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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/ varieties i.e., Kaveri Kalki (ABB), Adukku Monthan (ABB), CO_2 (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 (T_6) recorded high bunch weight, followed by Kaveri Saba (T_4) and Karpooravalli (T_8). From the above study the germplasm/varieties having the *Musa balbisiana* genome are 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 : Screening, Banana, Germplasm, Sodic soil, Soil pH, Soil EC, Exchangeable Sodium Percentage.

Introduction

The banana is considered to be one of the most important cultivated tropical fruits in India. Origin of Tropical regions of South East Asia (Assam, Burma and Indo-China region). Banana (*Musa* spp.) belongs to the family Musaceae. Banana is the leading fruit crop in tropical and subtropical regions of the world. It is the second most important fruit crop of India. Banana is one of the oldest fruit known to mankind and also important food for man. It is one of the oldest and commonest of the Indian fruit that has been cultivated since ancient times. It may be one of the reasons why banana is called "Apple of Paradise" and botanically named *Musa paradisiaca*. 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). It is used as staple fruit in most of the African countries and is used as ripe (table) or raw fruit (cooking). 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'. This is the fruit for all ages and it is a good laxative. It is one of the fruit among 'Mukkani' or Triplet fruits, comes last (Ma-pala-vazhai). It is equally suitable both for large scale cultivation as well as for home scale cultivation.

Most of the present day edible banana varieties have originated from the two species *viz.*, *Musa acuminate* and *Musa balbisiana*.

The notation of 'genome' was 'A' for acuminata and 'B' for balbisiana as suggested by Simmonds and Shepherd (1955) as a key to the classification. 'A' represent, acuminata genome with 11 chromosomes from *M. acuminata*. While, 'B' represents genome with 11 chromosome from *M. balbisiana*. Names of banana varieties are often confused by local synonyms.

AA - Matti, Sana Chenkadali, Namarai (Diploid acuminata types)

AAA - Gross Michel, Grand Naine, Dwarf Cavendish, Robusta & Red banana (Triploid acuminata types)

AAAA - Bodles Alta fort (Tetraploid acuminata)

AB - Ney poovan, Kunnan (Diploid mixed)

AAB - Poovan, Rasthali, Hill Banana, Ladan, Nendran (Triploid mixed)

ABB - Monthan, Karpura valli (Triploid mixed)

ABBB - Klue taperod (Tetraploid mixed)

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 on ‘‘Evaluation of banana germplasm under sodic soil” has been undertaken with the following objectives:

- To assess the variations in yield and fruit quality of banana germplasm/varieties.
- To assess the physiological and biochemical activities of banana germplasm/varieties.
- To identify the salt tolerant genome in banana germplasm/varieties.

Materials and Methods

The different materials were briefed in Table 1.

Table 1 : Treatment details of Banana germplasm/varieties.

Treatment	Germplasm/ Varieties	Genome
T_1	Kaveri Kalki	ABB
T_2	Adukku Monthan	ABB
T_3	CO_2	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

Experiment site

The experiment was conducted at Horticultural College and Research Institute for Women, Trichy during 2022-2023. The experiment was laid out in a Randomized Block Design with 11 treatments combinations

Yield characters

The chief characteristic of sodic soils from the agricultural stand point is that they contain sufficient exchangeable sodium to adversely affect the growth of most crop plants. For the purpose of definition, sodic soils are those which have an exchangeable sodium percentage (ESP) of more than 15. Excess exchangeable sodium has an adverse effect on the physical and nutritional properties of the soil, with consequent reduction in crop growth, significantly or entirely.

Bunch weight (kg)

A Banana bunch refers to a cluster or group of bananas that grow together on a single stem or stalk, which are harvested at one time as a collective unit. For the 11 germplasm/varieties planted in the field, plants are selected randomly and an average weight of the bunch is recorded for each germplasm/variety using a weighing machine.

Average yield per hectare (t/ha)

The average yield per hectare (ha) refers to the average amount of production obtained in banana from a hectare of land. This is a measurement commonly used in agriculture to evaluate the productivity and efficiency of land usage. It calculates the total output or yield divided by the total area of land, providing an average representation of the productivity per hectare.

Average yield = Total yield / Plant population in a hectare of land

Number of hands

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 is taken from them.

Number of fingers in a bunch

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.

Finger length (cm)

The length of the banana fingers was measured using


Plate 1 : Banana germplasm/varieties in experiment field.

a measuring tape and an average value of randomly selected fingers from a bunch is taken as the length value.

