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Physiological response of banana cv. Robusta (AAA) to foliar applied plant growth regulators on productivity

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Abstract: Chemical manipulations using plant growth regulators were carried out in banana cv. Robusta for better partitioning efficiency and yield improvement. Mepiquat chloride (1, 1-dimethyl piperidinium chloride), CCC (2-chloroethyl trimethyl ammonium chloride) and brassinolides were given as foliar application in different concentrations at specific stages of growth. Plant height was increased (209.6 cm) significantly by foliar application of brassinolides (0.2 ppm) at 4th and 6th month after planting. Phyllochron did not show any significant variations between the treatments. However, leaf area as well as leaf area index exhibited variations due to brassinolides (0.2 ppm). In the case of physiological parameters, foliar application of CCC 1000 ppm registered higher net photosynthesis (25.3 μmol $m^{-2}s^{-1}$), chlorophyll fluorescence (Fv/Fm: 0.863) and RWC (87.7%). But, transpiration was observed high in the plants treated with brassinolides 0.2 ppm (6.42 μg H_2O $m^{-2}s^{-1}$). It is evident that foliar application of CCC 1000 ppm at 4th and 6th month after planting resulted in higher yield by registering higher bunch weight (24.1 kg) and number of fingers (124.5). However, no significant difference was noticed in number of hands. Total sugars and TSS also exhibited higher values of 17.7 and 23.4 per cent respectively. But, titrable acidity was found to be insignificant between teratments.

Key words : Banana, plant growth regulators, physiology, yield.

Introduction

Banana, a major fruit crop of India is cultivated in 0.46 million hectares with an annual production of 15 million tonnes sharing 34 per cent of the total world production. Although many varieties are cultivated in India, Robusta (AAA), a member of Cavendish group is very popular among Indian farmers. It has been observed that the yield potential of Robusta banana could be improved by proper management practices. Kumar *et al.* (2002) reported that high density planting, fertigation technique and micronutrient fertilization have improved the banana productivity in the recent years. But, there is scope for further improvement in the growth and development of banana by chemical manipulations. Plant Growth regulators (PGRs) are being employed increasingly in the recent years to overcome physiological constraints leading to enhanced production in several crops. Among the PGRs, Brassinolides (BR) comprise a group of naturally occurring phytohormones which have been shown to regulate several physiological responses like cell division, cell elongation, synthesis of nucleic acids and proteins, and enhancement of yield in cereals and vegetables. BR has growth promoting effects similar to auxin and gibberellin (GA) and found to have promising effects on yield improvement and stress management in few agricultural and horticultural crops. Yokota and Torkahashi (1985) observed significant increase in fruit yield of tomato. Udayakumar (1993) reported that brassinosteroids in combination with gibberellin improved the berry size and bunch weight in grapes cv. Dilkush. Research works carried out in Tamil Nadu Agricultural University, Coimbatore has also shown promising effects of BR in different field crops (Lini, 2001).

Growth retardants are also widely used for yield improvement and abiotic stress management in field crops as well as horticultural crops. Mepiquat chloride (1, 1-dimethyl piperidinium chloride) is relatively a new plant growth retardant found to limit vegetative development and alter the partitioning of dry matter in the plant. Jeyakumar and Thangaraj (1998) reported significant improvement in plant nutrient status, chlorophyll content, soluble protein, nitrate reductase activity and thereby yield and quality in ground nut due to mepiquat chloride (MC). In mango, fruit yield and quality have been increased considerably by mepiquat chloride (MC) able 1. Effect of plant growth regulators on growth attributes at the stage of shooting

