# SUBSTITUTION OF MURIATE OF POTASH BY COMMON SALT IN BANANA *Musa* (AAA group CAVENDISH subgroup) 'ROBUSTA'

By

SUNU, S.



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**APPROVED BY:**

CHAIRPERSON

**Dr.(Mrs.) C.R. SUDHARMAI DEVI**
Associate Professor
Department of Soil Science & Ag. Chemistry
College of Agriculture, Vellayani.

Sudharmai
3/11/01

MEMBERS

**Dr. V.K. VENUGOPAL**
Professor and Head
Department of Soil Science & Ag. Chemistry
College of Agriculture, Vellayani

3/11/01

**Dr. V.L. GEETHAKUMARI**
Associate Professor
Department of Agronomy
College of Agriculture, Vellayani

3/11/01

**Dr. K. HARIKRISHNAN NAIR**
Associate Professor and Head
Instructional Farm
College of Agriculture, Vellayani

EXTERNAL EXAMINER

**Dr. K. KUMARASWAMY**
Professor
Department of Soil Science & Ag. Chemistry
Agricultural College & Research Institute,
Madurai – 625 104

3.11.01

# DECLARATION

I hereby declare that this thesis entitled "**Substitution of muriate of potash by common salt in banana *Musa* (AAA group Cavendish subgroup) 'Robusta'**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani,

18-6-2001

**SUNU .S**

# CERTIFICATE

Certified that the thesis entitled **"Substitution of muriate of potash by common salt in banana *Musa* (AAA group Cavendish subgroup) 'Robusta'"** is a record of research work done independently by **Mrs. Sunu .S.** (98-11-33) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani
18 - 6 - 2001

**Dr. C.R. Sudharmai Devi**
(Chairman, Advisory Committee)
Associate Professor
Department of Soil Science
and Agricultural Chemistry
College of Agriculture,
Vellayani
Thiruvananthapuram

*Dedicated to my beloved*
*parents & husband*

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| B:C | Benefit : Cost |
| cm | Centimeter |
| CS | Common Salt |
| cv. | Cultivar |
| EC | Electrical Conductivity |
| FIB | Farm Information Bureau |
| FYM | Farmyard manure |
| ha | Hectare |
| kg $ha^{-1}$ | Kilogram per hectare |
| LAI | Leaf area index |
| $m^2$ | square meter |
| MAP | Months after planting |
| mg | Milligram |
| MOP | Muriate of potash |
| MSL | Mean sea level |
| POP | Package of Practices |
| RLWC | Relative leaf water content |
| t | Tonnes |
| TSS | Total Soluble Solids |
| WHC | Water Holding Capacity |
| % | Per cent |

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# INTRODUCTION

# 1. INTRODUCTION

Potassium is the most abundant cation in the tissues of higher plants making up about 1.7 to 2.7 per cent of the dry matter of normal leaves (Evans and Sorger, 1966). Although potassium does not form part of the structure of plant constituents, it regulates many vital functions like carbon assimilation, translocation of proteins and sugars and water balance in plants thereby maintaining turgor pressure in the cell. It is known to improve quality of fruits by maintaining desirable sugar/acid ratio, ripening of fruit and many other physiological processes. Thus K is recognised as the key element in crop nutrition, the effect of which being manifested equally on the quantitative and qualitative aspects of the crop.

Banana is a leading tropical fruit in the world market and is one of the most important fruit crops of Kerala. In Kerala, an area of 78079 ha is being cultivated with banana and other plantains with an annual production of 647888 tonnes (FIB, 2001). Banana fruit is a rich source of starch, minerals and vitamins. It can be used for dessert as well as culinary purposes. Robusta is a dessert variety of banana.

Banana has a high K requirement, higher than that of any other crop. Hence there is a high demand for the supply of K fertilizers. But K fertilizers are expensive in India, as all the K fertilizers are imported from other countries. It will be highly economical if any other indigenous fertilizer can be used atleast as a partial substitute for K.

Here comes the need for research works using Na as a substitute for K. Several research works in this line indicate that Na of common salt can substitute K of MOP atleast partially (George, 1995; Devi, 1995 and Lekshmi, 2000). Common salt as a partial substitute for MOP saves a part of the cost of K fertilizers. Total cost of K fertilizer as MOP for Robusta banana is estimated to be about Rs. 3500 $ha^{-1}$(POP recommendations 1998).

Na can replace K to a large extent in some non-specific functions in the vacuole. This replacement within the vacuole makes K available for its specific functions in the plant cell (Leigh and Wyn Jones, 1984). Under limited K supply, Na performs some of the normal functions of K such as maintenance of ionic balance necessary for physiological processes (Tisdale *et al.*, 1992).

In fruit crops, only few research works have been conducted on the use of Na as a substitute for K. Hence this study was undertaken with the following objectives:

1) To find out whether substitution of K of MOP by Na of CS is possible in banana cv. Robusta.

2) If possible, to determine the extent of substitution possible to obtain maximum yield without affecting the quality.

3) To find out the economics of cultivation by the use of CS as a substitute for MOP.

# REVIEW OF LITERATURE

# 2. REVIEW OF LITERATURE

Potassium is the only univalent cation generally indispensible for the growth of all plants. Banana is well known for its water and nutrient exhaustive nature. It has a high requirement for K and N (Norris and Ayyar, 1942). Importance of K in banana nutrition has been emphasised by many scientists. Na, another univalent cation is found to have beneficial effects on the growth of many plants. The beneficial effect of Na has been explained as a sparing action of K through redistribution of K from places of abundance to those of deficiency. The effect of substitution of K by Na at various levels is investigated in this study. Literature pertaining to the effect of K and Na on various plant growth and yield parameters of different crops is reviewed in this chapter.

## 2.1 Growth characteristics

### 2.1.1 Plant height and growth

#### 2.1.1.1. Influence of Potassium

Yang and Pao (1962) observed that the height of plant was not significantly increased by increased doses of potash. But in a greenhouse study with Grosmichel banana, Medina and Lopez (1967) found that high K favoured better plant development. Jambulingam *et* *al.* (1975) in an experiment with banana cv. Robusta, noticed that the height and girth of pseudostem increased as the K application to the soil increased. Studies on K nutrition in rainfed banana cv. Palayankodan by Sheela (1982) revealed that height of pseudostem at late vegetative stage and shooting stage increased significantly when K supply was increased from 0-600 g $plant^{-1}$ in graded doses.

Baruah and Mohan (1985) observed that height and girth of pseudostem increased significantly with K application in banana cv. Jahaji. In studies with banana cv. Umalag, Fabregar (1986) reported that girth of pseudostem increased with increasing rate of K application upto 800 kg $ha^{-1}$. Mustaffa (1987) and Oubahou and Dafiri (1987) also recorded similar results.

A positive correlation between the highest level of K (320 g $K_2O$ per plant) and the height and the basal circumference of the pseudostem in banana cv. Dwarf Cavendish was reported by Khoreiby and Salem (1991).

**2.1.1.2 Influence of Sodium**

Gammon (1965) in an experiment on pangola grass observed that Na can substitute for two–third of potassium requirement without causing an appreciable reduction in growth. Sodium when present upto 2.4 per cent of dry weight caused no reduction in growth rate in tomato plants (Besford, 1978). Indira (1978) in an experiment on cassava with 0 – 4000 ppm NaCl found that retardation of plant growth and tuber initiation occurred at 2000 ppm and above levels of NaCl.

Nabil and Coudret (1995) while studying the effect of NaCl on the growth of *Acacia nilotica* plants observed that upto 100 mM NaCl concentration, plants were healthy and actively growing. However, decrease in growth occurred at higher salinity.

In sweet potato, maximum length of vine was produced when 50 per cent of K was substituted by Na (George, 1995). Devi (1995) observed that the growth in cassava was maximum when 50 per cent K as MOP was replaced with Na of common salt.

A field experiment with Robusta banana conducted by Palaniappan and Yerriswamy (1996) showed that irrigation with saline water of EC 5 $dSm^{-1}$ significantly reduced the growth of banana.

In rice, negative correlation coefficient was recorded between the NaCl concentrations and relative values of plant height (Khan *et al.*, 1997).

Sharma (1997) observed a reduction in plant growth with increase in salinity. With increase in salinity, a reduction in cane length was observed in sugar cane plants by Sharma *et al.* (1997).

In pigeon pea, Karikalan *et al.* (1999) observed that NaCl stress inhibited the root and shoot length of plants.

Lekshmi (2000) observed that the plant height in banana cv. Nendran was maximum in flowering and harvest stages when 50 per cent of K was substituted with Na. But beyond 50 per cent substitution, plant height decreased.

### 2.1.2 Number of leaves and Phyllochrone

#### 2.1.2.1 Influence of Potassium

No significant increase in the number of functional leaves by the application of K was observed by Yang and Pao (1962) in 'Fairyman' banana. Ho (1968) reported that application of K at the early stage produced more number of leaves in banana cv. Fairy man.

An increase in number of leaves with higher levels of K application in banana cv. Palayankodan was observed by Sheela (1982). Similarly Baruah and Mohan (1985) recorded the highest number of leaves in banana cv. Jahaji at 340 g $K_2O$ $plant^{-1}$.

Significant increase in the number of leaves in banana cv. Dwarf Cavendish by the application of K was reported by Chattopadhyay and Bose (1986). The number of leaves produced was higher when 400g $K_2O$ $plant^{-1}$ was applied (Mustaffa, 1987).

George (1994) and Parida *et al.* (1994) observed an increasing trend on the total number of leaves and the number of functional leaves in banana cv. Nendran and cv. Robusta respectively with increase in K levels.

**2.1.2.2 Influence of Sodium**

Prema *et al.* (1987a) observed increased number of leaves in coconut palm when 50 per cent K was substituted with Na. In tuberose, the number of leaves was found to decrease with increase in the concentration of NaCl from 6000 to 10,000 ppm (Malini and Khader, 1989).

Gupta and Srivastava (1989) while studying the effect of salt stress on morphophysiological parameters in wheat, reported reduction in leaf number with salt stress. Reduction in leaf number with increase in NaCl concentration was also reported by several authors (Yaseen *et al.* (1989) in barley, Yang *et al.* (1990) in sorghum, Ibrahim *et al.* (1991) and Mangal *et al.* (1993) in potato, Valia *et al.* (1993) in passion fruit, Nabil and Coudret (1995) in *Acacia nilotica*, Sharma (1997) in chickpea and Sharma *et al.* (1997) in sugarcane.

Contrary to the above findings, George (1995) observed that in sweet potato, 50 per cent substitution of K by Na produced more number of leaves.

Devasenapathy *et al.* (1996) while studying the effect of NaCl nutrition in coconut found that NaCl @ 1 kg $tree^{-1}$ $year^{-1}$ along with the recommended dose of NPK significantly increased the number of functional leaves produced.

In *Eucalyptus camaldulensis* and *Dalbergia sissoo*, salinity treatments induced significant variation in leaf number, which generally increased under lower salt levels but decreased under higher salt levels (Rawat and Banerjee, 1998).

During vegetative and flowering stages there was maximum number of leaves when 50 per cent K was substituted with Na of CS in banana cv. Nendran (Lekshmi, 2000). At harvest stage, 25 per cent substitution of K with Na recorded maximum number of leaves.

### 2.1.3 Leaf Area Index

#### 2.1.3.1 Influence of Potassium

There are several reports which show the importance of K in enhancing the LAI. Jambulingam *et al.* (1975) reported that higher doses of $K_2O$ significantly increased the leaf area in 'Robusta' banana. In Dwarf Cavendish banana, significant increase in leaf area was noted with increasing rate of K upto 750g $plant^{-1}$ by Ramaswamy *et al.* (1977).

Turner and Barkus (1980) observed 20 per cent reduction in total leaf area in banana at low levels of K. There was significant difference in the LAI at 6 MAP and at the shooting stage in banana cv. Jahaji due to K application (Baruah and Mohan, 1985).

Kohli *et al.* (1985) and Mustaffa (1987) recorded significant increase in leaf area and LAI in banana cv. Robusta at 250g and 400g

$K_2O$ plant$^{-1}$. However, Singh *et al.* (1990) could not observe any increase in LAI in Dwarf Cavendish banana with K application.

### 2.1.3.2 Influence of Sodium

Draycott and Farley (1971) and Durrant *et al.* (1978) observed an increase in LAI in sugar beet by Na application under irrigated conditions.

The length and width of leaves of carrot and radish were found to decrease with increase in salinity of the growth medium (Maliwal and Paliwal, 1979). Confirmatory observations were reported by Kayani and Rahman (1988) in maize, Yaseen *et al.* (1989) in barley and Gupta and Srivastava (1989) in wheat.

Yang *et al.*(1990) showed that in *Sorghum bicolor* and *Sorghum halepense,* leaf area was reduced by increasing concentration of NaCl in the growth medium. Similar results have been reported by Pezeshki and Pan (1990) in rice, Ibrahim *et al.* (1991) in coleus and Valia *et al.* (1993) in passion fruit.

In a study conducted to study the effect of NaCl on growth of *Acacia nilotica* subspecies it was found that high salinities above 100mM NaCl decreased the leaf area (Nabil and Coudret, 1995).

Devi (1995) in an experiment conducted to study the possibility of substitution of K by Na, reported that at all stages of growth, K and Na at equal concentrations recorded maximum LAI in cassava. With increase in the level of substitution, a general reduction in LAI was noted.

Sharma (1997) noticed a reduction in leaf area of chickpea when exposed to higher salinity. Similar results were reported by Sharma *et al.* (1997) in sugarcane, Pardossi *et al.* (1998) in *Apium graveolens* and Karikalan *et al.* (1999) in pigeon pea.

In banana cv. Nendran, Lekshmi (2000) recorded maximum LAI at all growth stages by the substitution of 50 per cent of K with Na of common salt. Further increase in substitution showed reduction in LAI.

**2.1.4 Relative Water Content in Leaves**

**2.1.4.1 Influence of Potassium**

Potassium is known to play important role in improving water use efficiency of plants. K is essential for proper stomatal movements, thereby regulating the water economy inside the plant cell.

Blanchet *et al.* (1969) and Brag (1972) observed that K application lowered the transpiration rate and improved the water use efficiency of plants. In cowpea seedlings, the relative water content was found to be high in K enriched plants (Sastry, 1982).

**2.1.4.2 Influence of Sodium**

A decreasing trend in leaf water potential due to soil salinity has been observed by Dutt (1988) in barley plants at ear emergence and grain filling stages. Nejad (1988), Onkware (1990) and Flowers *et al.* (1991) also observed that leaf water content had negative correlation with Na concentration.

In *Vigna mungo*, Ashraf (1989) observed that the water content of leaves was increased by salinity. Similar observations were obtained by Walker (1989) in trials conducted in quandong (*Santalum acuminatum*). Maintenance of leaf water status under saline conditions resulted mainly from increased stomatal closure with a subsequent reduction in leaf transpiration (Ziska and Hutmacher, 1989)

When KCl and NaCl were given in equal concentrations, Lindhaver *et al.* (1990) found that the drop in leaf osmotic potential was less in sugar beet plants. But in experiments conducted by Dhindwal *et al.* (1992), low levels of salinity increased the leaf water potential in barley seedlings. The leaf water content was either maintained or increased with salt treatment in experiment by Legaz *et al.* (1993).

Ashraf (1993) while studying the effect of sodium chloride on water relations in *Melilotus indica* observed that leaf water potential decreased linearly with increasing salt concentration. In cucumber (*Cucumis sativus*), plant water uptake and relative water content were significantly reduced in conditions of high salinity (Al-Harbi and Burrage, 1993).

Guerrier (1996) noticed that in *Lycopersicon pimpinellifolium*, the leaf succulence as well as leaf water content of salinized plants increased significantly. Similarly Pardossi *et al.* (1998) noticed an increase in the leaf water potential in 50 mM NaCl treated plants of *Apium graveolens*. But higher salinity reduced the leaf water potential.

Experiments conducted in cassava by Devi (1995) revealed that when 50 per cent K was substituted by Na, there was a high status of relative water content throughout the growth period.

### 2.1.5 Chlorophyll content

#### 2.1.5.1 Influence of Potassium

Forster (1976) observed that chlorophyll concentration in the leaf of spring wheat increased with the application of K. But in spring barley, Votruba and Kase (1979) observed that increased rates of K application decreased the chlorophyll concentration.

Collins and Duke (1981) could also observe a linear increase in chlorophyll concentration with increased application of K in alfalfa. Increased potassium supply resulted in a positive relationship with chlorophyll content in studies conducted in tobacco (Patil *et al.*, 1987)

#### 2.1.5.2 Influence of Sodium

There are several reports that low levels of salinity has a stimulative effect on chlorophyll production in several plants. Total chlorophyll content in many plants was found to increase as a result of NaCl addition (Parasher and Varma, 1987; Abdullah and Ahmad, 1990 and Dhindwal *et al.*, 1992). But negative response has also been reported by many scientists (Pandey and Saxena, 1987; Ashraf, 1989; Legaz *et al.*, 1993)

Ohta *et al.* (1987) found that the chlorophyll content per unit leaf area increased markedly in leaves of *Amaranthus tricolor L.* plants when Na was added to the nutrient culture medium. Ando and Oguchi (1990) opined that chlorophyll content increased because Na takes part in chlorophyll synthesis.