Finger breadth (cm)

The breadth of each germplasm/variety is 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 are taken randomly from sodic soil area and all the impurities are 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 it is 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. Poentiometry (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 deciSiemens per meter (dS/m) or milliSiemens per meter (mS/m).

The soil sample is collected and air dried at room temperature. It is then sieved to remove the debris present in the sample. The sieved soil is 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 is measured (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 = Exchangeable {(Na) / (Ca + Mg + K + Na)} × 100

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

Leaf chlorophyll content (mg g^{-1})

Total chlorophyll contents were estimated using 80 per cent acetone as per the method suggested by Arnon (1949).

Nitrogen content

The nitrogen content in soil samples was estimated by Micro-Kjeldhal (Piper, 1966) and the mean values expressed in percentage

Potassium content

The potassium content in soil samples was estimated by using Flame Photometer (Piper, 1966) and expressed in percentage.

Results and Discussion

Banana (*Musa* spp.) was a tropical fruit that belongs to the family of Musaceae. Banana plant typically grows in tropical regions and is characterized by large, elongated leaves (Lebot and Aradhya, 1993). Bananas are rich in Potassium, fiber and vitamin C, making them an excellent choice for promoting good heart health and digestion. Sodic soil possesses high levels of sodium, which

adversely affects plant growth and development in banana. Hence, conducting germplasm screening is crucial for assessing the banana germplasm/variety's tolerance and adaptability to sodic soil conditions, to enhance banana production and its contribution sustainable banana industry.

Species

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 inclosed 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.

Table 2 : Bunch weight, yield and number of hands in a bunch of Germplasm/varieties.

S. no.	Germplasm/ Varieties	Bunch weight (kg)	Average yield per ha(t/ha)	Number of Hands in a bunch
T_1	Kaveri Kalki	8.8	28.52	7
T_2	Adukku Monthan	8.4	27.21	5
T_3	CO_2	6.3	20.41	4
T_4	Kaveri Saba	10.3	33.37	6
T_5	Monthan	7.2	23.33	6
T_6	Udhayam	11	35.64	8
T_7	Poovan	7.6	24.63	5
T_8	Karpooravalli	9.8	31.75	7
T_9	Kaveri Haritha	7.5	24.30	4
T_{10}	Ney Poovan	5.9	19.11	4
T_{11}	Vayal Vazhai	6.7	21.71	5
SEd =		0.18	0.6124	0.12
CD(P=0.05)		0.51	1.74	0.35
CV% =		2.74	2.85	2.78

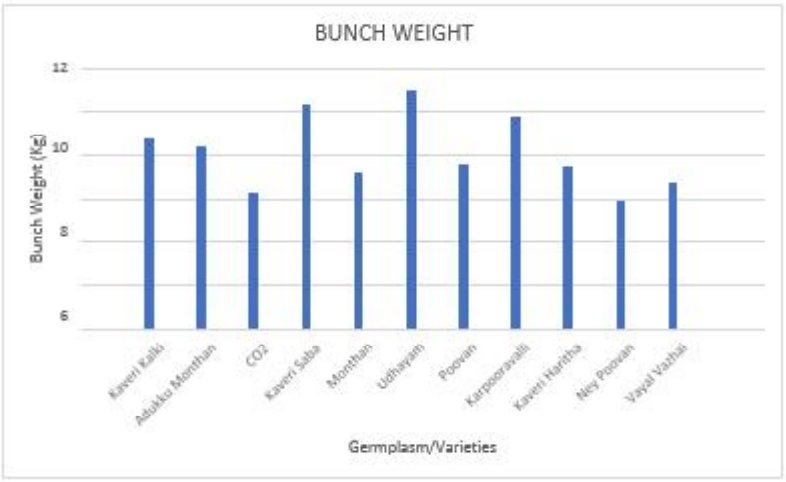

Fig. 1 : Bunch weight recorded for the Germplasm/Varieties.

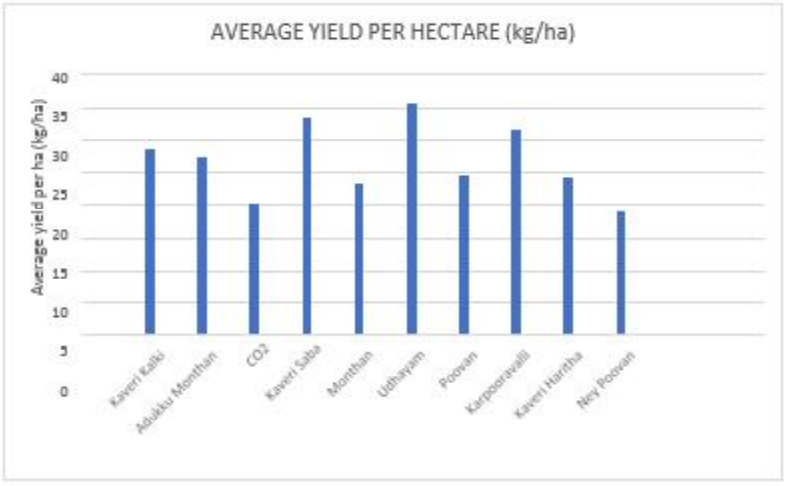

Fig. 2 : Average yield per heactare calculated for the germplasm/varieties.

