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Research Article

EVALUATION OF BANANA (*Musa SPP.*) GENOTYPES FOR MOISTURE STRESS TOLERANCE

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Abstract- India stands first in area and production of banana. It is cheapest source of energy, which is available throughout the year. It requires uniformly warm and moist conditions for optimum growth and development. Some reviews have revealed that a temperature below 10ºC and above 38ºC has affected the growth of the banana plants. In the present investigation the experiment was done with three categories *viz*., i) with well watered, ii) stress imposition (withholding water) and iii) recovery in well watered condition. The observations on 21 morphological parameters were recorded in all the categories of the experiment. In the first category of experiment, the morphological traits like shoot length, pseudostem girth, petiole length, leaf length, leaf weight, percent leaf moisture loss after 48 hrs, constant dry weight at 80ºC, total plant weight, shoot weight and root traits like number of roots, root girth, percent moisture loss after 24 hours and after 48 hours in roots showed significant difference, while number of leaves, leaf breadth and percent leaf moisture loss after 24 hrs, total leaf weight, root weight, root volume, root length and constant dry weight at 80ºC were non-significant. In the second category of the experiment, during water stress more number of green leaves was observed in cultivars Adukkankunnan (AB), Karibale (AAB), Rasthali (AAB) and wild *Musa balbisiana*tani (BB) indicating their tolerance to water stress. Less number of green leaves or absence of green leaves was observed in wild Amturkela (BB), cultivars Neypoovan (AB), Petitnaine (AAA), Palayankodan (AAB) and Pisang Jari Buya (AA) indicating their sensitivity to water stress. In third category of experiment that is, during recovery all characters showed significant difference except, the characters like percent leaf moisture loss after 24 hours and 48hours, which had non-significant differences.

Keywords- Banana germplasm, moisture stress, Stress recovery, Screening.

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Introduction

Banana (*Musa spp.*) is the second most important fruit crops of India. It is used primarily as dessert fruit and also some cultivars as vegetable. The fruit is a good source of high energy for rural and urban consumers. It is also an important source of income to small and big farming community. Banana is a plant of tropics and sub tropics requiring hot and humid climate with optimum temperature for growth about 31 to 32ºC. Most favorable climatic factors for banana production are rainfall in excess of 100 mm per month and a temperature range of 10-38ºC with an optimum temperature between 25-30ºC [1]. It is long duration crop among the herbaceous plant, is more sensitive to moisture stress than other fruit crops and requires continuous sources of soil moisture for optimum growth and yield. Water requirements of banana per year vary between 1200 mm in the humid tropics to 2200 mm in dry tropics [2]. In general, irrigation of banana plantations every 3-4 days during the hot period and at 7-8 days interval during cool weather is suggested. Irrigation is required at 5 to 10 days intervals in dry weather for banana [3]. Whereas irrigating bananas at 10 to 15 days from October to February and 6 to 8 days from March to May [4]. Water is one of the major limiting factors in banana production. This abiotic stress during vegetative period affects the rate of leaf development, leaf growth, pseudostem girth and root establishment. Short intervals of stress between irrigation have a pronounced effect on high rate of leaf development, leaf growth, pseudostem girth and root establishment. The growth, development and productivity of banana are influenced by soil moisture levels. Under irrigated, total production will be higher when full crop water requirements are met over a limited area than when crop water necessities are reasonably met over an extended area. The banana plant has a sparse, shallow root system; most feeding roots are spread laterally near the soil surface, up to 3-4 meters around main stem. Rooting depth will generally not exceed 0.75 m. In general most of the water absorbed by roots is from first 0.5 m to 0.8 m soil depth where 60 percent is from the first 0.3 metre. Banana plants are sensitive to soil moisture stress which is reflected as changes in abridged growth through reduced stomatal conductance and leaf size reduction observed [5].The increased leaf senescence was reported [6]. The genetic improvement of drought resistance in crop plants require identification of pertinent drought defense mechanisms and the development of a suitable methodology for their measurement in the screening of germplasm as suggested [7]. The present investigation was undertaken to determine the effects of moisture stress on plant morphological and root characters of some banana genotypes.

