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Evaluation of Banana Germplasm under Sodic Soil

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ABSTRACT

Banana can be grown in a wide range of soils. Soil and land parameters are one of the important requirements deciding the production and productivity of the crop. Sodic soils are those which have an exchangeable sodium percentage (ESP) of more than 15.The present study was conducted at Horticultural college and Research Institute for women, Trichy for Evaluation of banana germplasm under sodic soil. The experiment was laid out in Randomized block Design (RBD). The treatments comprised eleven types of germplasm or varieties *i.e.,* Kaveri Kalki (ABB), Adukku Monthan (ABB), CO2 (AB), Kaveri Saba (ABB), Monthan (ABB), Udhayam (ABB), Poovan (AAB), Karpooravalli (ABB), Kaveri Haritha (ABB), Ney Poovan (AB), and Vayal Vazhai (ABB). Among the 11 treatments screened Udhayam (T6) recorded highest bunch weight, followed by Kaveri Saba (T4) and Karpooravalli (T8). Highest yield was recorded in the cultivars having ABB genome in them, such as Udhayam (T6), Kaveri Saba (T4) and Karpooravalli (T8). The germplasm/varieties like Udhayam, Kaveri Kalki and Karpooravalli showed maximum number of hands. The maximum number of fingers was observed in Udhayam (T6) and Karpooravalli (T8). From the above study the germplasm/varieties having the *Musa balbisiana* genome were found to perform well under the sodic soil conditions, when compared to the *Musa acuminata* species due to their physiological characteristics to survive under adverse climatic conditions.

Key Words: Banana, Exchangeable sodium , Germplasm, Screening, Soil, Sodic soil.

INTRODUCTION

The banana is considered to be one of the most important cultivated tropical fruits in India. Banana (*Musa spp*.) belongs to the family Musaceae and is the leading fruit crop in tropical and subtropical regions of the world. It is the second most important fruit crop of India. Banana plants refer to Biblical legend as Tree of wisdom for good and evil in the Garden of Eden. Banana by virtue of its multiple uses is popularly known as Kalpataru (a plant with virtue).

Edible bananas are mostly hybrids of the two species from *M. acuminata* and *M. balbisiana*. They set fruits by parthenocarpy. It is called as Apple of paradise and Adam's fig. It is equally suitable both for large scale cultivation as well as for home scale cultivation. Banana mostly cultivated wide range of soils. Soil and land parameters are one of the important requirements deciding the production and productivity of the crop. Sodic soils are characterized by excess level of sodium ion (Na+) in the soil solution phase as well as on cation exchange complex, exhibiting unique structural problems as a result of certain physical processes (slaking, swelling, and dispersion of clay) and specific conditions (surfacing, crusting and hard setting). The growth rate of banana crop under the sodic soil condition may vary according to the genotype. In order to study and identify the well performing genotype, 11 germplasm/varieties were selected and observed for its suitability under sodic soil conditions. Considering the effect of the soil properties in the plant growth and establishment depending upon the genotype of the species, the present investigation was undertaken to assess the variations in yield and fruit quality, physiological and biochemical activities and to identify the salt tolerant genome in banana germplasm.

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Table 1. Treatment details of Banana germplasm/varieties

Treatment	Germplasm/ Varieties	Genome
T 1	Kaveri Kalki	ABB
T 2	Adukku Monthan	ABB
T 3	CO2	AB
T 4	Kaveri Saba	ABB
T 5	Monthan	ABB
T 6	Udhayam	ABB
T 7	Poovan	AAB
T 8	Karpuravalli	ABB
T 9	Kaveri Haritha	ABB
T 10	Ney Poovan	AB
T 11	Vayal Vazhai	ABB

Fig. 1. Banana germplasm/varieties in experiment field

MATERIALS AND METHODS

The experiment was conducted at Horticultural College and Research Institute for Women, Trichy during 2022-2023 (Fig.1) . The experiment was laid out in a Randomized Block Design with 11 treatments combinations (Table 1). For the 11 germplasm/varieties planted in the field, plants were selected randomly and an average weight of the bunch was recorded for each germplasm/variety using a weighing machine. A cluster of bananas are known as hands and each hand consists of a total of 10 to 20 bananas or fingers. The number of hands present in a bunch for all the 11 germplasm/ varieties were calculated randomly and an average value was calculated.

Total number of bananas/fingers present in a bunch was calculated by taking an average value of fingers present in the plant for every germplasm/variety. The length of the banana fingers was measured using a measuring tape. The breadth of each germplasm/variety was taken using a measuring tape and an average value is taken from the randomly selected fingers of the bunch.

