259	0.29908	0.18915	

L_1 - First Location; L_2 – Second Location; S_1 - Without SOP spray; S_2 – With SOP @;G_1 - Without Growth regulator; G_2 - 50 ppm GA_3 G_3-25 ppm 2,4-D G_4 - 2 ppm CPPU; G_5 - 2 ppm Brassinosteroid

Table 5: Effect of pre harvest spray of SOP and growth regulators on pulp weight (g) of fruits of banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	119.76	130.75	125.25	124.58	134.10	129.34	122.17	132.42
G_2	138.86	157.56	148.21	142.60	163.51	153.05	140.73	160.53
G_3	134.89	166.78	150.83	148.84	173.50	161.17	141.87	170.14
G_4	130.53	156.71	143.62	146.66	159.50	153.08	138.59	158.10
G_5	146.11	176.60	161.35	152.00	183.85	167.92	149.05	180.22
Interaction Mean	180.22	157.68	145.85	142.93	162.89	152.91		
Mean	S_1(138.48)	S_2 (160.28)	G_1(127.29)	G_2(150.00)	G_3(156.63)	G_4(148.35)	G_5(164.64)	
	L	S	G	L x S	L x G	S x G	L x S x G	
S Ed	0.28939*	0.50116**	0.79241**	0.57871**	1.04326**	1.12063**	1.12063**	
CD(0.05)	1.24518	1.01651	1.60725	1.50296	2.29865	2.27300	2.27300	

L_1 - First Location; L_2 – Second Location; S_1 - Without SOP spray; S_2 – With SOP @;G_1 - Without Growth regulator; G_2 - 50 ppm GA_3 G_3-25 ppm 2,4-D G_4 - 2 ppm CPPU; G_5 - 2 ppm Brassinosteroid

Table 6. Effect of pre harvest spray of SOP and growth regulators on pulp to peel ratio of fruits of banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Factor Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	162.20	166.50	164.35	164.60	168.40	166.50	163.40	167.45
G_2	172.30	190.90	181.60	174.70	192.80	183.75	173.50	191.85
G_3	174.00	200.50	187.25	176.27	201.60	188.93	175.31	201.05
G_4	169.40	185.80	177.60	175.30	187.90	181.60	172.34	186.85
G_5	181.30	208.80	195.05	183.40	210.30	196.85	182.35	209.55
Interaction Mean	171.84	190.50	181.17	174.85	192.20	183.53		
Mean	S_1(173.34)	S_2(191.35)	G_1(165.42)	G_2(182.42)	G_3(188.09)	G_4(179.59)	G_5(195.95)	
	L	S	G	L x S	L x G	S x G	L x S x G	
S Ed	0.16598 *	0.57312**	0.90618**	0.59667	1.15819	1.28153**	1.28153	
CD(0.05)	0.71418	1.16247	1.83802	NS	NS	2.59936	NS	

L_1 - First Location; L_2 – Second Location; S_1 - Without SOP spray; S_2 – With SOP @;G_1 - Without Growth regulator; G_2 - 50 ppm GA_3 G_3-25 ppm 2,4-D G_4 - 2 ppm CPPU; G_5 - 2 ppm Brassinosteroid

Table 7: Effect of pre harvest sprays of SOP and growth regulators on total yield (ton / ha) of banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	24.13	24.38	24.38	24.62	25.00	24.80	24.38	24.70
G_2	25.65	27.88	25.88	26.12	28.50	27.30	25.89	28.20
G_3	25.46	28.55	25.85	26.23	29.00	27.60	25.85	28.78
G_4	25.00	27.25	25.70	26.38	27.75	27.10	25.70	27.50
G_5	27.84	29.12	26.83	27.12	29.63	28.38	26.84	29.38
Interaction Mean	26.39	27.43	26.40	26.10	28.00	27.00		
Mean	S_1(25.70)	S_2(27.70)	G_1(24.50)	G_2(27.00)	G_3(27.30)	G_4(26.60)	G_5(28.10)	
	L	S**	G**	L x S	L x G	S x G	L x S x G	
S Ed	1..98*	5.17	8.17	6.02	11.2	11.5	8.2	
CD(0.05)	4.7200	10.4894	16.5850	NS	NS	23.45	NS	