Material and methods

The field experiment was carried out at Indian Institute of Horticultural Research Bengaluru, during 2011-2012. Annual relative humidity ranges from 33.3-66.6% and annual mean temperature was between 26.1-33.6ºC while, annual rainfall ranges between 531.3-604.3 mm. Disease free suckers of uniform size and age belonging to nine genotypes of banana involving AA, AAA, AAB, AB & BB groups with 3 replications each were raised in 20L plastic containers in open field condition with recommended cultural practices. The entire experiment was divided into three categories *viz*., i) with well watered for three months (irrigation were given regularly at 3-4 days intervals), ii) stress imposition (withholding water for 45 days) and iii) recovery with well watered condition (regular irrigation was resumed

at 3-4 days intervals). The data on morphological and root traits of different genotypes was recorded before stress and after stress implementation. The growth parameters like plant height (cm) was measured which is the distance between the soil level up to the level of last 2 unfurled leaves, while plant girth (cm) was measured as the diameter of the pseudo stem at 10 cm above the soil level with the help of vernier caliper, total plant weight (g), number of functional leaves and leaf length(cm), breadth(cm) and petiole length (cm) of fully matured third leaf, leaf weight (g), % Leaf moisture loss after 24hrs, % Leaf moisture loss after 48hrs, indicating moisture loss, constant dry weight at 80ºC and the root parameters like total root weight(g), root volume(cc), number of roots, root length (cm) and root girth(cm), % Root moisture loss after 24hrs, % Root moisture loss after 48hrs and constant dry weight at 80ºC were determined at first and third category of the experiment, where as in case of second schedule of the experiment, where plants were under stress number of green leaves (full green), number of partly yellow leaves or partly green leaves, number of yellow leaves and number of dried leaves were recorded. The experimental data was subjected to statistical analysis of variance and the test of significance as per standard procedure [8].

Result and Discussion

Banana is herbaceous, moisture loving plants and it requires uniformly warm and moist conditions for optimum growth and yield. There is need to make available sufficient water supply for growth and development of the plant was suggested [9,10]. Drought tolerance in banana is the ability to survive under water scarcity during various stages of crop growth and without significant yield reductions.

In the present study, in first category of experiment, the potted plants were irrigated with hose pipe at regular intervals of 3-4 days, for 3 months and the observations on morphological parameters like number of leaves, petiole length, leaf length, leaf breadth, shoot length and stem girth were recorded and it was also observed that there was no visible yellowing symptoms of leaves. The results revealed that the morphological traits like shoot length, stem girth, petiole length, leaf length, 3rd leaf weight, % leaf moisture loss after 48 hrs, constant dry weight at 80ºC, total shoot weight, plant weight and root traits like number of roots, root girth, percent moisture loss after 24 hours and percent moisture loss after 48 hours of roots showed significant difference, while number of leaves, leaf breadth and total leaf weight, percent moisture loss after 24 hours of leaves, root weight, root volume, root length and constant dry weight at 80ºC had non-significant difference. This might be due to genotypic variation [Table-1] where AA, AAA, AAB, AB& BB group genotypes were involved. The banana plant's responses to soil moisture stress showed that the plants gradually stopped growing, showed evidence of desiccation, became yellow and finally wilted. The important sign of water stress is expressed as yellow cast of the foliage, accompanied by long periods of transient wilting of the leaves during the warmest part of the day. The water stress treatment strongly reduced the height of the plants. The rate of growth expansion was visibly lower from day 7 after which plants exhibited slight increment up to day 10 and no enhancement was noticed afterward, which leads into stunted plants as compared with well watered condition. Similar pattern was observed with reference to stem girth expansion. The most evident effort of water deficit to the plant was growth inhibition also explained [11]. The most sensitive indicator of soil water deficit in banana is the rate of emergence of the new leaf [12-14]. If the soil dries rapidly, the leaf may stop emerging after 2 to 10 days; if it dries slowly, leaves may stop emerging after 23 day.