But Gupta and Srivastava (1989) could not observe any change in chlorophyll content due to salt treatment in their experiments. However, Devi (1995) could observe an increase in total chlorophyll content with Na substitution in cassava. The total amount of chlorophyll was maximum when 50 per cent K was substituted with Na.

In cluster bean, the chlorophyll content progressively declined with increasing salinity levels (Garg *et al.*,1997). Rawat and Banerjee (1998), in their experiments in *Eucalyptus camaldulensis* and *Dalbergia sissoo* noticed that at lower salinity levels there was an increase in chlorophyll concentration but higher salinity reduced it.

## 2.2 Yield and Yield attributes

### 2.2.1 Influence of Potassium

The role of potassium in improving yield and yield attributes is well known. Chu (1961) stated that K application greatly increased fruit yield of banana. Increasing banana bunch weight by the application of K was reported by Hewitt and Osborne (1962). Yang and Pao (1962) noticed a favourable effect of increased doses of K on nearly every feature of fruit growth. Thickness and weight of peel, length and girth of fingers etc. were increased. Beneficial effect of K on the yield of bunches was also reported by Jagirdar and Ansari (1966).

Leigh (1969) observed increase in fruit weight, length and circumference of fruit and rind thickness with increasing supplies of K in banana. Significant increase in the size of fruits at harvest was recorded with higher levels of K in banana cv. Dwarf Cavendish (Ramaswamy, 1971).

In banana cv. Americani, yields increased with increasing K levels, the highest increase of 93 per cent being in response to the highest dose of 1350 kg $K_2O$ $ha^{-1}$ (Moreau and Robin, 1972). They noticed significant increase in weight, volume and density of fruit with the application of K.

Bunch weight increased in banana cv. Palayankodan when the K levels increased from 0-600g $K_2O$ $plant^{-1}$ (Sheela,1982). Garita and

Jarmillo (1984) found that 750 kg $K_2O$ $ha^{-1}$ $year^{-1}$ resulted in highest yield in banana.

Obiefuna (1984) in studies with 'plantains' worked out the optimal dose of K as 300g $plant^{-1}$ and observed significant increase in bunch weight (73.9 per cent), number of marketable fingers and finger weight $plant^{-1}$ over the control.

Shaikh *et al.* (1985) found 786 kg $K_2O$ $ha^{-1}$ as the optimal dose for banana with regard to plant growth and yield. Bunch weight of banana increased when $K_2O$ increased from 0-480g $plant^{-1}$ (Chattopadhyay and Bose, 1986). Mustaffa (1987) recorded the highest fruit yield of 45.4 t $ha^{-1}$ with 300g $K_2O$ $plant^{-1}$, 35 per cent higher than that at zero potash level in banana cv. Robusta. A linear increase in yield was obtained up to 600g $K_2O$ $plant^{-1}$ for Nendran, grown in rice fallows. Hands and fingers per bunch also increased with increasing levels of K (Nair,1988).

In Dwarf Cavendish, highest yield (45.18 t $ha^{-1}$) was recorded with 300g $K_2O$ $plant^{-1}$ (Yadav *et al.*, 1988). Sheela *et al.* (1990) observed marked increase in bunch weight with K applications in banana.

An increase in yield along with an increase in the number of hands, fingers and finger weight was observed when the $K_2O$ level increased from 0-300g $plant^{-1}$ (Hegde and Srinivas, 1991).

In banana cv. Harichal, Pathak *et al.* (1992) observed that 300g $K_2O$ $plant^{1-}$ produced the highest number of hands and fingers $bunch^{-1}$ and in turn increased the weight of hands. Agussalim *et al.* (1994) observed maximum yield in banana cv. Barangan when 600g KCl $plant^{-1}$ was applied in two splits.

In the experiments with Nendran variety of banana, George (1994) recorded maximum number of hands, fingers $bunch^{-1}$ and weight of hand with 225g $K_2O$ $plant^{-1}$. Length, girth and weight of index fingers also increased at the above dose. Highest fruit weight in banana was recorded with an annual rate of 720 kg $K_2O$ $ha^{-1}$ (Lopez Morales, 1994).

Sheela (1995) noted an increase in length and weight of fingers with increasing levels of K in tissue cultured banana cv. Nendran. Sindhu (1997) observed highest bunch weight and fingers $bunch^{-1}$ at 450g $K_2O$ $plant^{-1}$.

### 2.2.2 Influence of Sodium

Dray cott and Durrant (1976) established that Na salt can largely replace K fertilizers in sugar beet and the elements K and Na increase root yield. Yields of barley and sugar beet were found to increase but the yield of broad beans was adversely affected by the application of Na (Hamid and Talibudeen, 1976).

Nair *et al.* (1980) recorded higher tuber yield at 200 kg NaCl $ha^{-1}$ out of the 3 levels *viz.*, 200, 400 and 600 kg NaCl $ha^{-1}$ in cassava.

According to Mathew *et al.* (1984), in coconut, substitution of $K_2O$ by $Na_2O$ to the extent of 50 to 75 per cent could maintain the yield as at 100 per cent K. Maximum increase in yield of coconut palms was recorded when 50 per cent $K_2O$ was substituted by $Na_2O$ (Prema *et al.*,1987a). In another experiment on coconut, Prema *et al.* (1987b) reported that when K was substituted with Na to the extent of 0-100 per cent, the treatments did not influence the copra weight $nut^{-1}$ significantly.

Higher salinity was found to reduce the yield of crops significantly by Al-Harbi and Burrage (1993) in cucumber, Palaniappan and Yerriswamy (1996) in potato, Lesch *et al.* (1996) in wheat, Sharma *et al.* (1997) in sugarcane and Maliwal (1997) in wheat.

All the yield contributing characters like number of tubers plant$^{-1}$, length and girth of tubers were highest at 50 per cent substitution of K by Na in sweet potato (George,1995).

Devi (1995) recorded the highest yield in cassava when 50 per cent of the K was substituted by Na of common salt. But 100 per cent substitution by Na reduced yields.

There was 29 per cent increase in nut yield by the application of NaCl @ 1kg tree$^{-1}$ year$^{-1}$ along with the recommended dose of NPK in coconut (Devasenapathy *et al.*, 1996). Nut weight and husked nut weight were higher in the treatments with the application of Na.

Lekshmi (2000) recorded maximum bunch yield at 50 per cent substitution of K by Na of common salt in banana cv. Nendran. Number of hands bunch$^{-1}$ was maximum at 75 per cent substitution but all other yield attributes like length of bunch, weight of hand, number of fingers bunch$^{-1}$, length of finger, girth of finger, weight of finger and pulp / peel ratio were highest at 50 per cent substitution.

## 2.3 Dry matter production

### 2.3.1 Influence of Potassium

Potassium fertilizers are found to improve vegetative growth and thereby dry matter accumulation in plants. In 1977, Ashokan and Sreedharan found that dry matter production in cassava (variety H 97) was maximum at 112.5 kg level of $K_2O$ $ha^{-1}$

Turner and Barkus (1980) while studying the effect of K on dry matter production in banana cv. Williams found that K deficiency resulted in a reduction of 79 per cent in the total dry matter content of fruits.

Increase in the total dry matter content with increase in the levels of K was observed by Sheela (1982) in banana cv. Palayankodan. The highest level of K application viz., 600g K $plant^{-1}$ produced increased dry matter content at the late vegetative stage. Increasing the K supply increased dry matter production in banana which helped in increasing the uptake of most of the elements (Turner and Barkus,1983).

Hegde and Srinivas (1991) found that increasing the K application from 100 to 200g $K_2O$ $plant^{-1}$significantly increased the total dry matter production in both the plant and ratoon crops of banana, but further increase in K to 300g $K_2O$ plant$^{-1}$ had no significant effect except on the fruit dry matter in the plant crop.

In potato when application of K up to 80 kg ha$^{-1}$ increased the dry matter production, further higher levels decreased it (Sharma and Ezekiel,1993). But Singh *et al.* (1993) reported higher dry matter production in wheat with increasing K application. The total dry matter production was maximum in the treatment with 600g $K_2O$ plant$^{-1}$ in banana cv. Nendran (George,1994).

### 2.3.2 Influence of Sodium

Brownell (1965) reported that dry matter production in *Atriplex vesicaria* increased four times when fertilized with Na. In an experiment on *Anabaena cylindrica,* Brownell and Nicholas (1967) observed an increase in dry matter yields with Na supply, reaching a maximum in culture solutions containing approximately 2 meq l$^{-1}$ NaCl.

El–Sheikh *et al.* (1967) found that in sugar beet plants, when Na was applied along with other nutrients, plant growth was increased. Plants of *Atriplex halimus* L. grew better in saline media containing equal concentration of NaCl and KCl (Mozafer *et al.*, 1970).

Warcholowa (1971) observed that in sugar beet Na increased the dry matter yield of roots and the effect was greatest when K was moderately deficient and also 50 per cent $K_2O$ and 50 per cent $Na_2O$ were supplied. In cassava, plant growth was retarded beyond 2000 ppm Na in growth medium (Indira, 1978). Chavan and Karadge (1980) noticed a reduction in the dry weight of all plant parts of peanut at high concentration of NaCl.

According to Khanna and Balaguru (1981 b) dry weight of shoots, collar and roots of wheat increased significantly with the application of Na up to 5 mM $l^{-1}$. A negative response in dry matter yield of shoots and spikes in wheat with increasing levels of salinity was reported by El–Sherbeiny *et al.* (1986).

Fakultet and Sad (1988) in an experiment to study the reaction of 2 pea (*Pisum sativum*) varieties to Na substitution for K observed that the dry matter production was highest when 20 per cent of K was substituted with Na. Highest fresh weight was obtained in *Amaranthus tricolor* when supplied with equal parts of NaCl and KCl (Ohta *et al.*, 1988).

Mills (1989) observed stimulation of growth and phylloid production in both shoot segments and plantlets in *Asparagus officinalis* under moderate concentration of NaCl (0.5 – 1.0 per cent). Plant dry weight was not reduced in tomato plants under low K stress when replaced with Na. But at toxic levels of Na, reduction in plant dry weight was observed (Figdore *et al.*, 1989). Gupta and Srivastava (1989) in an experiment on wheat found that NaCl reduced the dry weight of the plant.

A progressive reduction in the dry matter production with increasing NaCl concentration was noticed by several other workers (Ahmed *et al.*, 1993 in *Brachiaria mutica*; Alfocea *et al.* (1996) in tomato; Maliwal (1997) in wheat; Remadevi and Gopalakrishnan (1997) in cowpea; Chowdhury *et al.* (1998) in sugar cane and Karikalan *et al.* (1999) in pigeonpea).

Na increased cumulative dry matter yield in pasture, but the increase was not significant (Cushnahan *et al.*, 1995). Devi (1995) obtained maximum growth of plants in cassava when 50 per cent K was substituted by Na of common salt. But higher levels of Na reduced growth. Similar result was reported by George (1995) in sweet potato and Lekshmi (2000) in banana cv. Nendran.

## 2.4 Quality Attributes

### 2.4.1 Influence of Potassium

Several reports show the favorable effect of K on the quality of fruits. Chu (1961) stated that K application greatly improved the fruit quality and storage life in banana. Improved fruit conditions in banana after 20 days of storage with increasing supply of $K_2O$ was observed by Ho (1968). Van Uexkull (1970) found that K improved the sugar/acid ratio and keeping quality by increasing the thickness and firmness of rind in banana.

An appreciable improvement in the quality of fruits with increasing levels of K in banana cv. Robusta was observed by Singh *et al.* (1974). Jambulingam *et al.* (1975) reported significant positive effect of K on soluble solids in banana cv. Robusta.

Acidity of the fruit was lowered with the application of K in Cavendish banana (Venkatarayappa *et al.*, 1978). In studies with Robusta banana, Vadivel and Shanmughavelu (1978) observed significant increase in reducing sugars, non-reducing sugars, total sugars and TSS with increase in $K_2O$ (upto 300g plant$^{-1}$). Acidity was decreased while sugar/acid ratio increased. Similar results were reported by Sheela (1982) in banana cv. Palayankodan; Baruah and

Mohan (1986) in banana cv. Jahaji; Mustaffa (1987) in banana cv. Robusta and Sheela *et al.* (1990) in banana.

Zehler *et al.* (1981) reported positive influence of K in improving the storage properties of banana fruit as well as sugar/acid ratio. Acidity of fruits decreased and total sugar content increased with increasing levels of K in Dwarf Cavendish banana as noticed by Chattopadhyay and Bose (1986).

K improves the quality, flavour, sweetness and keeping quality of fruits (Tandon and Sekhon, 1988). Samra and Quadar (1990) reported that K increased total sugar content in tomato.

Increasing levels of K increased TSS but decreased the pulp/peel ratio in banana (Hegde and Srinivas, 1991). George (1994) reported an increase in the total sugars, non–reducing sugars and shelf life of fruits with K application in banana cv. Nendran. In this experiment reducing sugars decreased and pulp/peel ratio increased with increased K application.

Increased K levels increased sugar / acid ratio and lowered acidity in tissue cultured banana 'Nendran' (Sheela,1995). Sindhu (1997) obtained significant increasing trend of TSS, total sugars, non–reducing sugars, sugar/acid ratio, pulp/peel ratio and shelf life and a significant negative trend in acidity and reducing sugars with increase in K in banana cv. Nendran.

**2.4.2 Influence of Sodium**

Na application in sugar beet increased the TSS (Khanna and Balaguru 1981a). Adam and Ho (1989) observed an increase in sugar content of fruit juice of tomato with increased levels of salinity. An increase in the sugar and sucrose content of sugar beet in direct proportion with Na concentration was noticed by Chandler *et al.* (1989). Khan *et al.* (1989) reported a decrease in reducing and non-reducing sugar contents in sorghum with increase in sodium levels.

The sugar content in sweet potato increased when K and Na ions were applied in 50:50 ratio (George,1995). Devi (1995) observed an increase in the total sugars and reducing sugars with increase in substitution of K by Na as common salt in cassava

In the field experiment conducted by Palaniappan and Yerriswamy (1996) in banana cv. Robusta, irrigation with saline water of EC 5 $dSm^{-1}$ was found to adversely affect the quality of banana. At moderate salinity, the glucose and sucrose concentration increased by 1.5 to 3 times in tomato hybrid (Alfocea *et al.,* 1996). Sharma *et al.* (1997) in their experiment to study the effect of salt stress on sugarcane noticed that salinity adversely affected the quality of sugarcane by decreasing the sucrose content.

In the studies conducted by Lekshmi (2000) in banana cv. Nendran, TSS was maximum at 25 per cent substitution of K by Na of CS. Acidity was maximum at 50 per cent substitution where as total sugars and sugar / acid ratio and shelf life were maximum at 75 per cent substitution by Na.

### 2.5 Nutrient content and uptake

#### 2.5.1 Influence of Potassium

Hewitt (1955) found that 2.60%N, 0.45% $P_2O_5$ and 3.30% $K_2O$ were the critical concentrations and that no increase in yield could be obtained by additional application of $P_2O_5$ and $K_2O$ over and above their critical levels. The optimum levels of N, $P_2O_5$ and $K_2O$ were estimated as 2.8 – 3.0%, 0.40 – 0.55% and 3.8 to 4.0% respectively by Boland (1960).

Hewitt and Osborne (1962) observed that for high yields in Lacatan variety of banana, the leaf tissue should have 4.0% $K_2O$.

Potash application readily increased leaf potassium. Similar observation was made by Randhava *et al.* (1973) and Sheela (1982). Plants adequately supplied with K contained about 4.5 – 5.0% K in third fully unfurled leaf as reported by Van Uexkull (1970).

Ramaswamy (1971) estimated optimum $K_2O$ content in leaf of banana 'Robusta' as 3.11% for increasing yield. An antagonism between K and Na ions was observed by Lahav (1973).

In Robusta banana, the increase in K content was significant when the dose was increased beyond 360g $K_2O$ $plant^{-1}$ (Jambulingam *et al.*, 1975).

Lacoevilhe and Martinprevel (1977) analysed banana leaves for K concentration in third and fourth leaves (combined) during flowering stage. At flowering and harvest stages, the levels of $K_2O$ were 4.3 and 8.5% respectively.

Increase in the plant uptake of P and decrease in that of N with increased K supply was observed by Turner and Barkus (1983).