Table 8: Cost economics of pre harvest application of SOP and certain growth regulators on banana cv. Nendran (AAB)

Treatment	Cost of cultivation in Rs.per ha (excluding the treatment cost)	Treatment cost + labour cost (Rs.per ha)	Total cost of cultivation (Rs.per ha.)	Total yield (kg/ha)	Gross income (Rs.per ha.)	Net income (Rs.per ha.)	Benefit : cost ratio
T1	90,000	0	90,000	24375.00	243,750	153,750	2.50
T2	90,000	12,500	102,500	25887.5	258,875	156,375	2.70
T3	90,000	9000	99,000	26012.50	260,125	161,125	2.62
T4	90,000	10,500	100,500	25525.00	255,250	154,750	2.53
T5	90,000	10,000	100,000	26837.50	268,375	168,375	2.68
T6	90,000	2000	92,000	24662.50	246,625	154,625	2.68
T7	90,000	13,500	103,500	28162.50	281,625	178,125	2.72
T8	90,000	10,000	100,000	28775.00	287,750	187,750	2.87
T9	90,000	11,500	101,500	27500.00	275,000	173,500	2.70
T10	90,000	12,000	102,000	29375.00	293,750	191,750	2.87

Quantity of spray fluid required = 1 lit/ plant; Sale price of Nendran = Rs. 12 / Kg, Labour cost for spraying = Rs.500/ha, Cost of SOP = Rs.15 / kg, Cost of GA3 = Rs. 1200 / 100 g, Cost of 2, 4-D = Rs. 900 / 100 g, Cost of CPPU = Rs. 100 /g, Cost of BR = Rs. 80 / 50 ml

growth regulators G_5 (Brassinosteroid @ 2 ppm) registered higher pulp weight (164.64 g) followed by 2, 4-D (156.63 g) and lowest pulp weight was recorded with SOP alone treatment (127.29g). Among the interaction effects, SOP@2% + Brassinosteroid combination (S_2G_5) recorded the higher pulp weight (180.22 g) in location II than all other treatments.

Pulp-peel ratio

The data on pulp to peel ratio revealed that, location II recorded the higher pulp to peel ratio (4.16) and significantly different in location I (3.68) (Table 6). The pulp to peel ratio was recorded highest (4.32) with the treatment S_2 (SOP @ 2 %) and lowest pulp to peel ratio was registered with S_1 (3.51) at location II. Among the different growth regulators, brassinosteroid @ 2 ppm (G_5) recorded higher pulp to peel ratio (4.40) followed by 2, 4-D (4.15).The interaction effect was found significant and the combination of SOP @ 2% along with brassinosteroid (S_2G_5) recorded higher pulp to peel ratio (5.13) in location II.

Total yield (tonnes / ha)

The mean data on total yield at both locations are represented in Table 7. Among the locations, the location II recorded the highest total yield (27.00 tonnes / ha) and significantly different from location I (26.40 tonnes/ ha). Among the SOP treatments, the S_2 treatment (SOP @ 2%) recorded the highest total yield (27.70 tonnes/ ha) and highly significant from S_1 (without SOP) of 25.50 tonnes per hector in location II.

Spraying of growth regulators significantly influenced the total yield of banana at both locations. However application of brassinosteroid (G_5) registered significantly higher yield (28.10 tonnes) followed by 2, 4-D (27.30 tonnes) and lowest yield was recorded in SOP alone (24.50 ton). Total yield was significantly influenced due to the interaction of SOP and growth regulators at both locations. SOP @ 2% + brassinosteroid combination (S_2G_5) recorded the higher total yield (29.38 tonnes/ ha) in location II than all other treatments. The lowest yield was recorded in treatment combination of SOP @ 2 % alone + without growth regulator spray (24.38 tonnes/ ha) in location I.

Benefit- cost ratio

The benefit cost ratio differed significantly due to pre harvest bunch spraying of SOP along with growth regulators in banana cv. Nendran and presented in the Table 8. The maximum benefit cost ratio (2.87) was obtained in the treatment (T_{10}) where, the bunches were treated with 2 per cent sulphate of potash and 2 ppm brassinosteroid, which was followed by (T_8) 2 per cent sulphate of potash and 25 ppm 2,4-D (2.83). Whereas, the minimum benefit cost ratio (2.50) was obtained in control (T_1).