In the second category of experiment, stress was imposed for the plants by withholding irrigation for 45 days. The results revealed that the green leaves turned to yellow in few genotypes like Amturkela (BB), Ney poovan (AB), Petit naine (AAA), Palayankodan (AAB) and Pisang Jari Buya (AA) and remained green in other genotypes like Adukkankunnan (AB), Karibale (AAB), *Musa balbisiana* ssp. *tani* (BB) and Rasthali (AAB) after 7 days of stress imposition. At the end of treatment (45 days after stress imposition) of second schedule all the plants showed wilt symptoms but, no new leaves emerged compared to control plants. The more number of green leaves were observed in Adukkankunnan (AB), Karibale (AAB), *Musa balbisiana* ssp. *tani* (BB) and Rasthali (AAB) indicating tolerance to drought like situation and less number of green leaves or absence of green leaves was observed in, Amturkela (BB), Ney poovan (AB), Petit naine (AAA), Palayankodan (AAB) and Pisang Jari Buya (AA) indicating sensitive to drought [Table-2]. Water stress after 7 to 12 leaf stage affected all the plant characters [15].Visibly the reduction in plant height and girth of all the genotypes of banana plants were observed might be due to drought avoidance mechanism.

In third category where, the stress imposed plants were again irrigated at regular intervals of 3-4 days for 3 months. Recovery of banana germplasm from drought is related to its ability to retain green leaves during stress period. Number of leaves recovered 30 days after re-watering in banana germ plasm was recorded [Table-2] and at conclusion of the experiment (3 months after re-watering) almost all characters showed significant difference. But, the characters like % leaf moisture loss of leaf after 24 hours and 48 hours drying at room temperature showed non significant difference among the germ plasm [Table-3]. A number of workers have reported *Musa* genotypes have different inbuilt mechanism for tolerance/ avoidance to drought conditions. Research has been carried out on the effect of water deficit on commercial cultivars of banana [16].

From the above three categories of observations we can conclude that the traits like number of leaves, leaf breadth, total leaf weight, root weight, root volume, root length and constant dry weight of roots at 80ºC which showed non-significant differences under first category of the experiment were observed to differ significantly under third category of the experiment except the trait like percent moisture loss of leaf after 24 hours showed non- significant under both the categories. But, the traits like percent leaf moisture loss after 48 hours showed significant difference under first category which showed non-significant under third category of the experiment. Among all the genotypes studied the genotypes like Adukkankunnan (AB), Karibale (AAB), *Musa balbisiana* Ssp.*tani* (wild BB) and Rasthali (AAB) can be classified as drought tolerant and the genotypes like Amturkela (BB), Ney poovan (AB), Petit naine (AAA), Palayankodan (AAB) and Pisang Jari Buya (AA) as susceptible to drought. There is variable reaction among the genotypes cultivars of only AA genome with AAA and AA composition have shown to be more susceptible as compared to genotypes containing 'B' genome component. Their morphological and root parameters help in conducting experiments on moisture stress related studies in future and there is a need to determine strategies to improve efficient water use of plants during drought conditions. However all genotypes could survive up to 40-45 days without water, with variable capacity to rejuvenate. The identified tolerant genotypes may be subjected to further field studies involving growth, yield, physiological and biochemical aspects.