Buragohain and Shanmugavelu (1990) observed that banana plants contained higher amount of K than any other nutrient.

Increased K fertilization significantly increased the uptake of N and K (Hegde and Srinivas, 1991). Nutrients removed by Cavendish banana with an yield of 50 t $ha^{-1}$ was found to be 388 kg $ha^{-1}$ N, 52 kg $ha^{-1}$ P, 1438 kg $ha^{-1}$ K, 10.6 kg $ha^{-1}$ Na and 525 kg $ha^{-1}$ $Cl^-$ (Chadha and Pareek, 1993).

**2.5.2 Influence of Sodium**

Studies in *Zea mays*, *Glycine max*, *Citrus jambhiri* and *Persea americana* by Huffaker and Wallace (1959) showed that a low K level stimulated Na absorption and a high K level decreased it. Barrant (1975) reported that increased application of Na decreased the K uptake in coconut. Similarly increased application of K fertilizers depressed Na uptake.

According to Chavan and Karadge (1980) in peanut, with an increase in NaCl concentration Na accumulated in all plant parts whereas K content was decreased in leaf and stem and increased in root.

In sugarbeet Na concentration in all plant parts increased with the application of Na but decreased with an increase in K application (Khanna and Balaguru, 1981a).

Khanna and Balaguru (1981b) also reported that in wheat the Na content increased and the K content decreased with Na application. Similar observation was made by several workers (Hawker and Smith (1982) in cassava, Maliwal (1997) in wheat and Chowdhury *et al.* (1998)in sugarcane).

In coconut Na and K contents of leaves were influenced by Na substitution (Mathew *et al.*, 1984). Maximum K and Na contents were seen when 100 per cent K and 100 per cent Na were applied respectively.

According to Prema *et al.* (1987a) in coconut palm, substitution of K by Na showed no significant difference in their effect on total N, P and $Cl^-$ content of leaves whereas K and Na contents were significantly influenced by the treatments. Prema *et al.* (1987b) also reported that in coconut, substitution of K by Na did not significantly influence the N, P and K contents of copra. Increasing rate of Na application resulted in corresponding increase in the Na content of copra.

In *Amaranthus tricolor,* Ohta *et al.* (1987) noticed that the Na content was increased by Na application but the K uptake was not affected. Do (1990) in an experiment on maize with different levels of Na in nutrient solution (0 – 0.5%) found that increasing Na concentration decreased plant N, P and K contents and markedly increased the Na content.

In cassava, Devi (1995) found that all the treatments which received Na favoured absorption of N and P during the early stage. In tuber filling stages, the absorption of K was more in treatments where K and Na were applied at 50 per cent levels.

Lekshmi (2000) observed maximum uptake of N, P, K and Na in banana cv. Nendran when 50 per cent of K was substituted by Na as common salt.

**2.5.3 Influence of Chloride**

Decrease in plant dry weight and increased defoliation due to a high $Cl^-$ content has been reported by Banuls and Primo-millo (1992) in citrus. The need for supplemental $Cl^-$ in plant nutrition has been documented by research worldwide and has resulted in both higher crop yield and disease suppression in various crops (Potash and Phosphate Institute, 1993).

$Cl^-$ content increased from 0.03 to 0.61 per cent with increase in salinity in strawberry (Awang and Atherton, 1994). Similar results were obtained by Singh and Pathak (1994) in guava; Barakat (1996) in potato; Sharma (1997) in chickpea and Rhoades *et al.* (1998) in rice. In these experiments reduction in growth was attributed to high Na and $Cl^-$ contents.

**2.6 Soil Physical properties**

Prema *et al.* (1987 a) reported that the pH and EC of the soil did not vary among the treatments (0, 25,50,75 and 100 per cent substitution of MOP by CS). The application of Na had no adverse effect on pH, EC and CEC of the soil (Prema *et al.*, 1992).

Growth of most of the crop plants is reduced in sodic soils. There will be reduction in soil aggregation and permeability to air and water (Tisdale *et al.*, 1992). In sweet potato, George (1995) observed no significant difference in soil properties like EC and CEC. The pH of the soil showed a slight increase.

There was an increase in the soil pH at higher levels of substitution of K by Na in banana cv. Nendran (Lekshmi 2000). But EC and CEC did not vary significantly in the experiment.

## 2.7 Soil available nutrients

Jordan and Lewis (1953) reported that Na salts added to soil increased the available phosphate in soil.

Prema *et al.* (1987 a) observed no difference in total N, available P, Na and $Cl^-$ due to the influence of Na and K treatments in the soil. While studying the dynamics of added K in red soil under banana plantation, both readily and potentially available forms of K in the soil was increased by K application (Bhargava *et al.*, 1992).

George (1995) observed no significant difference in available status of K and Na between the treatments under no substitution and full substitution of K by Na in sweet potato.

In substitution studies in banana cv. Nendran, highest available status of soil N and K was recorded in no substitution treatment and of Na in the treatment with full substitution of K by Na. Soil available P status was maximum at 50 per cent substitution of K by Na of CS (Lekshmi, 2000).

# MATERIALS AND METHODS

# 3. MATERIALS AND METHODS

A field experiment to evaluate the extent of substitution of muriate of potash by common salt was carried out from August 1999 to June 2000 at the Instructional Farm, College of Agriculture, Vellayani. The details of the experimental site, season and weather conditions, materials used and methods adopted are presented in this chapter.

## 3.1 Experimental site

### 3.1.1 Location

The instructional farm, Vellayani is located at $8^0 30'$N latitude and $76^0 54'$ E longitude and at 29m above MSL.

### 3.1.2 Soil

The soil of the experimental site belongs to the family Loamy Skeletal Kaolinitic Isohyperthermic *Rhodic Haplustox*.

The physical and chemical characteristics of the soil where the experiment was conducted are given in Table 1.

### 3.2 Season

The experiment was conducted during the period of August 1999 to June 2000.

### 3.3 Weather conditions

The mean annual rainfall of the location was 2870 mm. The mean annual maximum and minimum temperatures were 30.52 and 23.07$^{0}$C respectively. Monthly distribution of rainfall and temperature prevailed during the cropping period is depicted in Fig 1.

### 3.4 Materials

### 3.4.1 Planting Material and Variety

The planting material of the banana variety Robusta was obtained from the Instructional Farm, Vellayani. Robusta is one of the most popular varieties of Banana.

### 3.4.2 Fertilizers

Cattle manure was applied @ 10 kg plant$^{-1}$. N and $P_2O_5$ were applied as per the recommendations of Package of Practices. $K_2O$ was

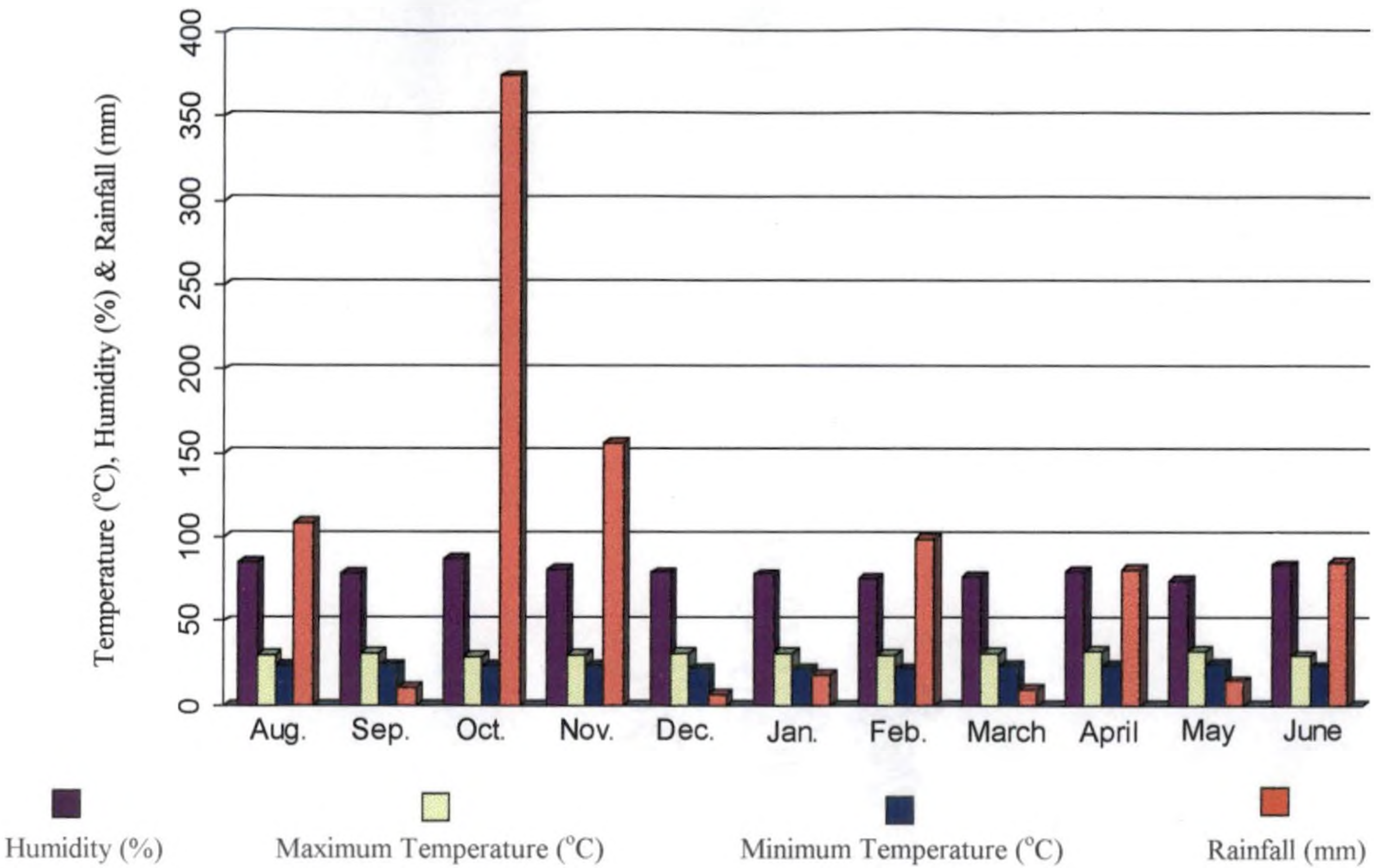



**Fig. 1 Meteorological observation from August 1999 to June 2000**

applied as per the treatments. Common salt was applied to substitute K as per the treatments.

## 3.5 Methods

### 3.5.1 Design and Layout of the experiment

| | | |
|---|---|---|
| Design | - | Randomized Block Design |
| Variety | - | Robusta |
| Replication | - | 3 |
| Treatments | - | 8 |
| Plot size | - | 16 plants $plot^{-1}$ |
| Spacing | - | 2.4m x 1.8m |

### 3.5.2 Treatments

NPK recommendation for Robusta according to POP – 160 : 160 : 320g $plant^{-1}$ $annum^{-1}$.

$T_1$ – 100% K as MOP (control)

$T_2$ – 25% K as MOP

$T_3$ – 50% K as MOP

$T_4$ – 75% K as MOP

$T_5$ – 75% K as MOP plus 25% Na as common salt.

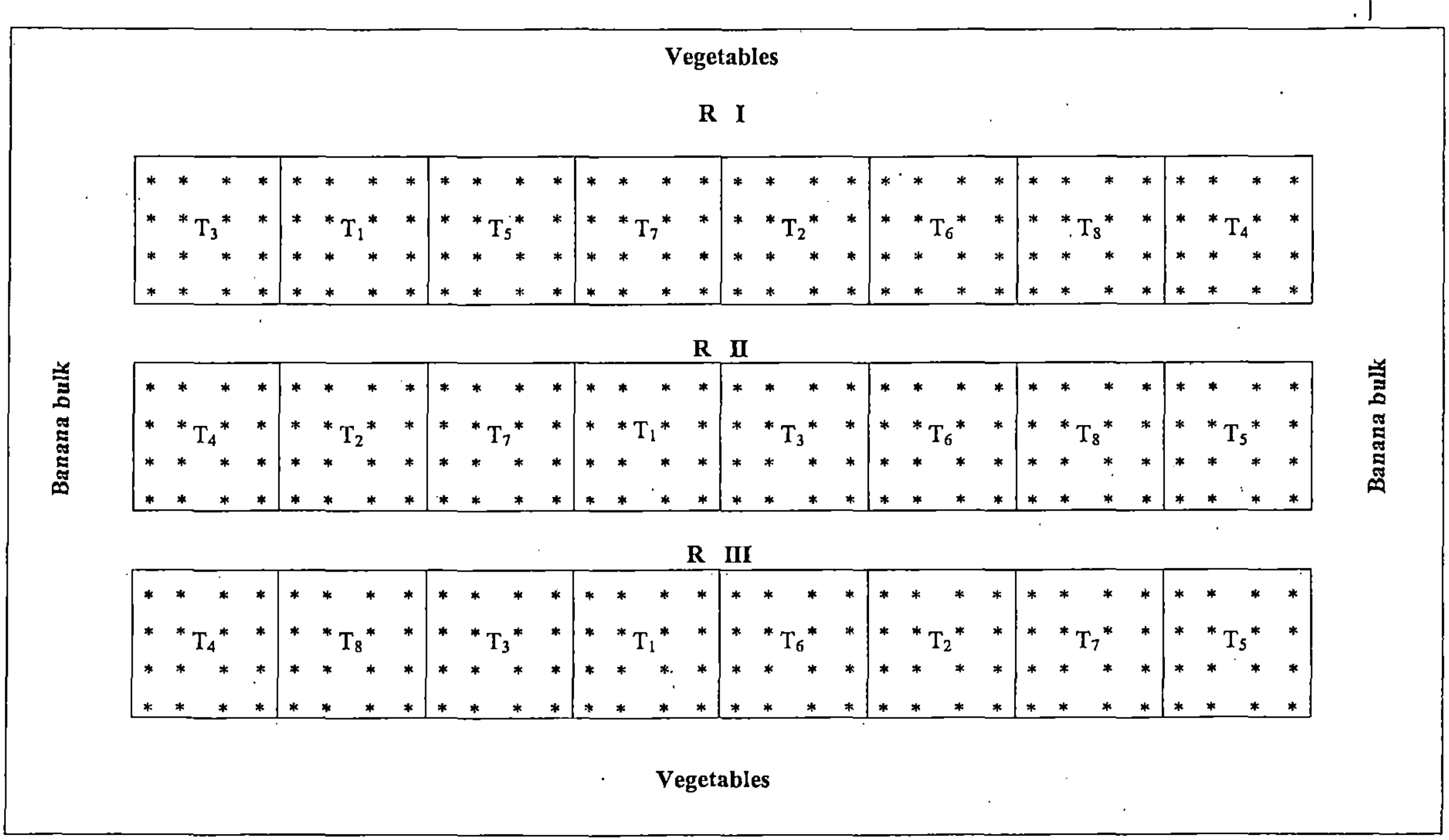
$T_6$ – 50% K as MOP plus 50% Na as common salt.

$T_7$ – 25% K as MOP plus 75% Na as common salt.

$T_8$ – 100% Na as common salt.

The layout plan of the experiment is presented in Fig. 2.

**Fig.2 Layout plan of the experiment**



### 3.6 Biometric Observations

The following biometric observations of the plant under different treatments were recorded at two months interval i.e., early vegetative stage (2MAP), late vegetative stage (4 MAP), shooting stage (6 MAP), bunch maturation stage (8 MAP) and harvest stage (at harvest). Observations were taken from plants, selected from each plot.

#### 3.6.1 Plant Height

Height of the plant was measured from the base of the pseudostem to the base of unopened leaf.

#### 3.6.2 Girth of plant

Girth of plant was measured at 10cm above ground level.

#### 3.6.3 Number of leaves

The total number of functional leaves in the plant at the sampling time was counted.

#### 3.6.4 Duration of Vegetative Phase

Number of days from planting to bunch emergence was noted.

### 3.6.5 Total Crop Duration

Number of days from planting to harvest was noted.

### 3.6.6 Phyllochrone

Days interval between two successive leaf emergence was noted.

## 3.7 Physiological Characters

The following parameters were recorded at 2 months interval.

### 3.7.1 Leaf Area Index (Watson, 1952)

$$LAI = \frac{\text{Leaf Area Plant}^{-1}}{\text{Land Area Plant}^{-1}}$$

Leaf Area (Robinson & Nel, 1988)

Leaf Area = 0.83 length x breadth of leaf.

### 3.7.2 Chlorophyll Content

Chlorophyll estimation was done in samples from the index leaf (third opened leaf from top) by colorimetric method as described by Arnon (1949).

### 3.7.3 Relative Water content in leaves

Index leaf samples were taken and relative water content in leaves was determined by the method proposed by Weatherley (1950) which was modified by Slatyer and Barrs (1965).

$$RLWC = \frac{\text{Fresh weight} - \text{Oven dry weight}}{\text{Turgid Weight} - \text{Oven dry weight}} \times 100$$

## 3.8 Yield Components

The following yield parameters were recorded at harvest.