Yield characters

Different germplasm/varieties of banana may have different yield potentials. Some varieties have been developed and selected specifically for high yield, larger fruit sizes and large bunches with more fruits per bunch with high fruit quality.

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 is high under the experimental field conditions. Sodic soil significantly reduced the phenological characters (Abdel Latef, 2011).

Plate 2 : Yield characters of the germplasm/varieties.

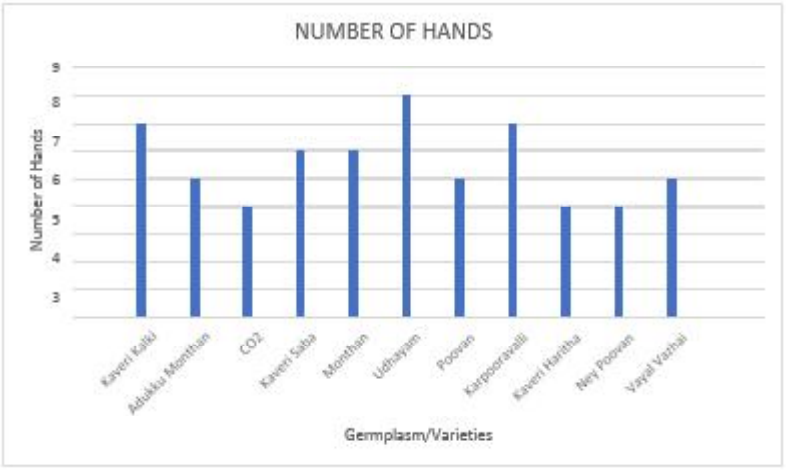

Fig. 3 : Number of hands observed in the Germplasm/Varieties.

Table 3 : Number of fingers, finger length and finger breadth of Germplasm/varieties.

S. no.	Germplasm/ Varieties	Number of fingers in bunch	Finger length (cm)	Finger breadth (cm)
T_1	Kaveri Kalki	57	9.8	4.6
T_2	Adukku Monthan	39	11	5.3
T_3	CO_2	44	10.6	4
T_4	Kaveri Saba	50	12	4.8
T_5	Monthan	42	10.4	5
T_6	Udhayam	65	11.8	5.4
T_7	Poovan	38	11.3	4.7
T_8	Karpooravalli	61	10.2	5.2
T_9	Kaveri Haritha	36	8.9	3.9
T_{10}	Ney Poovan	35	9.3	4.3
T_{11}	Vayal Vazhai	38	8.3	4.9
SEd =		1.13	0.29	0.29
CD(P=0.05)		3.22	0.83	0.83
CV% =		3.02	3.19	3.19

From the germplasm/varieties studied, the treatment of Udhayam (T_6), Kaveri Saba (T_4) and Karpooravalli (T_8) is high (Fig. 1, Plate 2). These varieties have 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 CO_2 (T_3) and Ney Poovan (T_{10}) have 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 (T_6), Kaveri Saba (T_4) and Karpooravalli (T_8) (Fig. 2, Table 2). *Musa acuminata* clones are considered sensitive to sodic soil (Israeli *et al*., 1986).

Number of Hands

Fruit set number greatly determines the weight of the banana bunch and its efficient market value. 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 shows maximum number of hands (Fig. 3.). The minimum number of hands was observed in CO_2 (T_3), Kaveri Haritha (T_9) and Ney Poovan (T_{10}) (Table 2). In the sodic soil condition, the germplasm/variety with ABB genome *i.e.*, *Musa balbisiana* species performs well and produces 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 (T_6) and Karpooravalli (T_8) (Fig. 4 and 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 (T_6), Adukku Monthan (T_2) and Karpooravalli (T_8) shows only slight variation between them, in term of length (Fig. 5.), while minimum finger length was observed in CO_2 (T_3) and Ney Poovan (T_{10}) when all the 11 germplasm/varieties are compared (Table 3).