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Conflict of Interest: None declared

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Table-1 *Influence of irrigation on shoot and leaf parameters of banana cultivars under field condition (Before stress imposition)*

Name	Shoot length (Cm)	Stem girth (Cm)	Number of leaves	Petiole length (Cm)	Leaf length (Cm)	Leaf breadth (Cm)	leaf weight (3rd)(g)	% moisture loss after 24 hrs (g)	% moisture loss after 48 hrs	Constant dry weight at 80ºC
Petit naine (AAA)	35.10	4.43	7.67	5.00	42.33	30.23	38.33	79.16	60.74	4.67
Kari bale (AAB)	56.67	5.90	6.67	9.67	61.00	28.17	56.66	80.00	64.22	7.67
Palayankodan (AAB)	53.00	4.93	5.67	10.50	55.00	25.83	56.66	67.86	56.15	7.50
Musa balbisiana ssp. tani (BB)	59.33	6.87	6.33	11.17	50.33	29.33	53.33	72.47	53.36	7.50
Rasthali (AAB)	67.33	5.93	7.33	15.00	64.67	31.07	50.00	79.49	66.09	8.00
Amturkela (BB)	58.00	6.33	7.33	9.83	54.67	32.33	60.00	80.55	38.89	8.33
Pisag jari buya (AA)	41.33	4.27	7.33	7.00	48.33	24.00	40.00	66.01	29.07	5.33
Adukkan kunnan (AB)	44.00	5.40	5.33	7.67	50.83	23.17	33.33	79.44	35.33	3.83
Ney poovan (AB)	40.50	4.33	8.00	9.30	46.17	23.00	33.33	55.00	30.28	5.00
SE.m±	4.25	0.46	0.67	1.01	3.06	2.75	6.52	7.58	8.60	1.01
CD @ 5%	12.75	1.38	NS	3.02	9.18	NS	19.56	NS	25.81	3.03

Contd.....

Germplasm	Total Shoot Weight(g)	Total leaf weight	Plant weight	Number of roots	Root weight	Root volume	Root length	Root girth	% weight loss after 24 hrs	% weight loss after 48 hrs	Constant dry weight at 80ºC
Petit naine (AAA)	193.33	221.67	1333.33	36.00	211.67	171.67	32.72	0.64	37.35	19.16	15.00
Kari bale (AAB)	445.00	310.00	2583.33	57.33	373.33	343.33	29.74	0.88	52.42	33.20	22.00
Palayankodan (AAB)	408.33	278.33	1700.00	69.00	306.67	316.67	24.46	0.77	43.64	29.66	18.83
Musa balbisiana ssp. tani (BB)	546.67	260.00	2450.00	68.00	343.33	345.00	32.48	0.90	47.24	31.41	24.50
Rasthali (AAB)	560.00	296.67	2216.67	104.67	408.33	376.67	37.77	0.76	40.65	29.27	21.83
Amturkela (BB)	620.00	381.67	2700.00	88.00	363.33	331.67	28.90	0.83	46.85	25.10	27.83
Pisag jari buya (AA)	260.00	235.00	1600.00	52.67	275.00	260.00	28.80	0.66	32.90	19.12	17.67
Adukkan kunnan (AB)	376.67	198.33	1800.00	51.67	243.33	230.00	24.67	0.53	27.21	13.16	15.17
Ney poovan (AB)	301.67	213.33	1333.33	98.67	246.67	315.00	27.18	0.35	31.19	16.34	14.00
SE.m±	84.11	46.97	282.49	13.57	59.33	57.48	3.24	0.06	5.03	3.84	4.47
CD @ 5%	252.16	NS	846.94	40.67	NS	NS	NS	0.18	15.08	11.53	NS

Table-2 *Number of leaves recorded for 9 accessions before and after stress imposition*

Sl. no.	Germplasm	Before stress imposition	45 days after stress imposition				Recovery after stress imposition
		Number of leaves (full green)	Number of leaves (full green)	Number of leaves (partly yellow)	Number of leaves (full yellow)	Number of dried leaves	Number of leaves(Green)
1	Adukkankunnan(AB)	7.67	2.66	-	0.33	2.33	8.00
2	Kari bale (AAB)	6.67	1.66	1.00	-	2.33	6.67
3	Musa balbisiana ssp.Tani (BB)	5.67	1.33	-	0.66	2.33	7.00
4	Rasthali(AAB)	6.33	1.00	0.33		5.33	8.33
5	Amturkela(BB)	7.33	0.66	0.66	-	3.00	6.63
6	Ney poovan(AB)	7.33	0.66	0.33	-	6.33	5.67
7	Petit naine (AAA)	7.33	0.33	-	0.33	8.66	7.33
8	Palayankodan (AAB)	5.33	-	0.66	-	2.66	8.67
9	Pisangjaribuya(AA)	8.00	-	0.33	-	4.66	8.00