### 3.8.1 Length of bunch

Length of bunch was measured as distance from the point of attachment of first hand to that of the last hand.

### 3.8.2 Bunch Weight

Weight of bunch including portion of peduncle upto the first scar (exposed outside the plant) was taken.

### 3.8.3 Number of hands per bunch

Number of hands in each bunch was counted.

### 3.8.4 Number of fingers per bunch

Number of fingers in each bunch was counted

**Fruit Characters**

The middle fruit in the top row of second hand (from the base of bunch) was selected as index finger. Observations were taken from this finger.

### 3.8.5 Length and girth of fingers

**Length**

Length was measured as distance from the tip of finger to point of attachment of the finger to the peduncle.

**Girth**

Girth was taken at the middle portion of the index finger.

### 3.9 Quality attributes

Fruits were collected fresh at harvest from the plots and analysed for various quality parameters. The parameters studied and the analytical methods followed are given in Table 2.

### 3.9.1 Pulp / Peel ratio

Weight of pulp of the index finger and weight of peel of the same was taken separately and found out the ratio of pulp / peel.

### 3.9.2 Shelf Life of fruits

Number of days taken from harvest to the development of black colour in the peel was recorded to determine the shelf life or storage life of fruits at room temperature (Stover and Simmonds, 1987).

## 3.10 Plant Analysis

Leaf, pseudostem and rhizome samples were mixed and fruit samples were separately analysed for the contents of N, P, K, Na and $Cl^-$ at harvest time.

N was estimated by modified Kjeldahl method after digestion with concentrated $H_2SO_4$ (Jackson, 1973). Determination of P, K and Na were done after digestion with $HNO_3$: $HClO_4$: $H_2SO_4$ mixture (Piper, 1966). P was estimated by the vanadomolybdic yellow colour method in a Klett Summerson photoelectric colorimeter (Jackson, 1973). Na and K were estimated using the flame photometer. $Cl^-$ was estimated titrimetrically as per the method described by Humphries (1979).

### 3.11 Uptake of nutrients

Uptake of N, P, K, Na and $Cl^-$ was calculated from their contents in the plant parts multiplied by the respective dry weight.

### 3.12 Total Dry Matter

Weight of the plants after drying in hot air oven at $70^0C$ for 48 h. was found out.

### 3.13 Soil Analysis

Soil samples from each plot were analysed for $p^H$, EC, organic carbon, available P, K, N and Na.

Soil physical properties like WHC were also studied. The procedures followed are given in Table 3.

### 3.14 Economic Analysis

The economics of cultivation were worked out considering the cost of cultivation and income derived from the plant with respect to all treatments. It was calculated as per the norms and rates fixed by the Instructional farm, College of Agriculture, Vellayani.

$$\text{Benefit: Cost ratio} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

**3.15 Statistical Analysis**

Statistical methods of analysis such as analysis of variance, correlation and regression were carried out to find out the relationship between variables and to draw definite conclusions.

**Table – 1 Physical and Chemical Properties of the soil of the experimental site**

| | |
|---|---|
| 1. Mechanical composition | |
| Sand (%) | 79.8 |
| Silt (%) | 11.6 |
| Clay (%) | 8.1 |
| 2. Texture | Sandy Loam |
| 3. pH | 4.9 |
| 4. EC ($dSm^{-1}$) | 0.02 |
| 5. CEC (cmol $kg^{-1}$) | 3.2 |
| 6. WHC (%) | 28.2 |
| 7. Organic carbon (%) | 0.18 |
| 8. Available N (kg $ha^{-1}$) | 134 |
| 9. Available P (kg $ha^{-1}$) | 44.6 |
| 10. Available K (kg $ha^{-1}$) | 72.8 |
| 11. Available Na (kg $ha^{-1}$) | 35 |

**Table – 2 Analytical methods followed in fruit quality study**

| Sl. No. | Parameter studied | Method followed | References |
|---|---|---|---|
| 1. | Total sugars | Titrimetry | Chopra and Kanwar (1976) |
| 2. | TSS | Refractometry | Chopra and Kanwar (1976) |
| 3. | Acid | Titrimetry | Chopra and Kanwar (1976) |

**Table – 3 Analytical methods followed in soil analysis**

| Characteristics studied | Method of estimation | Instrument used | References |
|---|---|---|---|
| pH | Direct reading | pH meter | Jackson (1973) |
| EC | Direct reading | EC meter | Jackson (1973) |
| Organic carbon | Walkley – Black rapid titration | Titration | Jackson (1973) |
| Available N | Alkaline permanganate method | Titration | Subbiah and Asija (1956) |
| Available P | Molybdinum – blue method (Bray extraction method) | Klett – Summerson Photo electric colorimeter | Jackson (1973) |
| Available K | Direct reading (neutral normal ammonium acetate extraction) | Flame photometer | Jackson (1973) |
| Available Na | Direct reading (neutral normal ammonium acetate extraction) | Flame photometer | Jackson (1973) |
| WHC | Keen – Rack - zowski method | Keen – Rack - zowski Box | Iswaran (1980) |

# RESULTS

# 4. RESULTS

The investigation entitled "Substitution of muriate of potash by common salt in banana *Musa* (AAA group Cavendish subgroup) 'Robusta' was conducted to study the extent of substitution of MOP by CS in banana cv. Robusta. The salient results of this study are presented in this chapter.

## 4.1 Growth Characteristics

### 4.1.1 Plant height

The mean values of height of plant for the different treatments at 2 months interval from planting to harvest are presented in Table 4. There were significant differences in height due to the treatments.

Maximum plant height was recorded in the treatment $T_6$ (50 per cent substitution by Na as common salt) at all stages of the crop. The lowest plant height was recorded at all stages by the treatment $T_2$ (50 per cent K alone) followed by $T_8$ (100 per cent Na). Plant heights at 25 and 75 per cent substitution by Na were on par with the height at 100 per cent potash.

### 4.1.2 Girth of pseudostem

Girth of pseudostem at 10 cm above the ground level recorded at 2 months interval from planting to harvest is presented in Table 5.

There were significant differences due to the treatments at all stages.

Maximum plant girth (at early vegetative stage) was recorded in $T_6$ (39.83cm) and minimum was in $T_2$ (31.83cm). $T_8$ i.e., 100 per cent Na substitution gave plant girth of 35.33cm. Plant girths at 25 and 75 per cent substitution by Na were on par with that at 100 per cent potash level.

### 4.1.3 Number of leaves

Total number of functional leaves was recorded at 2 months interval. The treatment means varied significantly. The data are presented in Table 6.

The number of functional leaves per plant in the treatments $T_1$ (100 per cent K), $T_5$ (25per cent substitution by Na) and $T_6$ (50 per cent K + 50 per cent Na) were on par and did not vary significantly at all stages of the crop. At 8 MAP and at harvest stages, 75 per cent substitution of K by Na also produced number of functional leaves which was on par with that of $T_6$. But 100 per cent substitution by Na and application of 25 per cent K alone produced plants with number of functional leaves significantly lesser than that of $T_6$ and $T_1$. and $T_5$ (25 per cent substitution by Na) was comparable to that by $T_6$. Hundred per cent Na substitution ($T_8$) and 25 per cent K alone ($T_2$) produced lesser number of functional leaves at all growth stages.

**Table 4. Plant Height (cm) at different growth stages as affected by treatments.**

| Treatment | 2MAP | 4MAP | 6MAP | 8MAP | At Harvest |
|---|---|---|---|---|---|
| $T_1$ | 103.17 | 150.67 | 181.00 | 194.00 | 195.33 |
| $T_2$ | 98.33 | 143.33 | 174.33 | 186.33 | 186.83 |
| $T_3$ | 101.00 | 146.67 | 176.33 | 188.33 | 189.50 |
| $T_4$ | 102.17 | 149.33 | 177.00 | 190.33 | 191.50 |
| $T_5$ | 102.33 | 151.67 | 178.33 | 191.00 | 192.33 |
| $T_6$ | 104.67 | 152.83 | 183.67 | 196.00 | 197.83 |
| $T_7$ | 102.50 | 150.33 | 180.00 | 194.00 | 194.83 |
| $T_8$ | 100.67 | 148.00 | 175.33 | 187.67 | 188.33 |
| CD- | 1.38** | 1.44** | 1.59** | 1.15** | 1.54** |

** Significant at 0.01 level

**Table 5. Girth of Plants (cm) as influenced by Na substitution**

| Treatment | 2MAP | 4MAP | 6MAP | 8MAP | At Harvest |
|---|---|---|---|---|---|
| $T_1$ | 38.67 | 50.17 | 58.83 | 63.83 | 66.67 |
| $T_2$ | 31.83 | 41.33 | 47.67 | 51.17 | 52.83 |
| $T_3$ | 36.00 | 47.00 | 55.50 | 60.00 | 62.50 |
| $T_4$ | 37.33 | 48.00 | 57.17 | 61.17 | 64.00 |
| $T_5$ | 38.17 | 49.83 | 58.50 | 63.17 | 65.83 |
| $T_6$ | 39.83 | 51.67 | 61.83 | 67.00 | 71.17 |
| $T_7$ | 37.67 | 45.67 | 54.00 | 59.67 | 62.00 |
| $T_8$ | 35.33 | 42.83 | 50.33 | 54.50 | 56.50 |
| CD | 2.15** | 1.22** | 1.71** | 2.00** | 1.70** |

** Significant at 0.01 level

### 4.1.4 Duration of vegetative phase

The variation in the duration of vegetative phase was significant due to the treatments. The mean values are presented in Table 7.

Fifty per cent substitution of Na as CS produced plants with least duration of vegetative phase (201.33 days). The duration of vegetative phase for plants supplied with treatments $T_1$ (100 per cent K) and $T_5$ (25 per cent substitution of K by Na) was 202.67 days which was on par with that of $T_6$. The treatments $T_2$ (25 per cent K alone) and $T_8$ (100 per cent substitution by Na) produced plants with maximum duration of vegetative phase.

### 4.1.5 Total crop duration

The mean values of total crop duration are presented in Table 8. There was significant variation due to treatments.The total crop duration ranged from 298 days (in $T_6$) to 307.33 days (in $T_2$). Substitution of K with Na above 50 per cent level was found to increase the total crop duration.

**Table 6. Number of Leaves as influenced by treatments**

| Treatment | 2MAP | 4MAP | 6MAP | 8MAP | At Harvest |
|---|---|---|---|---|---|
| $T_1$ | 9.67 | 9.00 | 9.00 | 8.67 | 4.00 |
| $T_2$ | 8.00 | 8.00 | 8.00 | 7.33 | 3.00 |
| $T_3$ | 8.67 | 8.00 | 9.00 | 8.00 | 4.00 |
| $T_4$ | 9.33 | 8.67 | 9.67 | 8.67 | 4.00 |
| $T_5$ | 9.67 | 8.67 | 9.67 | 8.67 | 4.00 |
| $T_6$ | 10.00 | 9.00 | 9.67 | 9.00 | 4.00 |
| $T_7$ | 8.67 | 8.33 | 8.67 | 8.67 | 3.67 |
| $T_8$ | 8.33 | 8.00 | 8.00 | 7.67 | 3.33 |
| CD | 0.93** | 0.60** | 0.95** | 0.80** | 0.49** |

** Significant at 0.01 level

**Table 7. Duration of Vegetative Phase (days) as influenced by treatments**

| Treatment | Duration (days) |
|---|---|
| $T_1$ | 202.67 |
| $T_2$ | 208.33 |
| $T_3$ | 206.67 |
| $T_4$ | 204.67 |
| $T_5$ | 202.67 |
| $T_6$ | 201.33 |
| $T_7$ | 205.00 |
| $T_8$ | 208.00 |
| CD | 1.09** |

** Significant at 0.01 level

### 4.1.6 Phyllochrone

The mean values of phyllochrone are presented in Table 9. In general, there was no significant difference in phyllochrone due to the treatments. But treatments $T_2$ (25 per cent K alone) and $T_8$ (100 per cent Na substitution) differed significantly from other treatments in all stages. All other treatments had same or comparable values in all stages of growth.

### 4.1.7 Leaf Area Index

The variation in LAI due to the treatments was significant. Mean values are presented in Table 10. Even from the early vegetative stage, the LAI was comparatively lesser in treatments receiving 25 per cent and 50 per cent K alone as MOP. Significant increase in LAI was noted with combined application of K and Na. At all stages, LAI was maximum in the treatment $T_6$ (50 per cent substitution by Na). The values were comparable to that in $T_1$(100 per cent K). At late vegetative stage the mean LAI in $T_6$ was 1.58 and in $T_1$ was 1.48. At this stage, $T_5$ (25 per cent substitution by Na) recorded higher LAI (1.52) than in $T_1$.

**Table 8. Total crop duration (days) as influenced by treatments**

| Treatment | Duration (days) |
|---|---|
| $T_1$ | 300.33 |
| $T_2$ | 307.33 |
| $T_3$ | 305.67 |
| $T_4$ | 302.67 |
| $T_5$ | 300.33 |
| $T_6$ | 298.00 |
| $T_7$ | 303.33 |
| $T_8$ | 307.00 |
| CD | 1.44** |

** Significant at 0.01 level

**Table 9. Phyllochrone (Number of days) as affected by treatments**

| Treatment | 2MAP | 4MAP | 6MAP | 8MAP |
|---|---|---|---|---|
| $T_1$ | 6.00 | 6.00 | 7.00 | 7.00 |
| $T_2$ | 6.67 | 6.67 | 7.67 | 8.00 |
| $T_3$ | 6.00 | 6.00 | 7.00 | 7.33 |
| $T_4$ | 6.00 | 6.00 | 7.00 | 7.00 |
| $T_5$ | 6.00 | 6.00 | 7.00 | 7.00 |
| $T_6$ | 6.00 | 6.00 | 7.00 | 7.00 |
| $T_7$ | 6.00 | 6.00 | 7.33 | 7.00 |
| $T_8$ | 6.67 | 7.00 | 8.00 | 7.67 |
| CD | 0.47* | 0.36** | 0.49** | 0.49** |

* Significant at 0.05 level
** Significant at 0.01 level

### 4.1.8 Total chlorophyll content

The variation in chlorophyll content due to treatments was significant. Values are shown in Table 11.

In all stages $T_2$ recorded the least chlorophyll content. At the early vegetative stage and bunch maturation stage, there was increase in chlorophyll content with increase in substitution and 100 per cent substitution by Na ($T_8$) was found to be the best. At 4 MAP (late vegetative stage) and 6 MAP (shooting stage), 75 per cent substitution by Na ($T_7$) was found to be the best with a chlorophyll content of 3.18 and 2.24 mg $g^{-1}$ respectively. At harvest stage, $T_6$ was found to have the highest chlorophyll content. There was a pronounced decrease in chlorophyll content when K alone was applied in the treatments.

### 4.1.9 Relative Leaf Water Content

Except at 6 MAP, all other stages showed significant variation in RLWC due to treatments (Table 12).

In general, there was an increase in the RLWC in the Na supplied treatments. $T_6$ recorded highest RLWC at early vegetative stage and at bunch maturation stage while at late vegetative stage and at harvest, $T_5$ had highest RLWC. $T_2$ recorded the least RLWC at early vegetative stage and bunch maturation stage. At late vegetative stage and at harvest, $T_1$ had least RLWC.

**Table 10. LAI as influenced by treatments**

| Treatment | 2MAP | 4MAP | 6MAP | 8MAP | At Harvest |
|---|---|---|---|---|---|
| $T_1$ | 1.01 | 1.48 | 2.04 | 2.26 | 1.71 |
| $T_2$ | 0.71 | 1.02 | 1.39 | 1.53 | 0.82 |
| $T_3$ | 0.83 | 1.22 | 1.49 | 1.63 | 0.98 |
| $T_4$ | 0.91 | 1.33 | 1.61 | 1.82 | 1.24 |
| $T_5$ | 0.96 | 1.52 | 1.89 | 2.04 | 1.49 |
| $T_6$ | 1.05 | 1.58 | 2.12 | 2.38 | 1.79 |
| $T_7$ | 0.91 | 1.49 | 1.84 | 2.03 | 1.45 |
| $T_8$ | 0.76 | 1.09 | 1.47 | 1.59 | 1.00 |
| CD | 0.10** | 0.09** | 0.07** | 0.09** | 0.15** |

** Significant at 0.01 level

**Table 11. Chlorophyll Content (mg $g^{-1}$) as influenced by treatments**

| Treatment | 2MAP | 4MAP | 6MAP | 8MAP | At Harvest |
|---|---|---|---|---|---|
| $T_1$ | 0.969 | 3.024 | 2.171 | 1.629 | 0.991 |
| $T_2$ | 0.844 | 2.063 | 1.789 | 0.983 | 0.764 |
| $T_3$ | 0.907 | 2.163 | 2.122 | 1.027 | 0.831 |
| $T_4$ | 0.936 | 2.373 | 2.138 | 1.335 | 0.878 |
| $T_5$ | 0.964 | 2.604 | 2.161 | 1.656 | 1.031 |
| $T_6$ | 0.977 | 3.174 | 2.192 | 1.699 | 1.105 |
| $T_7$ | 0.985 | 3.180 | 2.239 | 1.705 | 0.934 |
| $T_8$ | 0.993 | 3.015 | 2.229 | 1.707 | 0.932 |
| CD | 0.01** | 0.2** | 0.05** | 0.09** | 0.05** |

** Significant at 0.01 level

## 4.2 Yield and yield attributes

Yield and all the yield attributes showed significant variation due to treatments. The mean values are presented in Table 13.