Finger breadth

The breadth of banana fingers, when observed is usually high in the *Musa balbisiana* species. The maximum size was observed in Udhayam (T_6), Adukku Monthan (T_2), Karpooravalli (T_8) and Vayal Vazhai (T_{10}) (Fig. 6.), Other remaining treatments shows comparatively shorter finger breadth size (Table 3).

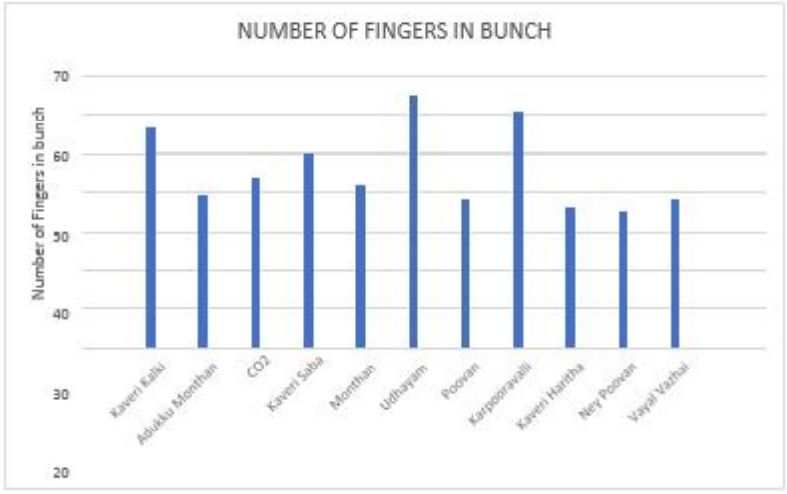

Fig. 4 : Number of Fingers in a bunch observed in the germplasm/varieties.

Table 4 : Chlorophyll content analysed for the Germplasm/varieties.

S. no.	Germplasm/varieties	Chlorophyll content (mg/g of leaf sample)
T_1	Kaveri Kalki	0.2879
T_2	Adukku Monthan	0.0171
T_3	CO2	0.0350
T_4	Kaveri Saba	0.0146
T_5	Monthan	0.0440
T_6	Udhayam	0.4281
T_7	Poovan	0.2533
T_8	Karpooravalli	0.1897
T_9	Kaveri Haritha	0.3920
T_{10}	Ney Poovan	0.3643
T_{11}	Vayal Vazhai	0.0834
SEd =		0.0032
CD(P=0.05)		0.0092
CV% =		7.40

Physiological and Biochemical Analyses

Soil pH : The soil sample from the experimental field recorded a pH value of 7.43. Among the two *Musa* spp., *Musa balbisiana* is found to be more suitable for sodic soil condition. As they are tropical in habitat, they 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'.

Soil EC : The recorded EC for the sample from experimental field is 1.20 dS/m. It shows 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 is obtained through the experiment.

Soils with ESP between 6 and 14 are designated as sodic while those having ESP>15 are classified as 'strongly sodic' (Rengasamy, 2006).

This high level of exchangeable sodium may lead to the reduction of other minerals in soil. It

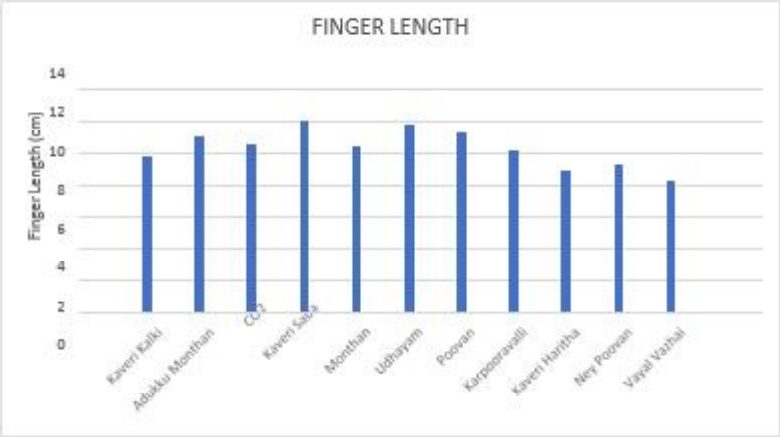

Fig. 5 : Finger Length measured for the Germplasm/Varieties.