Treatments	Pseudostem		Number of leaves	Leaf area (m^2 plant^{-1})	Leaf area index	Phyllo-chron
	Height (cm)	Girth (cm)				
T_1 : Control	205.3	66	17.4	20.40	6.29	7.82
T_2 : MC 500 ppm at 4th MAP	201.7	71	17.4	19.75	6.09	7.73
T_3 : MC 500 ppm at 6th MAP	203.6	69	17.4	19.64	6.06	7.74
T_4 : MC 500 ppm at 4th & 6th MAP	197.5	73	17.9	19.88	6.13	7.81
T_5 : BR 0.2 ppm at 4th MAP	207.2	67	18.1	21.43	6.61	7.68
T_6 : BR 0.2 ppm at 6th MAP	206.3	69	17.6	21.38	6.59	7.73
T_7 : BR 0.2 ppm 4th & 6th MAP	209.6	69	17.7	21.65	6.68	7.74
T_8 : CCC 1000 ppm at 4th MAP	184.5	81	18.0	18.51	5.71	7.69
T_9 : CCC 1000 ppm at 6th MAP	186.7	78	18.4	18.46	5.69	7.75
T_{10} : CCC 1000 ppm at 4th & 6th MAP	181.6	84	18.1	18.22	5.62	7.70
SEd	8.41	0.06	18.3	0.84	0.33	
CD (P=0.05)	18.3	0.11	NS	1.86	0.74	NS

able 2. Effect of plant growth regulators on physiological attributes at the stage of shooting

Treatments	P_n (µmol $CO_2 m^{-2}s^{-1}$)	Chl.Fluor (Fv/Fm)	E (µg H_2O $m^{-2}s^{-1}$)	RWC (%)	WUE
T_1 : Control	19.4	0.714	5.04	80.2	3.84
T_2 : MC 500 ppm at 4th MAP	21.6	0.794	4.82	84.8	4.48
T_3 : MC 500 ppm at 6th MAP	20.9	0.791	4.80	83.1	4.35
T_4 : MC 500 ppm at 4th & 6th MAP	21.9	0.801	4.78	85.4	4.58
T_5 : BR 0.2 ppm at 4th MAP	20.5	0.783	5.43	82.6	3.77
T_6 : BR 0.2 ppm at 6th MAP	20.3	0.776	5.51	81.5	3.68
T_7 : BR 0.2 ppm 4th & 6th MAP	21.0	0.780	6.42	82.4	3.27
T_8 : CCC 1000 ppm at 4th MAP	24.6	0.842	4.73	87.1	5.20
T_9 : CCC 1000 ppm at 6th MAP	22.4	0.812	4.72	86.5	4.74
T_{10} : CCC 1000 ppm at 4th & 6th MAP	25.3	0.863	4.24	87.7	5.96
SEd	1.45	0.02	0.84	1.95	0.63
CD (P=0.05)	3.12	0.05	1.82	4.26	1.32

and paclobutrazol applications (Vijayalakshmi and Srinivasan, 2000). Chlormequat chloride (CCC) is also a very active growth retardant compound with quarternary ammonium group and primarily used as anti-lodging agents in cereal production and to reduce excessive vegetative growth in plants. Rademacher (2000) reported that GA levels were found decreased by chlormequat chloride. Increased rates of photosynthesis and yield have been observed in pulses (Saha and Gupta, 1998) and horticultural crops (Shikamany and Narayana Reddy, 1994). With this background, investigations were carried out to study the influence of PGRs on morphological characters during growth and development, to understand the effect of plant growth regulators on ecophysiological changes and water relations, and to study the effect of plant growth regulators on yield and quality changes.

Materials and Methods

Planting material and growing conditions

The present experiment was conducted during the year 2000-2001 in the Orchard, Tamil Nadu Agricultural University, Coimbatore, India. Banana cv. Robusta was raised with a