### 4.2.1 Length of bunch

Maximum length of bunch was obtained in $T_6$ ie. 50 per cent substitution by Na (69.33cm). Further increase in substitution by Na was found to decrease the bunch length. By the addition of Na as CS upto 50 per cent substitution along with K, there was a definite increase in length of bunch.

### 4.2.2 Bunch weight

Bunch weight was highest (16.33kg) in the treatment $T_6$ (50 per cent substitution by Na). In the treatments $T_2$, $T_3$, and $T_4$, where the full recommended dose of K was not supplied, there was reduction in bunch weight. But by the addition of the balance quantity of K as Na of CS, there was increase in bunch weight. Treatments with 75 per cent and 100 per cent Na ($T_8$) recorded significantly lower bunch weight.

### 4.2.3 Number of hands per bunch

Number of hands per bunch in the treatments $T_6$,$T_1$,$T_5$ and $T_7$ were on par and significantly higher than in the other treatments. Maximum number of hands per bunch was recorded by the treatment $T_6$ (9). With increase in substitution by Na above 50 per cent level, number of hands per bunch decreased.

### 4.2.4 Number of fingers per bunch

Number of fingers per bunch recorded wide variation as a result of treatments. Maximum number of fingers per bunch was recorded by $T_6$ (128.67). With increase in substitution by Na above 50 per cent level, there was reduction in the number of fingers per bunch. In treatments $T_2$, $T_3$ and $T_4$ where the full dose of K was not supplied there was lesser number of fingers per bunch. But by the addition of balance quantity of K as Na of CS at 25 and 50per cent substitution there was significant increase in the number of fingers per bunch.

### 4.2.5 Length of fingers

Maximum length of fingers was recorded by the treatment $T_6$ i.e. 50 per cent substitution by Na (26cm). With increase in substitution by Na above 50 per cent level there was significant reduction in finger length. Finger length at 25 per cent substitution was on par with that at full potash level ($T_1$). Addition of Na along with K upto 50 per cent substitution was found to have a positive effect on the length of fingers.

### 4.2.6 Girth of fingers

Girth of fingers showed an increase with Na application upto 50 per cent level of substitution. Above this level there was decrease in the girth of fingers with increase in Na application. But application of Na along with K was found to increase the girth of fingers, when compared to the values recorded for treatments receiving 25 to 75 per cent K alone. Girth of fingers at 25 per cent substitution by Na was on par with that at $T_1$ (100 per cent K). Maximum finger girth was recorded by $T_6$ (12.83cm).

## 4.3 Quality Attributes

The quality attributes analysed (Table 14) were TSS, acidity, total sugars, sugar/acid ratio, pulp/peel ratio and shelf life. Except shelf life, all other quality attributes showed significant variation due to treatments.

**Table 12. RLWC (%) as affected by treatments**

| Treatment | 2MAP | 4MAP | 6MAP | 8MAP | At Harvest |
|---|---|---|---|---|---|
| $T_1$ | 85.48 | 83.77 | 89.65 | 88.83 | 69.63 |
| $T_2$ | 82.59 | 84.54 | 83.13 | 82.42 | 72.69 |
| $T_3$ | 87.05 | 91.25 | 87.45 | 84.31 | 69.66 |
| $T_4$ | 84.95 | 90.00 | 85.98 | 89.11 | 72.66 |
| $T_5$ | 90.52 | 92.11 | 87.77 | 91.79 | 84.38 |
| $T_6$ | 91.81 | 90.48 | 85.35 | 92.71 | 77.23 |
| $T_7$ | 90.10 | 91.23 | 85.90 | 90.82 | 72.91 |
| $T_8$ | 91.11 | 91.36 | 85.26 | 90.09 | 70.01 |
| CD | 2.34** | 2.82** | NS | 2.55** | 4.95** |

** Significant at 0.01 level

NS non significant

**Table 13. Yield Components as influenced by treatments**

| Treatment | Length of bunch (cm) | Bunch weight (kg) | No. of hands $bunch^{-1}$ | No. of fingers $bunch^{-1}$ | Length of fingers (cm) | Girth of fingers (cm) |
|---|---|---|---|---|---|---|
| $T_1$ | 63.33 | 14.67 | 8.67 | 118.33 | 23.33 | 12.50 |
| $T_2$ | 46.33 | 8.33 | 6.67 | 85.33 | 21.5 | 11.17 |
| $T_3$ | 53.00 | 11.00 | 7.67 | 90.67 | 21.67 | 11.67 |
| $T_4$ | 55.33 | 12.67 | 7.67 | 102.33 | 22.17 | 12.17 |
| $T_5$ | 62.33 | 13.67 | 8.33 | 111.67 | 23.17 | 12.33 |
| $T_6$ | 69.33 | 16.33 | 9.00 | 128.67 | 26.00 | 12.83 |
| $T_7$ | 55.00 | 10.67 | 8.00 | 98.67 | 22.67 | 11.50 |
| $T_8$ | 47.67 | 9.00 | 7.67 | 93.67 | 20.67 | 11.17 |
| CD | 2.18** | 1.32** | 1.04** | 5.71** | 0.98** | 0.66** |

** Significant at 0.01 level

### 4.3.1 TSS

TSS content was maximum in the treatment $T_6$ but was on par with that in $T_1$. With increase in substitution by Na above 50 per cent, there was reduction in TSS. The least TSS was at 100 per cent substitution by Na ($T_8$) and this was comparable to that at 75 per cent substitution by Na ($T_7$) and that at 25 per cent K alone ($T_2$).

### 4.3.2 Acidity

Acidity was least in the treatment $T_6$ (50 per cent substitution by Na) and the value was on par with that of $T_1$ (100 per cent K). Among the treatments which received K alone, there was increase in acidity with decrease in K supply. Among the eight treatments the highest acidity was for the treatment $T_2$ supplied with the least amount of K.

### 4.3.3 Total Sugars

Total sugar contents in $T_6$ with 50 per cent K and 50 per cent Na (23.17 %), $T_1$ with 100 per cent K (23.03 %), $T_5$ with 75 per cent K and 25 per cent Na (22.77 %), $T_7$ with 25 per cent K and 75 per cent Na (22.63 %) and $T_4$ with 75 per cent K (22.57 %) were on par and significantly higher than the sugar contents in the other treatments.

### 4.3.4 Sugar / acid ratio

Sugar/acid ratio was maximum in the treatment $T_6$ (85.8) followed by $T_1$ (83.25) and $T_5$ (79.43) and least in $T_2$ (66.45).

### 4.3.5 Pulp / peel ratio

Pulp/peel ratio was highest in $T_6$ (1.690) followed by $T_1$ (1.623) and lowest in $T_8$ with 100 per cent substitution with Na (1.377). Pulp/peel ratio increased from 1.403 at 25 per cent K level to 1.623 at 100 per cent K level.

### 4.3.6 Shelf life

No significant variation in shelf life was observed due to treatments. Maximum shelf life of 9 days was observed by the application of full recommended dose of potassium. Na application did not have any significant effect on the shelf life of fruits.

### 4.4 Total dry matter

Dry matter production values are shown in Table 15. Values varied significantly due to treatments. Application of Na along with K at 50:50 ratio was found to significantly increase the dry matter yield of plants. Maximum dry matter production was obtained by the substitution of 50 per cent of K by Na as CS. Above 50 per cent substitution by Na there was significant reduction in dry matter yield. The dry matter yield increased with increasing levels of K from 25 per cent to 100 per cent.

### 4.5 Nutrient content in whole plant

The nutrient content in whole plant varied significantly due to treatments. The values are shown in Table 16.

#### 4.5.1 Nitrogen

Nitrogen content in the banana whole plant ranged between 1.68 per cent in $T_8$ (100 % Na) and 1.74 per cent in $T_1$ (100 % K) and $T_5$ (75 % K + 25 % Na) treatments.

**Table 14. Quality Attributes as affected by treatments**

| Treatment | TSS (%) | Acidity (%) | Total Sugars (%) | Sugar / Acid Ratio | Pulp / peel ratio | Shelf life (days) |
|---|---|---|---|---|---|---|
| $T_1$ | 23.00 | 0.277 | 23.03 | 83.25 | 1.623 | 9.00 |
| $T_2$ | 21.67 | 0.327 | 21.70 | 66.45 | 1.403 | 7.67 |
| $T_3$ | 22.67 | 0.313 | 22.10 | 70.56 | 1.427 | 8.67 |
| $T_4$ | 22.67 | 0.297 | 22.57 | 76.08 | 1.493 | 8.67 |
| $T_5$ | 22.67 | 0.287 | 22.77 | 79.43 | 1.563 | 8.33 |
| $T_6$ | 23.67 | 0.270 | 23.17 | 85.80 | 1.690 | 8.67 |
| $T_7$ | 21.33 | 0.300 | 22.63 | 75.53 | 1.530 | 8.67 |
| $T_8$ | 21.00 | 0.310 | 22.27 | 71.91 | 1.377 | 8.00 |
| CD | 0.93** | 0.02** | 0.60** | 6.37** | 0.08** | NS |

** Significant at 0.01 level

NS non significant

**Table 15. Total Drymatter (kg ha$^{-1}$) as affected by treatments**

| Treatment | Drymatter (kg ha$^{-1}$) |
|---|---|
| $T_1$ | 19839 |
| $T_2$ | 16048 |
| $T_3$ | 17156 |
| $T_4$ | 19217 |
| $T_5$ | 19831 |
| $T_6$ | 20902 |
| $T_7$ | 18605 |
| $T_8$ | 16428 |
| CD | 284.20** |

** Significant at 0.01 level

#### 4.5.2 Phosphorus

Phosphorus content in the banana whole plant ranged between 0.21 per cent in $T_2$ (25 % K) and $T_4$ (75 % K) treatments and 0.24 per cent in $T_1$ (100 % K) and $T_6$ (50 % K + 50 % Na) treatments.

#### 4.5.3 Potassium

Potassium content in whole plant ranged between 3.91 per cent in $T_7$ (25 % K +75 % Na) treatment and 4.65 per cent in $T_1$ (100 % K) treatment. Potassium content was highest in 100 per cent K treatment.

#### 4.5.4 Sodium

Sodium content in the whole plant ranged between 0.06 per cent in $T_1$ (100% K) and 0.10 per cent in $T_7$ (25% K + 75% Na) and $T_8$ (100% Na) treatments Increase in the substitution of K by Na increased the Na content in plants with a maximum Na content of 0.10 per cent in $T_7$ (25% K + 75 % Na) and $T_8$ (100% Na) treatments.

#### 4.5.5 Chloride

Maximum chloride content (1.49 %) was found in $T_8$ (100 per cent Na) and the lowest content (1.28 %) in $T_6$ (50% K + 50% Na) treatment.

## 4.6 Nutrient content in bunches

Nutrient content in bunches varied significantly due to treatments. Table 17 shows data on nutrient content of bunches.

### 4.6.1 Nitrogen

Nitrogen content in banana bunch ranged between 0.71 per cent in $T_1$ (100 % K) treatment and 1.15 per cent in $T_7$ (25 % K + 75 % Na) treatment. Nitrogen content seemed to increase with substitution of K with Na from 25 per cent to 75 per cent level. But N content in the banana bunch was lowest (0.99 %) in $T_8$ (100 % Na) treatment.

### 4.6.2 Phosphorus

Phosphorus content in the banana bunch ranged between 0.19 per cent in $T_8$ (100% Na) and 0.23 per cent in $T_1$ (100 % K), $T_4$ (75% K) and $T_6$ (50 % K + 50 % Na) treatments. Application of Na along with K did not influence the P content in bunches.

### 4.6.3 Potassium

Potassium content in bunch ranged between 1.48 per cent in $T_2$ (25% K) treatment to 1.70 per cent in $T_6$ (50% K + 50% Na) treatment.

#### 4.6.4 Sodium

Sodium content in the bunch was 0.02 per cent irrespective of the treatments indicating the absorption of Na by the plants. Sodium content in bunches did not increase due to application of this element.

#### 4.6.5 Chloride

Chloride content in bunches was not found to be significantly affected by the application of Na along with K. Treatment $T_5$ (25 per cent substitution by Na) recorded the highest $Cl^-$ content of 0.89 per cent and treatment $T_2$ (25% K) recorded the lowest $Cl^-$ content of 0.55 per cent.

### 4.7 Nutrient uptake by plants

Uptake of various nutrients by plants was influenced significantly by the treatments. The values are shown in Table 18.

#### 4.7.1 Nitrogen

Fifty per cent substitution of K by Na recorded maximum uptake of N by plants (356.21kg $ha^{-1}$) and the uptake was lowest in the treatment $T_2$ receiving 25 per cent K (274.33kg). In general,

**Table 16. Nutrient content in whole plant (%) as influenced by treatments**

| Treatment | N | P | K | Na | Cl⁻ |
|---|---|---|---|---|---|
| $T_1$ | 1.74 | 0.24 | 4.65 | 0.06 | 1.35 |
| $T_2$ | 1.71 | 0.21 | 4.29 | 0.08 | 1.42 |
| $T_3$ | 1.70 | 0.22 | 4.40 | 0.072 | 1.38 |
| $T_4$ | 1.67 | 0.21 | 4.52 | 0.07 | 1.32 |
| $T_5$ | 1.74 | 0.23 | 4.60 | 0.07 | 1.35 |
| $T_6$ | 1.70 | 0.24 | 4.58 | 0.08 | 1.28 |
| $T_7$ | 1.77 | 0.22 | 3.91 | 0.10 | 1.38 |
| $T_8$ | 1.68 | 0.23 | 3.93 | 0.10 | 1.49 |
| CD | 0.03** | 0.01** | 0.19** | 0.003** | 0.04** |

** Significant at 0.01 level

**Table 17. Nutrient content in bunches (%) as influenced by treatments**

| Treatment | N | P | K | Na | Cl⁻ |
|---|---|---|---|---|---|
| $T_1$ | 0.71 | 0.23 | 1.67 | 0.02 | 0.74 |
| $T_2$ | 0.85 | 0.21 | 1.48 | 0.02 | 0.55 |
| $T_3$ | 0.83 | 0.22 | 1.62 | 0.02 | 0.88 |
| $T_4$ | 0.96 | 0.23 | 1.60 | 0.02 | 0.87 |
| $T_5$ | 1.07 | 0.22 | 1.59 | 0.02 | 0.89 |
| $T_6$ | 1.02 | 0.23 | 1.70 | 0.02 | 0.82 |
| $T_7$ | 1.15 | 0.21 | 1.51 | 0.02 | 0.61 |
| $T_8$ | 0.99 | 0.19 | 1.55 | 0.02 | 0.88 |
| CD | 0.12** | 0.01** | 0.12** | 0.004** | 0.08** |

** Significant at 0.01 level

partial substitution of K by Na stimulated higher uptake of N. But full substitution by Na reduced the N uptake.

### 4.7.2 Phosphorus

Hundred per cent substitution of K with Na reduced the P uptake significantly. $T_6$ (50 per cent substitution by Na) showed maximum uptake of P (49.16 kg $ha^{-1}$) followed by $T_1$ with 100 per cent K (48.09 kg $ha^{-1}$).

### 4.7.3 Potassium

Combined application of K and Na was found to increase K uptake when compared to application of K alone.

Treatment $T_1$ (100 per cent K as MOP) recorded K uptake of 923.83 kg $ha^{-1}$. When 50 per cent of K was substituted with Na ($T_6$) there was significantly higher uptake of K (1026.01 kg $ha^{-1}$). Full substitution of K by Na recorded the lowest K uptake (645.08 kg $ha^{-1}$).

### 4.7.4 Sodium

Treatments receiving sodium were found to recorded higher Na uptake and Na uptake increased with increase in substitution by Na upto 75 per cent level ($T_7$ with a Na uptake of 17.71 kg $ha^{-1}$) which was followed by $T_8$ (100 per cent substitution by Na) with a value of 16.5 kg $ha^{-1}$. Treatments which received only K as MOP had significantly lower K uptake values.