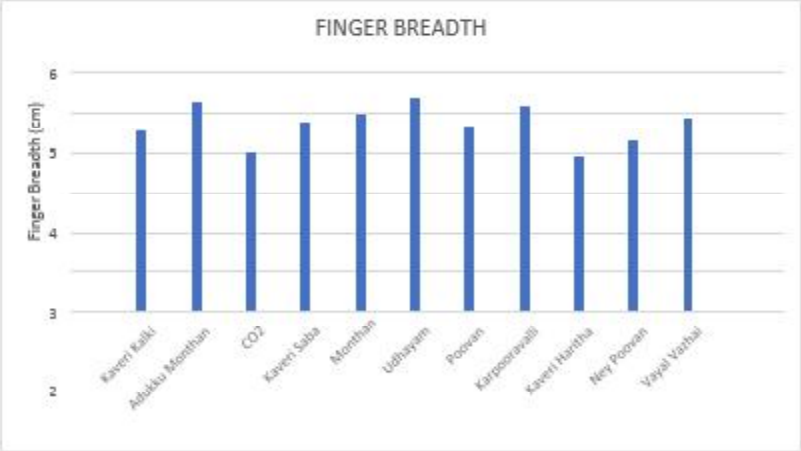

Fig. 6 : Finger Breadth measured for the Germplasm/Varieties.

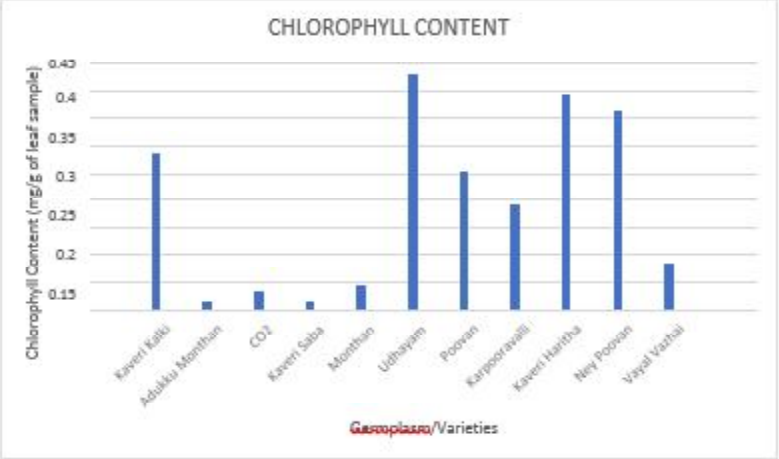

Fig. 7 : Chlorophyll content measured using the Spectrophotometer for all the 11 Germplasm/Varieties.

is primarily due to the competition between sodium ions and other cations for the uptake by plant roots. High sodium levels in soil reduces the uptake of calcium by plant roots by competing for binding sites, leading to calcium deficiency and with respect to potassium the high sodium concentration inhibits the absorption of potassium by plant roots, disrupting the most primary mechanisms in plants. 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) reported that the yield loss under sodicity varies with the extent of the increase in pH and ESP.

Chlorophyll content

Total chlorophyll content influences the photosynthetic rate and thereby the efficiency of the plants in assimilates production. Hence, Measurement of total chlorophyll content (Table 4) indirectly indicates the efficiency of the photosynthesis and photosynthates production (Fig. 7.). The total chlorophyll content was reduced with levels of sodicity. Yang *et al*. (2009) said that decrease in chlorophyll level under salt stress may be due to reduction in pigment biosynthesis or enzymatic chlorophyll degradation.

Banana varieties Udhayam (T_6) and Kaveri Haritha (T_9) shows 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 is 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 on "Identification of banana germplasm under sodic soil" during the period 2022-2023. Finally we can concluded that among the 11 treatments screened, the highest bunch weight and highest yield per hectare were recorded for the genotypes

Udhayam (T_6) followed by Kaveri Saba (T_4) and Karpooravalli (T_8). Highest number of hands was recorded for the genotypes Udhayam (T_6) followed by Kaveri Kalki (T_1) and Karpooravalli (T_8). Maximum number of fingers in a bunch was recorded by the germplasm Udhayam (T_6) and Kaveri Kalki (T_1). Regarding the finger length and finger breadth maximum recorded in Udhayam (T_6) and Kaveri Saba (T_4). The pH for the soil sample taken from the experimental field is found to be 7.43, which is slightly alkaline in nature. The Electrical conductivity (EC) of the soil sample of the experimental field is found to be 1.20 dS/m, which indicates low concentration of other minerals in the soil. The Exchangeable Sodium Percentage (ESP) for the soil sample is 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 (T_6), followed by Kaveri Haritha (T_8). The available nitrogen in soil was recorded to be 78.4 kg/ha, which is 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, is found to be low in concentration. The germplasm/varieties having the *Musa balbisiana* genome are 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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