Physiological and Biochemical analyses

Soil pH

The soil samples were taken randomly from sodic soil area and all the impurities were removed from the sample. The sample of air

dried on clean surface for few days and crushed into fine material. Then, a small portion of crushed soil is mixed with distilled water in 1:1 ratio and allowed to settle for about 30 minutes to let any suspended particles settle at the bottom. Using a pH meter, the pH of the supernatant liquid is measured. Potentiometry (soil-water suspension) Jackson (1973).

Soil EC

Soil Electrical Conductivity (EC) is an indicator of the soil's ability to conduct an electrical current. It is commonly used to assess soil salinity, nutrient availability, and overall soil health. Its value is expressed in deci Siemens per meter (dS/m) or milliSiemens per meter (mS/m). The soil sample was collected and air dried at room temperature. It is then sieved to remove the debris present in the sample. The sieved soil was mixed with distilled water at a ratio to maintain a proper moisture content. Then using a EC meter, the electrical conductivity of the soil-water extract was measured as per method suggested by Jackson (1973).

Exchangeable Sodium Percentage (ESP)

Exchangeable Sodium Percentage is the measurement of the amount of sodium in relation to other cations in the soil. It is used to assess the Sodicity level of soil, which refers to the presence of excess sodium ions that can cause soil structure degradation and reduced plant growth.

$$ESP = \text{Exchangeable } \{(Na) / (Ca + Mg + K + Na)\} \times 100$$

The soil sample was air dried, sieved and ground into a fine powder. The obtained soil powder was mixed with the solution of Ammonium acetate to extract the exchangeable sodium from soil. Next, the mixture was filtered using a filter paper or a sieve to separate soil particles from the liquid extract. The filtrate was collected in the beaker and used to measure the concentration of sodium using Flame photometer (Schollenberger *et al*, 1930).

Leaf chlorophyll content (mg/g)

Total chlorophyll contents were estimated using 80 per cent acetone as per the method suggested by Arnon (1949). The nitrogen content in soil samples was estimated by Micro-Kjeldhal (Piper, 1966) and the mean values expressed in percentage. The potassium content in soil samples was estimated by using Flame Photometer (Piper, 1966) and expressed in percentage.

RESULTS AND DISCUSSION

Banana (*Musa spp*.) plant typically grows in tropical regions and is characterized by large, elongated leaves (Lebot *et al,* 1993). *Musa acuminata* and *Musa balbisiana* are most commonly cultivated species of banana. *Musa acuminata* are slenderer than of cultivated banana, 3-8 m high, 6-25 cm diameter at base and stools moderately. The pseudostem colour is heavily marked with brown or black blotches. Their petiolar canal have erect margin or spreading with serial wings below; not clasping pseudostem. The bract shoulder is usually high and the bracts roll back after opening. In male flower, the free tepal is variably corrugated below the tips, about half as long as compound tepal. The seeds of this species are dull black in colour, minutely tuberculate.

Musa balbisiana are robust, 6-7 m high, 7-30 cm diameter at base and stools freely. The pseudostem colour is predominantly green or yellowish green, often with black blotches in upper part. Their petiolar canal have enclosed margin, not winged below with clasping pseudostem. The bract shoulder is usually low with lifted bracts but they are not rolled back like *Musa acuminata.* In male flower, the free tepal is rarely corrugated. About boat shaped, obtuse or truncate at base, about half as long as compound tepal. The seeds are black in colour, irregularly globose, minutely warty such that they are 5-6 cm in size across and 4-5 mm high.

Bunch weight

In a breeding programme, yield is one of the most important traits by which a genotype or variety will be evaluated. In banana, varieties with more fruits/fingers in a bunch are generally preferred, as it generates more yield in given area. The variation in bunch weight was high under the experimental field conditions. Sodic soil significantly reduced the phenological characters

Fig. 2. Yield characters of the germplasm/varieties

(Abdel, 2011). From the germplasm/varieties studied, Udhayam (T6), Kaveri Saba (T4) and Karpooravalli (T8) was high (Fig. 2) had the genome ABB, where the plants have thick pseudostem and can withhold heavy bunch amidst adverse weather conditions due to their clasping nature of pseudostem. The treatments such as CO2 (T3) and Ney Poovan (T10) gave minimum yield among all the treatments, with ABB as their genome (Table 2). AB genome species have relatively weak pseudostem, which makes the plant vulnerable to adverse climatic conditions.