#### 4.7.5 Chloride

Though $Cl^-$ uptake was highest (267.93 kg $ha^{-1}$) at 50 per cent substitution by Na in $T_6$, $T_1$ (100 per cent K) and $T_5$ (25 per cent substitution by Na) recorded almost equal values of $Cl^-$ uptake. Other treatments had significantly lesser $Cl^-$ uptake but Na was in general found to favour $Cl^-$ uptake. Partial substitution by Na significantly increased $Cl^-$ uptake.

### 4.8 Soil Analysis

#### 4.8.1 Soil pH

Soil pH after first and second fertilizer applications showed significant variation due to treatments (Table 19).

Partial substitution by Na did not have much influence on the soil pH but 100 per cent substitution by Na showed significantly higher pH. But at harvest, the pH did not vary significantly due to treatments.

#### 4.8.2 EC

EC values were less than 0.02 $dSm^{-1}$ in all treatment plots at all stages.

#### 4.8.3 WHC

Data on WHC are presented in Table 20. There was no significant variation in WHC at the first and second stages except at harvest.

**Table 18. Nutrient uptake (kg $ha^{-1}$) by plants as influenced by treatments**

| Treatment | N | P | K | Na | $Cl^-$ |
|---|---|---|---|---|---|
| $T_1$ | 344.48 | 48.09 | 923.83 | 12.81 | 267.27 |
| $T_2$ | 274.33 | 34.18 | 688.83 | 11.94 | 228.27 |
| $T_3$ | 291.39 | 38.33 | 755.16 | 12.43 | 236.73 |
| $T_4$ | 320.26 | 40.21 | 868.52 | 12.83 | 254.27 |
| $T_5$ | 344.91 | 44.75 | 911.86 | 14.22 | 267.23 |
| $T_6$ | 356.21 | 49.16 | 1026.01 | 15.91 | 267.93 |
| $T_7$ | 329.38 | 40.25 | 726.77 | 17.71 | 256.83 |
| $T_8$ | 275.71 | 37.08 | 645.08 | 16.50 | 245.20 |
| CD | 4.52** | 1.13** | 74.71** | 0.70** | 6.18** |

** Significant at 0.01 level

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**Table 19. Soil pH as affected by treatments**

| Treatment | After first fertilizer application | After second fertilizer application | At Harvest |
|---|---|---|---|
| $T_1$ | 4.70 | 4.55 | 4.59 |
| $T_2$ | 4.75 | 4.42 | 4.55 |
| $T_3$ | 4.63 | 4.37 | 4.51 |
| $T_4$ | 4.56 | 4.36 | 4.35 |
| $T_5$ | 4.53 | 4.88 | 4.67 |
| $T_6$ | 4.60 | 4.74 | 4.61 |
| $T_7$ | 4.65 | 4.26 | 4.45 |
| $T_8$ | 4.72 | 4.85 | 4.69 |
| CD | 0.13* | 0.20** | NS |

* Significant at 0.05 level

** Significant at 0.01 level

NS non significant

#### 4.8.4 Organic carbon

Organic carbon values are presented in Table 21. Organic carbon content varied in the different treatments, $T_6$ (0.75%) treatment being the highest and $T_2$ (0.43%) treatment the lowest at the first and second sampling stages. At the harvest stage the lowest value was recorded by the treatment $T_8$ (0.43%).

At harvest, 100 per cent substitution had the least soil organic carbon content.

#### 4.8.5 Available N

Soil available N values are presented in Table 22. The values differed significantly at the first and second stages due to treatments except at harvest. At harvest stage highest value was recorded by the treatment $T_8$ (100 % Na).

#### 4.8.6 Available P

Soil available P varied significantly due to treatments. Values are shown in Table 23. At harvest the available P values in all the plots decreased.

#### 4.8.7 Available K

Soil available K values (Table 24) varied significantly between treatments at the first and second stage of sampling. Highest value was recorded by the treatment $T_6$ at the first stage and $T_1$ at the second stage. At harvest stage it was highest in $T_8$ (214 kg $ha^{-1}$).

**Table 20. WHC (%) as influenced by treatments**

| Treatment | After first fertilizer application | After second fertilizer application. | At Harvest |
|---|---|---|---|
| $T_1$ | 33.56 | 27.63 | 33.30 |
| $T_2$ | 31.59 | 28.13 | 28.32 |
| $T_3$ | 31.92 | 29.45 | 36.68 |
| $T_4$ | 34.50 | 30.12 | 26.38 |
| $T_5$ | 32.46 | 29.49 | 27.32 |
| $T_6$ | 33.19 | 29.53 | 27.36 |
| $T_7$ | 32.26 | 26.92 | 30.64 |
| $T_8$ | 33.98 | 28.04 | 28.14 |
| CD | NS | NS | 4.43** |

** Significant at 0.01 level

NS non significant

**Table 21. Organic carbon (%) as influenced by treatments**

| Treatment | After first fertilizer application. | After second fertilizer. application | At Harvest |
|---|---|---|---|
| $T_1$ | 0.70 | 0.50 | 0.65 |
| $T_2$ | 0.43 | 0.34 | 0.49 |
| $T_3$ | 0.52 | 0.42 | 0.54 |
| $T_4$ | 0.55 | 0.45 | 0.58 |
| $T_5$ | 0.67 | 0.50 | 0.60 |
| $T_6$ | 0.75 | 0.60 | 0.66 |
| $T_7$ | 0.54 | 0.39 | 0.56 |
| $T_8$ | 0.50 | 0.30 | 0.43 |
| CD | 0.14** | 0.05** | 0.07** |

** Significant at 0.01 level

Table 22. Available N (kg $ha^{-1}$) as influenced by treatments

| Treatment | After first fertilizer application | After second fertilizer application | At Harvest |
|---|---|---|---|
| $T_1$ | 198 | 198 | 194 |
| $T_2$ | 174 | 167 | 197 |
| $T_3$ | 179 | 172 | 210 |
| $T_4$ | 183 | 178 | 196 |
| $T_5$ | 192 | 175 | 154 |
| $T_6$ | 201 | 196 | 193 |
| $T_7$ | 186 | 168 | 204 |
| $T_8$ | 170 | 162 | 214 |
| CD | 12.22** | 14.66** | NS |

** Significant at 0.01 level

NS non significant

Table 23. Available P (kg $ha^{-1}$) as affected by treatments

| Treatment | After first fertilizer application | After second fertilizer application | At Harvest |
|---|---|---|---|
| $T_1$ | 63.5 | 73.3 | 31.5 |
| $T_2$ | 54.0 | 61.4 | 36.5 |
| $T_3$ | 57.7 | 63.6 | 37.0 |
| $T_4$ | 60.0 | 68.4 | 37.8 |
| $T_5$ | 63.4 | 73.1 | 34.9 |
| $T_6$ | 66.0 | 74.8 | 36.8 |
| $T_7$ | 56.0 | 66.4 | 34.4 |
| $T_8$ | 51.0 | 59.9 | 36.8 |
| CD | 4.20** | 5.45** | 2.05** |

** Significant at 0.01 level

### 4.8.8 Available Na

Available Na values are presented in Table 25. Highest value was observed in treatment $T_6$ at all stages and the lowest was in $T_2$.

### 4.9 Economic analysis

B:C ratios varied significantly due to treatments. Values are shown in Table 27.

Maximum profit was obtained in $T_6$ (50 per cent substitution by Na) with a B: C ratio of 1.99 followed by $T_1$ (100 per cent K) with a value of 1.78. $T_2$ (25 per cent K alone) was found to be least profitable. Substitution by Na above 50 per cent level reduced the B: C ratio.

### 4.10 Correlation studies

The correlation of various parameters to yield was studied. Plant girth (2MAP), LAI (6MAP), total chlorophyll content (4MAP) and total dry matter showed significant positive correlation to yield, with values of 0.7096**, 0.8407**, 0.4220** and 0.9323** respectively(Table 28).

**Table 24. Available K (kg $ha^{-1}$) as influenced by treatments**

| Treatment | After first fertilizer application | After second fertilizer application | At Harvest |
|---|---|---|---|
| $T_1$ | 127.0 | 149.1 | 91.8 |
| $T_2$ | 105.9 | 89.9 | 61.5 |
| $T_3$ | 112.6 | 100.9 | 75.3 |
| $T_4$ | 117.1 | 133.1 | 85.3 |
| $T_5$ | 128.7 | 173.3 | 139.6 |
| $T_6$ | 138.4 | 170.3 | 89.6 |
| $T_7$ | 111.3 | 99.5 | 70.7 |
| $T_8$ | 110.6 | 106.4 | 82.3 |
| CD | 14.98** | 39.95** | 24.68** |

** Significant at 0.01 level

**Table 25. Available Na (kg $ha^{-1}$) as influenced by treatments**

| Treatment | After first fertilizer application | After second fertilizer application | At Harvest |
|---|---|---|---|
| $T_1$ | 70.3 | 67.0 | 61.0 |
| $T_2$ | 49.3 | 49.0 | 43.2 |
| $T_3$ | 59.0 | 50.7 | 44.3 |
| $T_4$ | 56.3 | 63.3 | 58.5 |
| $T_5$ | 68.3 | 58.3 | 50.2 |
| $T_6$ | 75.7 | 72.7 | 63.3 |
| $T_7$ | 66.0 | 62.3 | 51.4 |
| $T_8$ | 55.3 | 58.7 | 52.3 |
| CD | 5.65** | 10.49** | 15.76** |

** Significant at 0.01 level

**Table26. Economics of banana cultivation**

| Treatment | Total returns (Rs. $ha^{-1}$) | Total expenditure (Rs. $ha^{-1}$) | Profit (Rs. $ha^{-1}$) |
|---|---|---|---|
| $T_1$ | 179493 | 100594 | 78899 |
| $T_2$ | 105616 | 96886 | 8730 |
| $T_3$ | 136470 | 98122 | 38348 |
| $T_4$ | 155953 | 99358 | 56595 |
| $T_5$ | 168123 | 100306 | 67817 |
| $T_6$ | 198977 | 100022 | 98955 |
| $T_7$ | 132613 | 99736 | 32877 |
| $T_8$ | 113330 | 99450 | 13880 |

**Table 27. Economic Analysis**

| Treatment | B:C ratio |
|---|---|
| $T_1$ | 1.78 |
| $T_2$ | 1.09 |
| $T_3$ | 1.39 |
| $T_4$ | 1.57 |
| $T_5$ | 1.67 |
| $T_6$ | 1.99 |
| $T_7$ | 1.33 |
| $T_8$ | 1.14 |
| CD | 0.16** |

** Significant at 0.01 level

**Table 28. Correlation of different parameters to yield**

| Character | Correlation coefficient |
|---|---|
| Plant girth (2MAP) | 0.7096** |
| Duration of vegetative phase | -0.9241** |
| LAI (6MAP) | 0.8407** |
| Total Chlorophyll (4MAP) | 0.4220** |
| Total dry matter | 0.9323** |

** Significant at 0.01 level

# DISCUSSION

# 5. DISCUSSION

The experiment entitled 'Substitution of muriate of potash by common salt in banana *Musa* (AAA group Cavendish subgroup) 'Robusta' was conducted in the Instructional Farm, College of Agriculture, Vellayani from August 1999 to June 2000. Inorder to find out the extent of substitution of MOP by CS, varying levels of substitution of MOP by CS were applied. The results of the experiment are discussed in this chapter.

## 5.1 Growth Characteristics:

Maximum plant height and girth were recorded when K and Na were supplied at equal concentrations (50:50). At this level these parameters were greater than the full potash treatment at all stages. In treatments receiving K alone at 25, 50 and 75 per cent of the recommended level, these parameters were lower indicating that K supply was not sufficient in these treatments for the normal growth of the plants.

It has been reported that the girth of the pseudostem and yield of plants in banana are positively correlated (Mathew, 1980).

Therefore a high value of girth at early stages of growth is very important as far as crop yield is concerned.

The pseudostem in banana is a concentric bundle of leaf sheaths emerging from the underground corm. The normal phyllotaxy of the plant is at an angle of $160^0$. In the treatment where K and Na were added at 50:50 proportion the girth and height of plants were significantly higher than in the treatment with 100 per cent K at 4, 6 and 8 MAP and at harvest stages. Increased plant height by combined application of K and Na at equal proportions was reported by Devi (1995) in cassava and Lekshmi (2000) in banana cv. Nendran.

Height of the banana plant has a direct relationship with the number of leaves produced by it (Summerville, 1994). $T_6$ ie. 50 per cent substitution by Na recorded maximum values for number of leaves and LAI at all stages of growth. But, with increase in substitution above 50 per cent, there was a reduction in leaf number and LAI(Fig.3).

Girth of the pseudostem also has a direct bearing on the number of leaves produced as the pseudostem in banana is made up of tightly packed leaf sheaths. Hundred per cent substitution of K by Na was found to have adverse effects on growth by reducing the leaf number and LAI.

Leaf production in banana is related to increased rate of plant growth. The increased photosynthetic efficiency by means of producing more number of leaves, greater height and pseudostem girth increase the potential for producing heavier bunches(Barker and Steward, 1962). Common salt application along with muriate of potash at equal K : Na proportion was found to stimulate the growth parameters.

When K and Na were supplied at 50:50 proportion, Prema *et al.* (1992) recorded maximum number of leaves in experiment with coconut. Devi (1995) reported that at all stages of growth, the treatment 50 per cent MOP + 50 per cent CS recorded maximum LAI in cassava. Lekshmi (2000) also observed similarly in banana cv. Nendran.

The chlorophyll contents in $T_1$ (100% K) and $T_6$ (50 per cent substitution of K by Na) were on par at all but harvest stage. Even at 100 per cent substitution by Na, there was high chlorophyll production (Fig. 4). Treatments $T_2$, $T_3$ and $T_4$ recorded