Table 3. Effect of plant growth regulators on yield and quality attributes

Treatments	Bunch weight (kg)	Number of Hands	Number of Finger	Total sugars (%)	TSS (%)	Acidity (%)
T_1 : Control	20.2	9.42	112.3	15.2	21.0	0.40
T_2 : MC 500 ppm at 4th MAP	22.6	9.51	120.2	16.6	22.0	0.41
T_3 : MC 500 ppm at 6th MAP	22.2	9.56	119.2	16.5	21.4	0.39
T_4 : MC 500 ppm at 4th & 6th MAP	23.2	9.50	120.4	16.8	22.2	0.38
T_5 : BR 0.2 ppm at 4th MAP	21.4	9.47	114.3	16.3	21.2	0.37
T_6 : BR 0.2 ppm at 6th MAP	20.6	9.62	112.4	15.4	21.3	0.39
T_7 : BR 0.2 ppm 4th & 6th MAP	21.7	9.53	115.7	16.0	21.5	0.40
T_8 : CCC 1000 ppm at 4th MAP	23.5	9.52	121.6	17.4	23.1	0.38
T_9 : CCC 1000 ppm at 6th MAP	23.2	9.61	120.3	17.2	22.8	0.39
T_{10} : CCC 1000 ppm at 4th & 6th MAP	24.1	9.63	124.5	17.7	23.4	0.37
SEd	1.01		3.57	0.62	0.85	
CD (P=0.05)	2.17	NS	7.65	1.33	1.82	NS

spacing of 1.8 m x 1.8m. The soil type was clayey loam with available N:P:K of 155:47:430 kg/ha. Organic matter content in the soil was 0.74 per cent with soil pH 7.1 and EC 0.32 dsm^{-1}. Irrigation was given by the basin method in such a way that the plants never experienced water stress at any stage of growth.

Treatments

The number of treatments was ten comprising brassinolides, mepiquat chloride, and chlormequat chloride applied to the crop in different concentrations at different stages as indicated below.

Treatmental details

T_1 - Control

T_2 - Mepiquat Chloride (MC) 500 ppm at 4th month after planting (MAP)

T_3 - Mepiquat Chloride (MC) 500 ppm at 6th month after planting (MAP)

T_4 - Mepiquat Chloride (MC) 500 ppm at 4th and 6th month after planting (MAP)

T_5 - Brassinolides (BR) 0.2 ppm at 4th month after planting (MAP)

T_6 - Brassinolides (BR) 0.2 ppm at 6th month after planting (MAP)

T_7 - Brassinolides (BR) 0.2 ppm at 4th and 6th month after planting (MAP)

T_8 - Chloro Choline Chloride (CCC) 1000 ppm at 4th month after planting

T_9 - Chloro Choline Chloride (CCC) 1000 ppm at 6th month after planting

T_{10} - Chloro Choline Chloride (CCC) 1000 ppm at 4th and 6th month after planting

The experiment was laid out with three replications in randomized block design (RBD). The recommended fertilizer dose of 110:35:330 g N: P_2O_5; K_2O was supplied to the plants by soil application. Phosphorus was applied in full (100%) during third month of planting along with 30% N and 20% K. During fifth month after plantng, 50% N and 40% K were applied and in the seventh month, 20% N and 32% K were supplied to the plant. The balance K was supplied during tenth to eleventh month after planting.

Growth measurements

The growth and development of the plant was assessed through different growth attributes *viz.* plant height, pseudostem girth, number of leaves, leaf area, leaf area index and phyllochron. The plant height (pseudostem height) was measured from the base of the trunk to the axil of the youngest leaf and expressed in centimeter. The pseudostem girth was measured at 20 cm height from the ground level. Leaf area was estimated by multiplying the product of length and width of the lamina of individual leaves by the factor 0.8, added and expressed in cm^2 (Murrary, 1960). Healthy leaves at the time of shooting were counted and expressed as number of leaves. Leaf area index was calculated as suggested by Watson (1952).

Physiological parameters

The gaseous exchange measurements comprising net photosynthesis (*Pn*) and transpiration (*E*) were taken using CI 301 PS CO_2 analyser (CID Inc, USA) during 10.30 to 11.30 hours on cloud free days. All the measurements were taken in the distal end of the leaf as reported by Ekanayake *et al.* (1995). The photosynthetically active radiation (PAR) was around 1150 $\mu mol\ m^{-2}\ s^{-1}$ and, the average ambient temperature and relative humidity (RH) were 32°C and 67 per cent respectively. Diverse measurements were taken on leaves, as described by Eckstein and Robinson (1995). Water use efficiency in terms of *Pn/E* was calculated from the values measured using portable photosynthesis system. Chlorophyll fluorescence, the rapid and non-destructive method to assess the photochemical efficiency of the plant was measured in terms of Fv/Fm where, Fv is variable fluorescence and Fm is maximal fluorescence. Fv was arrived by substracting the minimal fluorescence or fluorescence at zero level (Fo) from Fm. Plant efficiency analyzer (Hansatech, UK) was used to measure the Fv/Fm in the sampled leaves by giving dark adaptation for 30 minutes before taking measurements. Relative water content in the leaf samples was assessed following Barrs and Weatherley (1962).