Table-3 *Influence of irrigation on growth parameters of banana cultivars under field condition (After stress imposition)*

Germplasm	Shoot length	Stem girth	Number of leaves	Petiole length	Leaf length	Leaf breadth	3rd leaf weight	% weight loss after 24 hrs	% weight loss after 48 hrs	Constant dry weight at 80ºC
Petit naine (AAA)	27.00	4.33	8.00	5.33	39.00	21.67	26.67	63.11	42.89	4.13
Kari bale (AAB)	58.00	5.73	6.67	11.67	62.67	29.33	60.00	57.31	39.07	10.07
Palayankodan (AAB)	57.33	5.73	7.00	11.67	58.00	31.00	56.67	46.69	35.31	9.00
Musa balbisiana ssp. tani (BB)	60.67	6.67	8.33	10.33	47.67	28.00	40.00	55.33	40.50	7.20
Rasthali (AAB)	73.00	5.70	6.63	16.33	63.33	27.00	53.33	44.45	30.41	7.60
Amturkela (BB)	69.67	6.30	5.67	15.00	60.67	35.00	70.00	68.28	53.14	11.40
Pisag jari buya (AA)	47.33	4.23	7.33	9.67	50.00	24.33	46.67	47.53	35.53	6.60
Adukkan kunnan (AB)	59.67	5.23	8.67	8.67	50.00	24.33	36.67	51.60	38.71	5.87
Ney poovan (AB)	58.67	5.20	8.00	12.00	56.00	23.83	53.33	48.51	37.75	5.80
SE.m±	2.85	0.31	0.41	0.97	3.02	1.28	4.00	6.12	5.62	0.62
CD @ 5%	8.55	0.94	1.25	2.93	9.07	3.85	12.01	NS	NS	1.86

Contd.....

Germplasm	Total Shoot Weight	Total leaf weight	Plant weight	Number of roots	Root weight	Root volume	Root length	Root girth	% weight loss after 24 hrs	% weight loss after 48 hrs	Constant dry weight at 80ºC
Petit naine (AAA)	183.33	193.33	850.00	29.67	80.00	110.00	33.00	0.36	26.24	13.59	8.13
Kari bale (AAB)	286.67	353.33	2566.67	65.00	403.33	446.67	44.87	0.54	50.73	25.09	37.80
Palayankodan (AAB)	363.33	366.67	2183.33	86.33	450.00	443.33	26.80	0.61	34.65	15.98	31.07
Musa balbisiana ssp. tani (BB)	363.33	316.67	2500.00	94.33	400.00	293.33	35.54	0.49	43.56	23.29	34.07
Rasthali (AAB)	416.67	303.33	2166.67	129.33	250.00	320.00	25.27	0.42	53.44	32.45	25.47
Amturkela (BB)	516.67	380.00	3000.00	59.00	403.33	330.00	36.13	0.47	71.93	49.17	45.27
Pisang jari buya (AA)	183.33	250.00	1433.33	82.67	233.33	243.33	23.87	0.58	51.07	22.68	22.33
Adukkan kunnan (AB)	283.33	260.00	1616.67	82.67	243.33	200.00	23.39	0.39	34.11	16.13	23.20
Ney poovan (AB)	250.00	260.00	1350.00	118.33	206.67	180.00	23.39	0.45	52.42	26.66	18.27
SE.m±	45.71	29.41	174.69	16.63	48.64	46.75	4.11	0.03	4.64	3.34	3.39
CD @ 5%	137.06	88.18	523.74	49.88	145.84	140.19	12.35	0.11	13.92	10.02	10.18