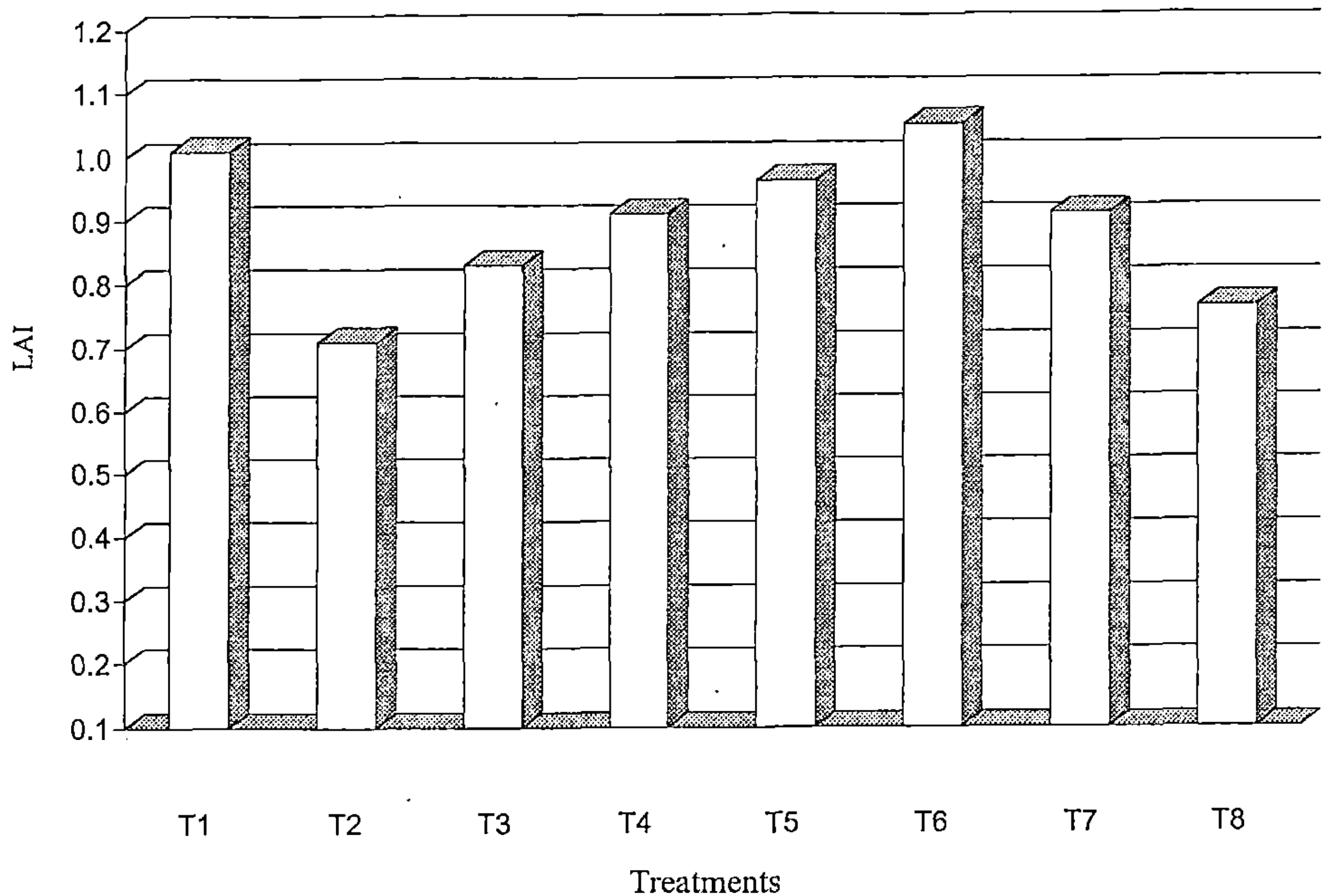


**Fig. 3 LAI of plants (2 MAP) as affected by different treatments**

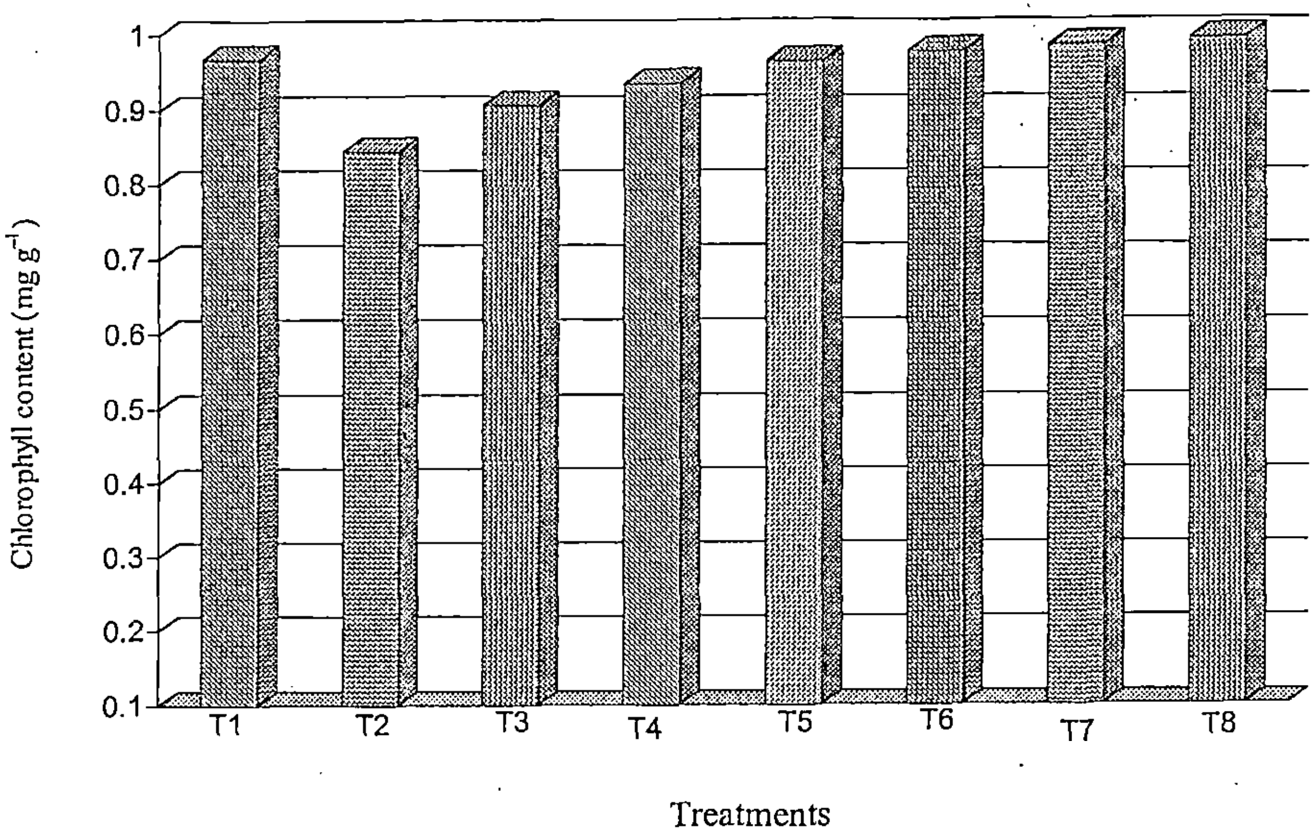


**Fig. 4 Chlorophyll content of plants (2 MAP) (mg $g^{-1}$) as influenced by different treatments**

lesser chlorophyll content with $T_2$ the least. When the balance quantity of K in these treatments was substituted by Na (treatments $T_7$, $T_6$ and $T_5$ respectively) the chlorophyll content was found to increase. This shows that Na is playing a role in chlorophyll production. Sodium is found to increase the chlorophyll content of plants (Ando and Oguchi, 1990). It participates in chlorophyll biosynthesis after 5-amino laevulinic acid synthesis. Devi (1995) also observed an increase in total chlorophyll content with Na substitution in cassava. The total amount of chlorophyll was also maximum in plots where 50 per cent K was substituted by Na of common salt.

The RLWC also showed significant variation due to the treatments. In general, there was an increase in leaf water content by the addition of sodium. Banana being a mesophyte, requires large amount of water because of the large foliage area and high moisture content of the pseudostem. Krishnan and Shanmughavelu (1980) conducted studies on water requirements of banana seedling var. Robusta. The height and girth of the pseudostem, total leaf area and number of leaves per plant at shooting stage increased significantly with increase in moisture absorption. The high relative water content in Na treated plants at all growth stages showed that the WUE of the plants increased with Na supply. Leaf moisture content in banana especially cv. Robusta is crucial in determining the plant growth, development and yield. Thus the addition of Na helped the plants to maintain a relatively high leaf water content which led to a high WUE and ultimately to total dry matter production. This is achieved by a reduction of transpiration rate. Na and $Cl^-$ ions accumulate mainly in the vacuole rather than in the cytoplasm (Greenway and Munns, 1980), their accumulation therefore being conducive to osmotic adjustment and turgor maintenance. Gorham *et al.* (1985) reported that reduction of transpiration rate is a characteristic response to salinity. Devi (1995) observed that when 50 per cent of K was substituted by Na, there was higher RLWC upto harvest stage in cassava.

### 5.2 Yield and yield attributes

The yield and yield components are presented in Table 13. The various yield parameters and yield varied significantly due to treatments. In general, the yield parameters were higher in $T_6$ ( 50 per cent substitution by Na). With increase in substitution above this level, there was a reduction in yield and yield parameters(Fig. 5). The yield components such as length of bunch, bunch weight, number of fingers per bunch and length of fingers were significantly higher in $T_6$ compared to other treatments. Other parameters such as number of hands per bunch, girth of fingers and pulp/peel ratio, eventhough higher, were on par with the values in $T_1$.

The stimulation in growth obtained by plants receiving Na in the early stages of growth was reflected in yield and yield attributes. The physiological parameters like chlorophyll content and RLWC were found significantly higher in the treatment receiving K and Na in equal proportions. The general vigour attained by the plant from the early vegetative phase of the plant helped in maximum absorption and uptake of mineral nutrients and water leading to a vigorous growth. As a result, the growth attributes were also higher helping the plant in tapping maximum solar radiation and water thereby increasing the photosynthetic and water use efficiencies of the plant leading to higher production rate. This is evident from the significant positive correlation of plant girth, LAI, chlorophyll content, total dry matter production, length of bunch and number of fingers per bunch with bunch yield. Sheela (1995) obtained high positive correlation of

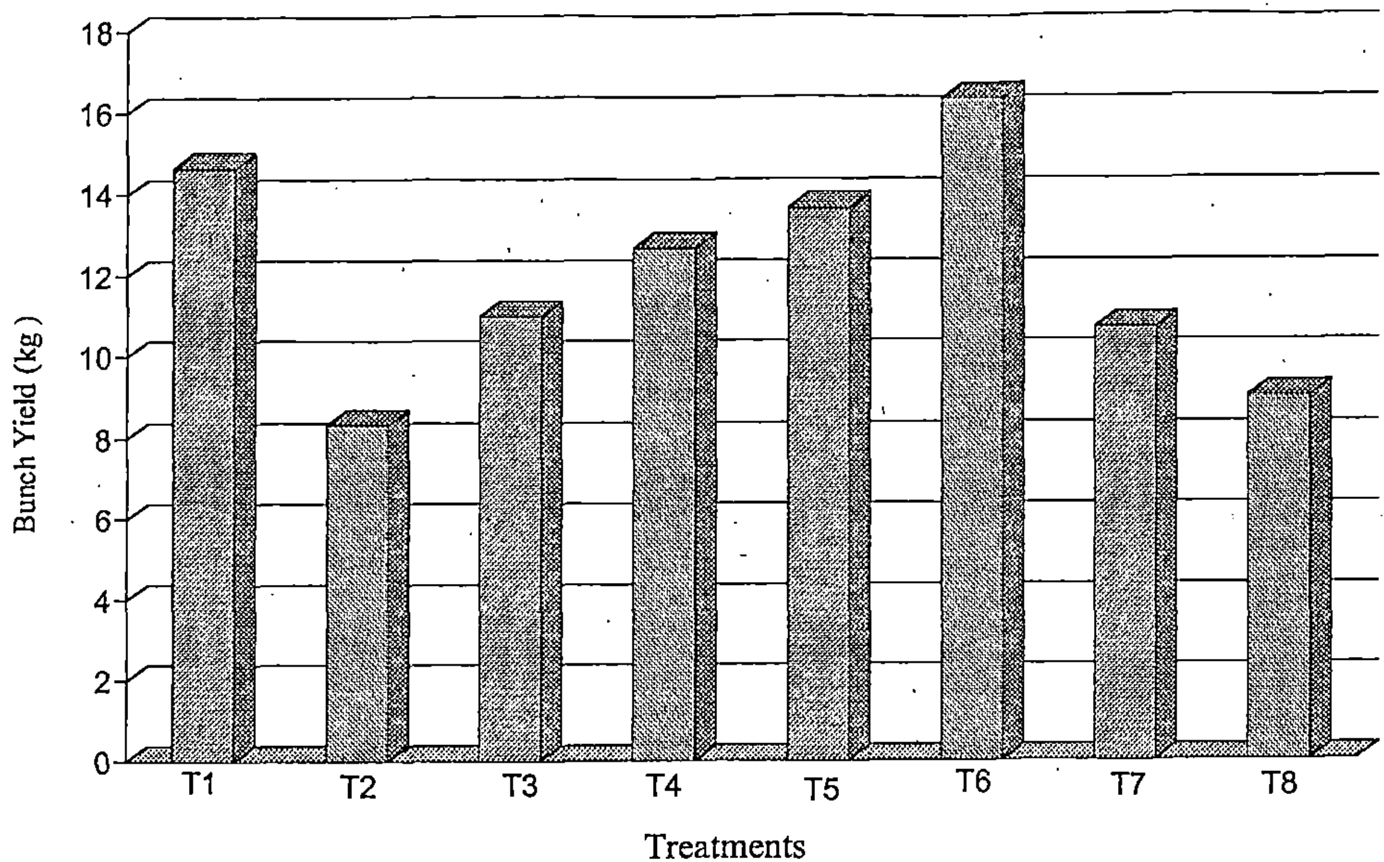


**Fig. 5 Bunch Yield (kg) of plants as influenced by different treatments**

height and girth of plants at shooting, total leaf production, leaf area and number of functional leaves at shooting with the yield. Among the yield attributes the number of fingers and length of bunch had the highest correlation with yield (0.93 each). Similar result was reported by Vijayaraghavakumar (1981).

In the treatments $T_2$, $T_3$, and $T_4$ there was a pronounced reduction in yield and yield attributes. In these treatments which received K in lesser amounts than the recommended quantity the plants were not able to attain optimum growth from the early stages of growth. Consequently the various growth parameters recorded lower values compared to the growth in the treatment with full recommended dose of K and the treatments receiving Na along with K. This indicates that for optimum growth and yield, plants should receive K at the recommended dose. But the comparative higher values of yield and yield attributes in treatments $T_5$ and $T_6$ revealed that the optimum and adequate growth can be attained by the plants even if the K requirement is partially substituted.This may be because of the ability of Na to take over some of the functions of K sparing K for its more specific functions.

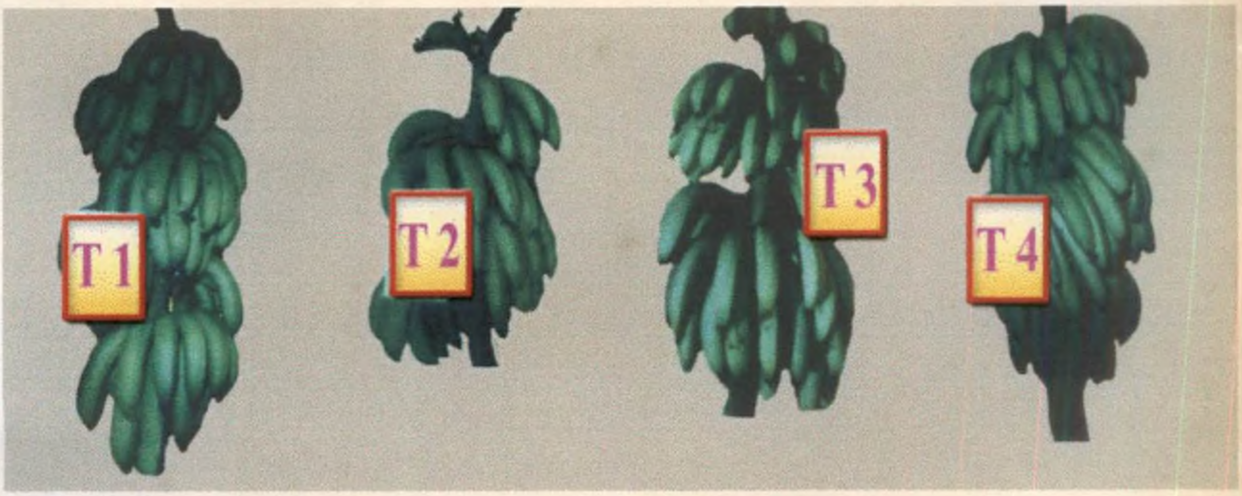


Plate1:- Effect of treatments T1, T2, T3 and T4 on bunch yield of 'Robusta' banana.

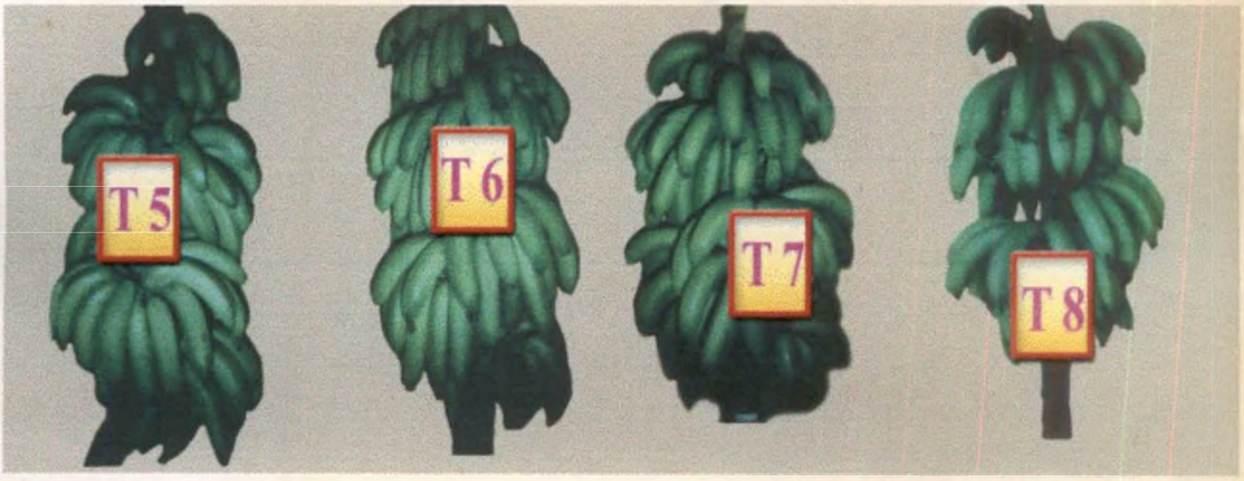


Plate2 :- Effect of treatments T5, T6, T7 and T8 on bunch yield of 'Robusta' banana.

### 5.3. Dry matter production

The comparatively high rate of growth as a result of application of K and Na at equal concentrations resulted in comparatively high biomass accumulation rates leading to higher rates of dry matter production. Maximum dry matter production was recorded in $T_6$ (50 per cent substitution of K by Na). Dry matter production in $T_5$ (25% substitution of K by Na) and $T_1$(100% K) was on par(Fig.6).