Yield and quality attributes

The fruit yield was assessed in terms of bunch weight, number of hands and number of fingers in the second hand of the bunch. The fully ripened fruits were taken for quality assessment. Total sugars were estimated following the method of Somogyi (1952). Total soluble solids (TSS) was measured using Carl-Zeiss hand refractometer and experssed in percentage. The titrable acidity in the fruit samples was assessed by AOAC method (1960).

Results and Discussion

The measurements on growth parameters at shooting stage exhibited the significant influence of plant growth regulators on all the characters studied except number of leaves and phyllochron (Table 1). Among the growth parameters, plant height was increased significantly by foliar application of BR (0.2 ppm) at 4^{th} and 6^{th} month after planting (T7) by registering 209.6 centimeter. But, CCC treatments improved the pseudostem girth (78-84 cm) and reduced the pseudostem height by inhibition of cell division and elongation of sub apical meristem, and by affecting gibberellin synthesis. Chattopadhyay and Jana (1988) also reported reduction in pseudostem height due to CCC application but they observed reduced pseudostem girth in contrary to the present observation. Phyllochron did not show any significant difference. However, leaf area as well as leaf area index exhibited variations in T_7 by recording higher values of 21.65 $m^2\ plant^{-1}$ and 6.68 respectively. The highest leaf area in BR treated plants could be due to delay in leaf senescence/abscission (Iwahari *et al.* 1990) which may again be a manifestation of increased chlorophyll content (Shen *et al.* 1990).

In the case of physiological parameters, CCC 1000 ppm at 4^{th} and 6^{th} month after planting registered higher net photosynthesis (25.3 $\mu mol\ m^{-2}s^{-1}$) and improved the photochemical efficiency by higher chlorophyll fluorescence (Fv/FM: 0.863) (Table 2). It is established that CCC improves chlorophyll content in a wide range of crops, and the higher chlorophyll content and the improvement in leaf water balance as indicated by increased RWC (87.7%) might have helped in increasing the photosynthetic rates in the present study. However, the transpiration was observed high in the plants treated with BR 0.2 ppm at 4^{th} and 6^{th} month after planting (6.42 $\mu g\ H2O\ m^{-2}s^{-1}$) due to improved plant growth. The higher net photosynthesis and lower transpiration in the CCC treatments resulted in higher water use efficiency (4.74 to 5.96) as reported by Rademacher (2000).

It is evident from Table 3 that foliar application of CCC 1000 ppm at 4^{th} and 6^{th} month after planting resulted in increased yield by registering higher bunch weight (24.1 kg) and number of fingers (124.5). However, no signfiicant difference was noticed in number of hands. Application of CCC might have resulted in increased light infiltration into the canopies, photosynthetic capacity and expansion of the xylem and increased transpot ability and, in turn resulted in heavier bunches. Total sugars and TSS also exhibited higher values of 17.7 and 23.4 per cent but, titrable acidity was found insignificant between treatments. The improvement in the qualitycharacters such as total sugars and TSS might be due to the influence of growth retardants on physiological process, particularly respiration and photosynthesis which possibly led to accumulation of dry matter, minerals and carbohydrate and in turn high sugar content. It can be concluded from the present study that the growth retardants were found effective in altering dry matter partitioning, and improving yield and quality as evidenced by reduced plant height and transpirational loss of water, and improved pseudostem girth, net photosynthesis, chlorophyll fluorescence, relative water content and water use efficiency.

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