DISCUSSION

The combination of SOP and growth regulators revealed significant influence on yield and quality attributes of cv. Nendran in the present study. The results are discussed below.

The results obtained from the present investigation, on bunch yield revealed that the preharvest sprays with SOP and growth regulators influenced the bunch weight positively. The treatment combination of 2 % SOP and 2 ppm brassinosteroid

(T_{10}) registered the highest mean bunch weight and total yield. Irrespective of the locations G_5 *i.e.,* Brassinosteroids @ 2 ppm concentration was found to improve the plant yield attributing characters.

From results obtained it can be inferred that SOP and brassionsteroid can have a complementary role in improving bunch weight. Preharvest spraying SOP either alone or along with growth regulators did not have any significant influence with respect to the different finger characters like number of fingers per hand, number of hands per bunch and total fingers per bunch. This is mainly because of the imposition of treatments after flag leaf emergence or after last hand opening stage. By the time of spray, the actual differentiation of fingers and hands are well over and hence there is no likelihood of improving the numbers of hand or fingers. In earlier studies by Nandan *et al.* (2011), Madhu (2013) and Kaviarasu (2013) also there were no significant improvement in number of hands and fingers.

The field trials conducted in the present study in two locations clearly pointed out that, the increased total yield was mainly due to improvement in finger weight. The favourable influences on bunch traits by SOP can be because of the presence of sulphur or potassium or both in the SOP. Given as a foliar spray, the absorption of both sulphur and potassium could have played a key role in assimilate partitioning and diversion to the rapidly developing fingers.

Sulphur present in the sulphate of potash (SOP) is considered to play a crucial role in formation of ferridoxin (Iron-sulphur protein) in plants. Ferridoxin is known to have direct impact on metabolism of the plant by activating the catalase and perodoxidase enzymes. Presence of sulphur in SOP may also have a synergistic effect with zinc influencing carbon dioxide absorption and utilization, synthesis of RNA and auxin (Pandey and Sinha, 1999). SOP has been attributed to play major roles in energy transformation, nitrate assimilation, as a constituent of amino acid and protein production, binding of nucleic acid with proteins, activation of enzymes in carbohydrate metabolism subsequently resulting in greater partitioning of photosynthates in yield attributes of bananas (Ramesh Kumar and Kumar, 2007 and 2010).

Sulphur of potash is very well known to trigger nitrate reductase in the majority of growth stages. Since nitrate reductase is the key enzyme in the assimilation of nitrate, the maintenance of the high rate of enzyme activity is imperative for enhanced protein content of the plants. The higher yield and yield attributing parameters obtained in the study could have been also brought by the influence on soluble protein too.

The increase in bunch yield and finger weight due to SOP application in the present study is similar to the earlier findings of Algarsamy and Neelakandan (2008) in Robusta, Madhu in banana cv. Grand Naine. (2013) , Ramesh Kumar and Kumar (2007 and 2010) in cv. Ney Poovan and Ramesh Kumar *et al.* (2008) in cv. Robusta and Madhu (2013) in banana cv. Grand Naine.

Brassinosteroid has multifunctional role in plants. It induces cell division, elongation and differentiation and stimulates photosynthetic activity by accelerating CO_2 fixation and further increasing protein biosynthesis. Besides, BR is known to promote nucleic acid level, nitrogen fixation and enhance soluble protein content and increase in DNA and RNA concentrations (Jayakumar *et al.*, 2010). Increase in leaf chlorophyll content, leaf area and leaf area index was brought out by Anitha by application of brassinosteroids (2007). Apart from these physiological responses, BR has growth promoting effects similar to auxin and gibberellins and found to have promising effects on total yield improvement (Vardhini and Rao 1998). Similar results were revealed by Bhat *et al.* (2011) in grapes, Peng *et al.* (2004) in litchi and Gomez *et al.* (2006) in yellow passion fruit.