Average yield per hectare

The average yield per hectare was greatly influenced by the nutritional and environmental factors available in experimental field. Sodic soil, drastic reductions in yield of wheat occurred at EC less than 4 dS/m in Na sensitive cultivars (Choudary *et al,* 1996). The species of *Musa balbisiana*, having a shorter pseudostem can withhold bunches with more weight during adverse climatic conditions, which reduces the loss occurring through the breaking of pseudostem . Thus, the yield observed was maximum in the cultivars having ABB genome in them, such as Udhayam (T6), Kaveri Saba (T4) and Karpooravalli (T8) Table 2. *Musa acuminata* clones are considered sensitive to sodic soil (Israeli *et al*, 1986). The general ranking of the banana varieties for salt tolerance was FHIA -1 > Saba > Karpooravalli > Bangrier > Ash Monthan > Veneetu Mannan > Udhayam. A comparative field trial for the 15 banana varieties showed that Saba, FHIA -1 and Karpooravalli could withstand sodic conditions in the field in terms of bunch characteristics, biochemical parameters and plant growth. Grand Naine, Rasthali and CO 1 were vulnerable to sodicity stress. Regardless of cultivar, sodicity stress increased the days needed for shooting and harvest (Nithya Devi *et al*., 2024).

Number of Hands

Fruit set number greatly determines the weight of the banana bunch and its efficient market value.

Table 2. Number of fingers, finger length ,finger breadth , Bunch weight, yield and number of hands in a bunch of Germplasm/varieties.

Sr. No.	Germplasm/ Varieties	Number of Fingers in bunch	Finger Length (cm)	Finger Breadth (cm)	Bunch weight (Kg)	Average yield per ha (kg/ha)	Number of Hands in a bunch
T1	Kaveri Kalki	57	9.8	4.6	8.8	28.52	7
T2	Adukku Monthan	39	11	5.3	8.4	27.21	5
T3	CO_2	44	10.6	4	6.3	20.41	4
T4	Kaveri Saba	50	12	4.8	10.3	33.37	6
T5	Monthan	42	10.4	5	7.2	23.33	6
T6	Udhayam	65	11.8	5.4	11	35.64	8
T7	Poovan	38	11.3	4.7	7.6	24.63	5
T8	Karpooravall	61	10.2	5.2	9.8	31.75	7
T9	KaveriHaritha	36	8.9	3.9	7.5	24.30	4
T10	Ney Poovan	35	9.3	4.3	5.9	19.11	4
T11	Vayal Vazhai	38	8.3	4.9	6.7	21.71	5
SEd =		1.13	0.29	0.29	0.18	0.6124	0.12
CD(P=0.05)		3.22	0.83	0.83	0.51	1.74	0.35
CV% =		3.02	3.19	3.19	2.74	2.85	2.78

The Number of hands in a banana bunch is mainly determined by environmental factors, such as climatic conditions and cultural practices, along with the genetic factors related to the variety or cultivars. The germplasm/varieties like Udhayam, Kaveri Kalki and Karpooravalli showed maximum number of hands. The minimum number of hands was observed in CO2 (T3), Kaveri Haritha (T9) and Ney Poovan (T10) Table 2. In the sodic soil condition, the germplasm/variety with ABB genome *i.e., Musa balbisiana* species performed well and produced more hands than the other species.

Fingers in bunch

Fingers in a bunch vary in a bunch depending on the factors such as the specific cultivar, growing conditions, and other factors. Among the germplasm/varieties observed in the experimental field, the maximum number of fingers was observed in Udhayam (T6) and Karpooravalli (T8) Table 3. The genetic characteristics for these varieties may be the major reason for more fingers in a bunch, when compared to the variety like Ney Poovan, having minimum fingers with different characteristics.

Finger length

Banana's finger length varies within each species, depending on specific cultivar or variety. In sodic soil condition, the *Musa balbisiana* species tend to show large finger length than the *Musa acuminata* cultivars. Similar report was done by (Ravi *et al,* 2014). The varieties such as Udhayam (T6), Adukku Monthan (T2) and Karpooravalli (T8) showed only slight variation between them, in term of length, while minimum finger length was observed in CO2 (T3) and Ney Poovan (T10) when all the 11 germplasm/varieties compared.

Finger breadth

The breadth of banana fingers, when observed is usually high in the *Musa balbisiana* species. The maximum size was observed in Udhayam (T6), Adukku Monthan (T2), Karpooravalli (T8) and Vayal Vazhai (T10), other remaining treatments shows comparatively shorter finger breadth size.