While the earlier studies in banana indicated the positive influence of SOP alone or brassinosteroid alone, in the present study the synergistic effect of both SOP and brassinosteroid could be visualised by the enhanced yields in the treatment combination S_2G_5 *i.e.,*2 % SOP and ppm brassinosteroid. The positive influence of SOP was seen to have been dynamically influenced further by the brassiosteroids as revealed by as high as 16 per cent in yield and 32 % in finger weight. The multifunctional physiological role of brassinosteroids could be due to improved photosynthetic processes and sink efficiency.

Among the two locations, the maximum bunch weight and highest total yield was observed in location II which might be attributed to the differences in soil factors, local weather parameters and differences in the approaches in field maintenance by the growers prior to the initiation of experiment.

Increase in length and girth may be also due to complementary action of sulphur on zinc to synthesize auxins which are responsible for the cell elongation by increasing the cell permeability to water and osmotic solutes of the cells. Besides, auxins are also responsible for inducing the synthesis of specific DNA dependent new m-RNA and specific enzymatic proteins causes increased cell plasticity and extension resulting ultimately in cell enlargement (Ahmed *et al.,* 1998). Increased finger length and girth due to SOP was also reported in studies by Madhu (2013), Mustaffa *et al.* (2004), Nandan *et al.* (2011) and Ramesh and Kumar (2007) in banana.

Increased finger lengths and girths due to the application of auxins (2, 4-D) and gibberellins as recorded in the present study were also reported in earlier studies by Xiao *et al.* (1997), Patil and Hulmani, (1998) Athani *et al.* (1999) in banana.

With regard to the physical quality parameters like pulp weight, peel weight,

pulp-peel ratio and fruit volume, superior performance was registered by application of 2 % SOP and 2 ppm of BR as pre-harvest spray at two stages of bunch development. This can be due to efficient partitioning of carbohydrates and mobilisation in developing bunches resulting in good pulp recovery. The influence on filling of fingers by the element potassium in banana has been registered by earlier workers like Mustaffa *et al.* (2004). Higher pulp weight recorded in the treatment S_2G_5 can be further attributed to the accelerated rate of cell division and enlargement favoured by auxin biosynthesis prompted by sulphur and potsaasium and as well as accelerated sink development aided by the brassinosterods. A similar effect can be attributed to peel weight.

Peng *et al.* (2004) has described the role of BR's in influencing the finger characters by inducing cell division, elongation and differentiation. In addition, brassinosteroid stimulate the accumulation of photosynthates through increase carbohydrate assimilation and enhanced mobilization of metabolites to the fruits (Fujioka, 1997). The findings in the present study are in consonance with the findings of (Bhat *et al.,* 2011) in grape and Gomez *et al.* (2006) in yellow passion fruit.

The rate of photosynthesis is high in plants receiving adequate amounts of potassium may be due to the positive effect of potassium ions on the transfer of the products of photosynthesis because it speed up the flow of assimilates as reported by Suseela and Mruthunjaya (2000). The present results are similar to the findings of Madhu (2013), Ramesh Kumar *et al.* (2008) and Ramesh and Kumar (2007 and 2010).

The increase in bunch weight, finger attributes and other bunch and finger parameters observed in the present study with the other growth regulators *i.e.,* 2, 4-D, CPPU and GA_3 can be also attributed to their impact on cell development, cell division and mobilisation of photosynthetic assimilates to the developing fruits. Increased yield of banana due to application of these growth regulators have been observed by many workers.

The enhanced impact due to GA_3 was earlier observed by Chattopadhyaya and Jana, 1988; Pradhan *et al.*, 1988; Mary and Sathiamoorthy, 1996; Kumar and Reddy , 1998; Athani, *et al.,*1999; Balakrishnan *et al.*, 2002; Barman and Das , 2002; Sanna Ebeed, 2008). Similarly enhancement in yield was reported by Rao and Chundawat (1986). Significant enhancement in finger weight with increased pulp: peel ratio and TSS due to post shooting spray of 2, 4-D was also observed by Tomi *et al.* (1997), Patil and Hulmani, (1998), Athani *et al.*, (1999), Barman and Das (2002), Tamilselvi *et al.* (2006). Kaviarasu (2012) reported that the bunch weight was significantly influenced by CPPU and 2, 4-D applications. The findings in the present study have similarity to the above findings and confirm that these growth regulators in combination with SOP can be employed for cv. Nendran for improving bunch yield.

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