Physiological and Biochemical Analyses:

Table 3. Chlorophyll content analysed for the Germplasm/varieties

Sr.No.	Germplasm/Varieties	Chlorophyll content (mg/g of leaf sample)
T1	Kaveri Kalki	0.2879
T2	Adukku Monthan	0.0171
T3	CO_2	0.0350
T4	Kaveri Saba	0.0146
T5	Monthan	0.0440
T6	Udhayam	0.4281
T7	Poovan	0.2533
T8	Karpooravalli	0.1897
T9	Kaveri Haritha	0.3920
T10	Ney Poovan	0.3643
T11	Vayal Vazhai	0.0834
SEd =		0.0032
CD(P=0.05)		0.0092
CV% =		7.40

Soil pH

The soil sample from the experimental field recorded a pH value of 7.43. Among the two *Musa spp., Musa balbisiana* was found to be more suitable for sodic soil condition. As they are tropical in habitat, have adapted to thrive in alkaline soil with high level of nutrient availability. Rengasamy (2006) reported in Australia, soils with ESP between 6 and 14 are designated as sodic while those having ESP>15 are classified as strongly sodic. Rajkishore Kumar *et al*. (2017) also reported land characterization and soil-site suitability- evaluation of banana growing areas of South Gujarat, India.

Soil EC

The recorded EC for the sample from experimental field is 1.20 dS/m. It showed relatively low concentration of other minerals (calcium, potassium and magnesium) in the soil, which still may cause some detrimental effects on the plants. Improper salt concentration leads to poor soil structure, reduced water infiltration and increased surface runoff.

Exchangeable Sodium Percentage (ESP)

An ESP of 16.65%, which is relatively high was obtained through the experiment. High level of exchangeable sodium may lead to the reduction of other minerals in soil. It is primarily due to the competition between sodium ions and other cations for the uptake by plant roots. Elevated sodium levels can indirectly affect magnesium availability to plants. Its accumulation at the root zone causes increased osmotic stress, which can inhibit magnesium uptake (Choudhary *et al,* 1996).

Chlorophyll content

Sodic soil condition can induce chlorosis condition in plants, where the leaves turn yellow due to a lack of chlorophyll. Chlorophyll is essential for photosynthesis, whose reduction in plant hampers the ability to photosynthesize effectively, leading to reduces growth and productivity. Xiao-tang Yang *et al*. (2009). Banana varieties Udhayam (T6) and Kaveri Haritha (T9) showed high chlorophyll content (*Musa balbisiana spp*.), showing the presence of healthy greenish leaves on the plants, compared to other treatment germplasm/varieties (Table 4).

Available nitrogen in soil

The analysis recorded a low-level availability of nitrogen in sodic soil conditions which may lead to stunted growth as deficiency of nitrogen can lead to slow or stunted growth, along with yellowing of leaves, reduced fruit production and poorly developed roots.

Available potassium in soil

Recorded value for available potassium was low in level and the low potassium level may lead to visible symptoms like leaf discoloration and necrosis, reduced growth, decreased yield and

increased susceptibility to pests and diseases. These effects may lead to development of unfavorable appearance on the fruit and leaves, decreasing its market value (Jeyabhaskaran, 2000).

CONCLUSION

The results of the study conducted that among the 11 treatments screened, the highest bunch weight and highest yield per hectare were recorded for the genotypes Udhayam (T6) followed by Kaveri Saba (T4) and Karpooravalli (T8). Highest number of hands was recorded for the genotypes Udhayam (T6) followed by Kaveri Kalki (T1) and Karpooravalli (T8). Maximum number of fingers in a bunch was recorded by the germplasm Udhayam (T6) and Kaveri Kalki (T1). Regarding the finger length and finger breadth maximum recorded in Udhayam (T6) and Kaveri Saba (T4). The pH for the soil sample taken from the experimental field was found to be 7.43, which is slightly alkaline in nature. The Electrical conductivity (EC) of the soil sample of the experimental field was found to be 1.20 dS/m, which indicated low concentration of other minerals in the soil. The exchangeable sodium percentage (ESP) for the soil sample was found to be 16.65%, which is relatively high in concentration. Among the 11 germplasm/varieties screened, the maximum chlorophyll concentration was recorded in Udhayam (T6), followed by Kaveri Haritha (T8). The available nitrogen in soil was recorded to be 78.4 kg/ha, which was considered to be low based on the rating of soil in available nitrogen range. The available potassium in soil was recorded to be 56.67 kg/ha, which as per the range of potassium presence in soil, found to be low in concentration .The germplasm/varieties having the *Musa balbisiana* genome were found to perform well under the sodic soil conditions, when compared to the *Musa acuminata* species due to their physiological characteristics to survive under adverse climatic conditions.

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