With increase in Na substitution beyond 50 percent level the dry matter production was found to decrease. This may be due to the adverse effects of improper nutrient balance. Treatments $T_2$, $T_3$ and $T_4$ recorded lower dry matter production as the growth parameters recorded lower values in these treatments which reduced the growth and yield of these plants. But with the addition of balance amount of K as Na of common salt in the treatments $T_7$, $T_6$ and $T_5$, there was significant increase in dry matter production showing that Na is effective as a partial substitute for K, though full K requirement of the plant cannot be satisfied by Na.

At 50:50 substitution, there was better growth of plants as the $Na^+$ and $K^+$ were present in equal concentration. When $Na^+$ in the protoplasm of the cell increases, some of the K ions present in the

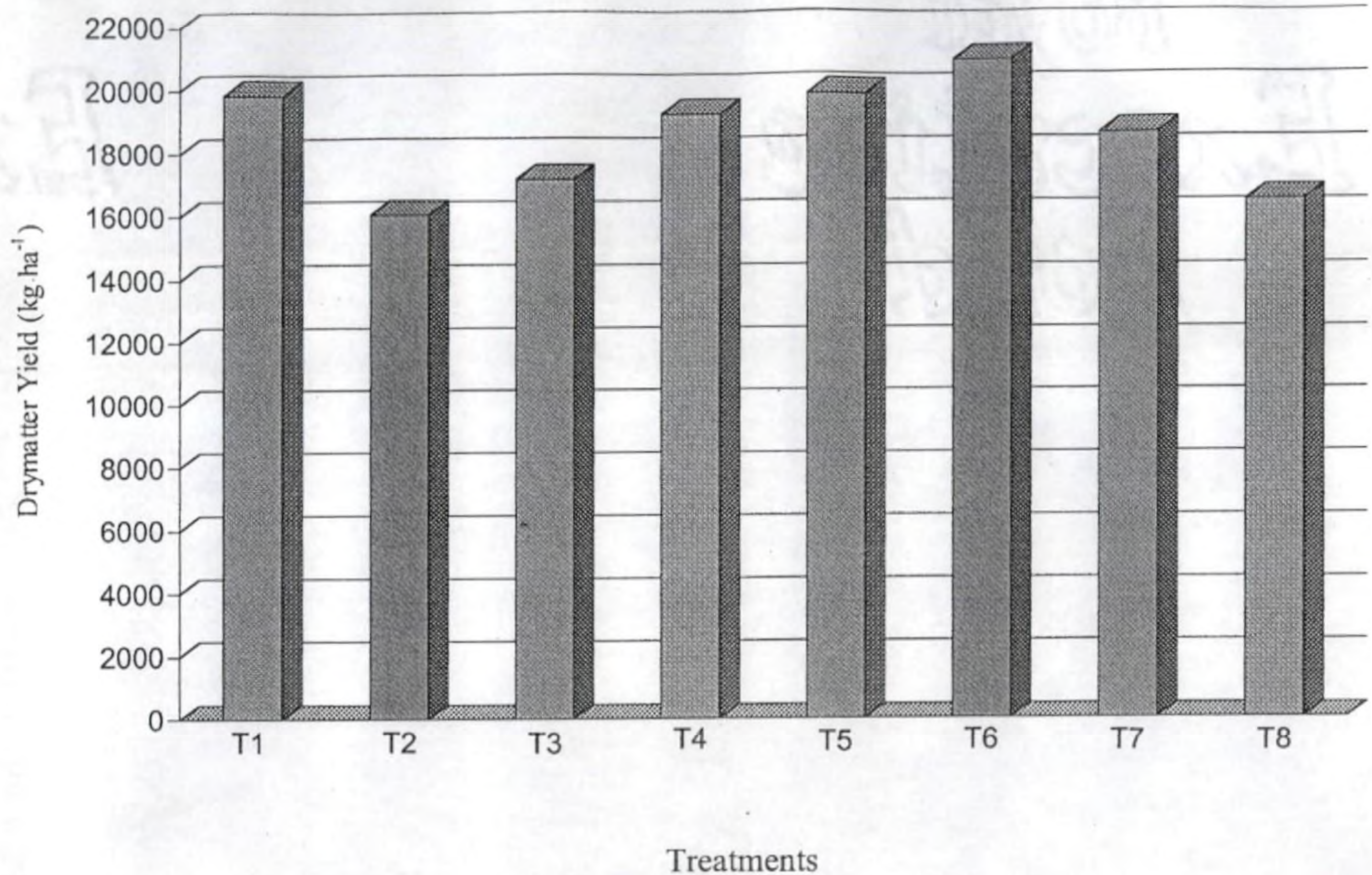


**Fig. 6 Total Dry Matter (kg ha$^{-1}$) of plants as influenced by different treatments**

vacuole may be substituted by Na ions in the protoplasm, making K available for specific functions. The degree of replacement of K by Na depends upon the plant species (Harmer and Benne, 1945).

Lekshmi (2000) observed that with increase in the substitution of K by Na above 50 per cent, there was reduction in dry matter production in banana cv. Nendran. Maximum dry matter production was obtained by 50 per cent substitution of K by Na of CS.

**5.4 Quality parameters**

The quality parameters of TSS, acidity, total sugars, sugar/acid ratio, pulp/peel ratio and shelf life of fruits were studied. These parameters, except shelf life, showed significant variation due to treatments. The quality parameters in the treatments $T_1$ (100% K) and $T_6$ (50% K and 50% Na) were on par indicating that the quality of banana was not affected adversely upto 50 per cent substitution of K with Na. Substitution of K with Na above 50 per cent reduced the quality of fruits due to increase in acidity and decrease in TSS, total sugar content and sugar/acid ratio.

Among the various quality parameters, the total sugar content of the fruit is much valued because Robusta is a dessert variety of banana. It is interesting to note that addition of CS along with MOP upto 50:50 ratio increased the total sugar content of the fruit. The same trend was reflected in the sugar/acid ratio also. Acidity of the fruit was maximum in the treatment receiving K alone at the lowest level. In experiments conducted by Chandler *et al.* (1989) in sugar beet, total sugar and sucrose content of tuber increased slightly in direct proportion with Na concentration. Devi and Padmaja (1996) also recorded similar results in cassava tubers. Corroborative observations were made by Lekshmi (2000) in banana cv. Nendran.

According to Sinhar *et al.* (1989) conversion of sucrose to starch is mediated through a series of intermediary metabolites like Glucose 1-phosphate, UDP-glucose etc. in the cytosol and amyloplast, with the involvement of enzymes starch synthetase and phosphorylase. When K and Na were supplied together at equal proportion, an optimal functioning of sucrose synthetase and suppression of hydrolytic enzymes would have taken place, the net result of which might be build-up of more quantity of sugars in proplastids. It has been reported that Na, when supplied with K, is able to stimulate the activity of several enzymes (Hansson and Kylin, 1969; Devi and Padmaja, 1996; Berteli *et al.*, 1995). In the treatments $T_2$, $T_3$ and $T_4$ (K alone in different doses) the total sugar content was significantly lower due to insufficiency of K.

Among the treatments supplied with K alone ($T_1$, $T_2$, $T_3$ and $T_4$) at various levels, it was seen that with increase in K application there was improvement in fruit quality. Maximum quality was recorded in $T_1$ (100 per cent K alone) and minimum in $T_2$ (25 per cent K alone). Treatment $T_1$ recorded high TSS, total sugar content and sugar/acid ratio with less acidity, thus improving fruit quality. An increase in TSS, total sugar content and sugar/acid ratio and reduction in acidity were recorded by several workers by increasing levels of K (Vadivel and shanmughavelu, 1988; Singh *et al.*, 1974; Tandon and Sekhon, 1988).

The pulp/peel ratio was significantly lower in treatments $T_2$, $T_3$, $T_4$ (K at 25, 50 and 75 per cent level). The pulp/peel ratios in $T_1$ (100% K) and $T_6$ (50:50 proportion of K and Na) were on par showing that even by substitution of K by Na upto 50 per cent a desirable pulp/peel ratio can be maintained.

The shelf life of fruits which is an important parameter as far as quality is concerned did not vary significantly indicating insignificant influence of Na on shelf-life.

### 5.5 Nutrient uptake

Banana requires high amount of nutrients to give high yields. In general, banana has high demands for N and K.

Nitrogen content in the whole plant did not vary significantly among the treatments but the N uptake by the banana plant was significantly higher in the treatment $T_6$ (50% K + 50% Na) due to significantly higher drymatter (Fig. 7). The lower values of N uptake in treatments $T_2$ and $T_8$ was due to poor vegetative growth of the plants in these treatments.

Significantly higher P uptake was recorded in treatments $T_6$ (50% K + 50% Na) and in $T_1$(100% K) than in the other treatments (Fig.8). Although P content in the whole plant is same in the treatments $T_1$and $T_6$ (0.24%) the total P uptake by the plant in $T_6$ treatment is higher due to higher drymatter yield in the treatment $T_6$.

Although K content in the whole plant is higher in $T_1$ treatment (4.65%) than in the $T_6$ treatment (4.58%) the total K uptake is significantly higher in the treatment $T_6$ (50% K + 50% Na) than in the treatment $T_1$ (100% K) due to significantly higher drymatter yield in $T_6$. K uptake was lowest in $T_8$ (100% Na) treatment (Fig.9).

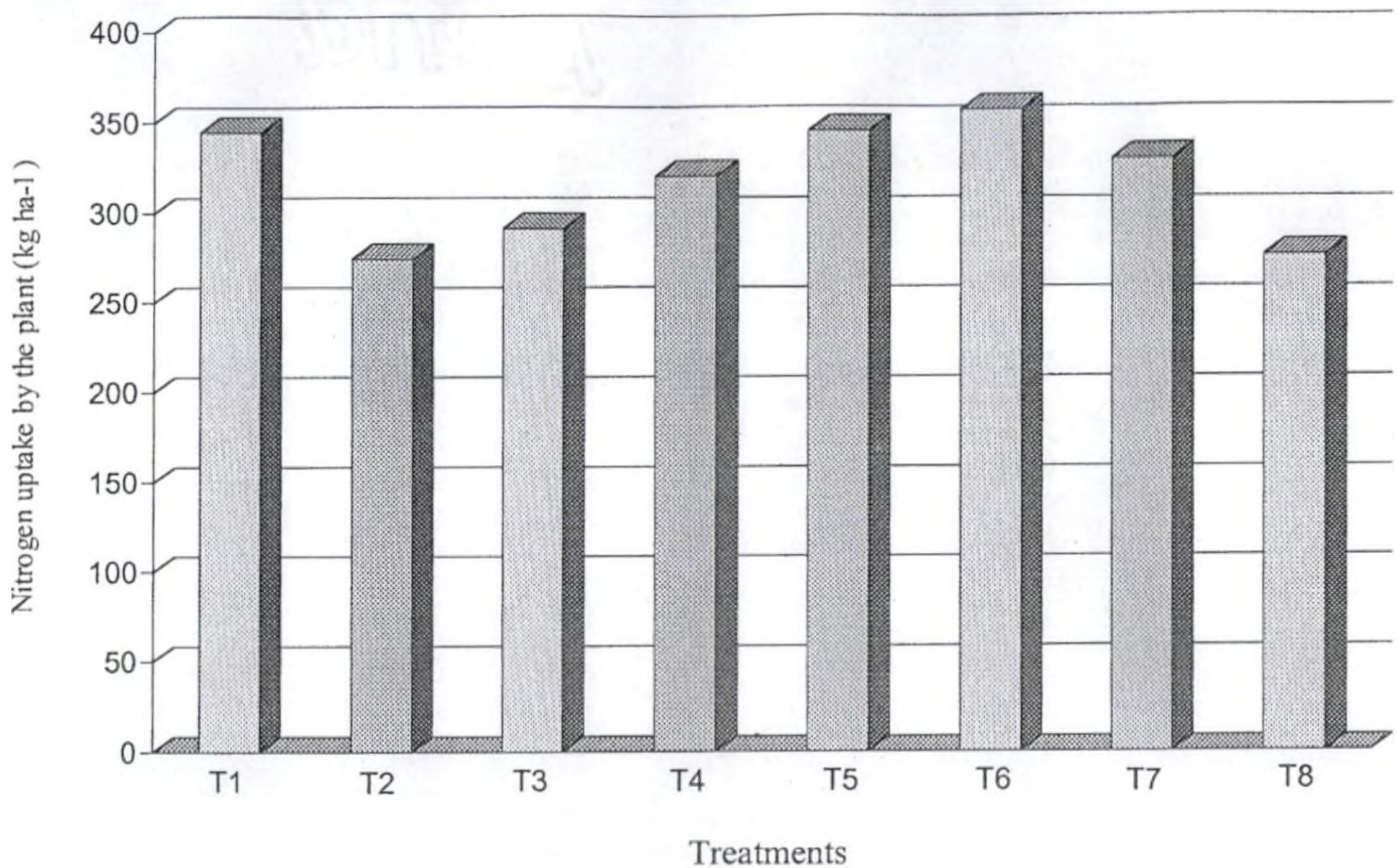


**Fig.7 Nitrogen Uptake (kg ha$^{-1}$) by plants as affected by different treatments**

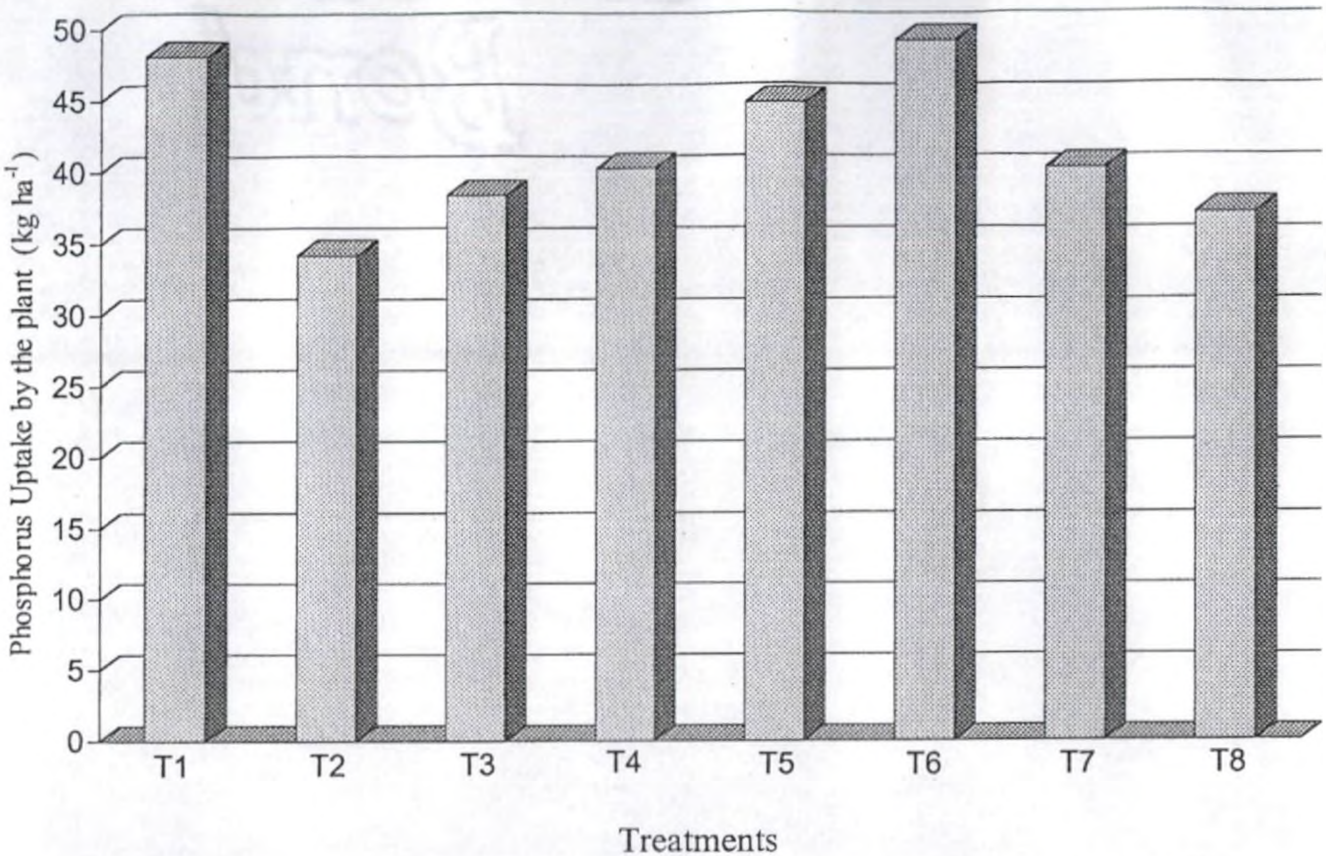


**Fig. 8 Phosphorus Uptake (kg $ha^{-1}$) by plants as influenced by different treatments**

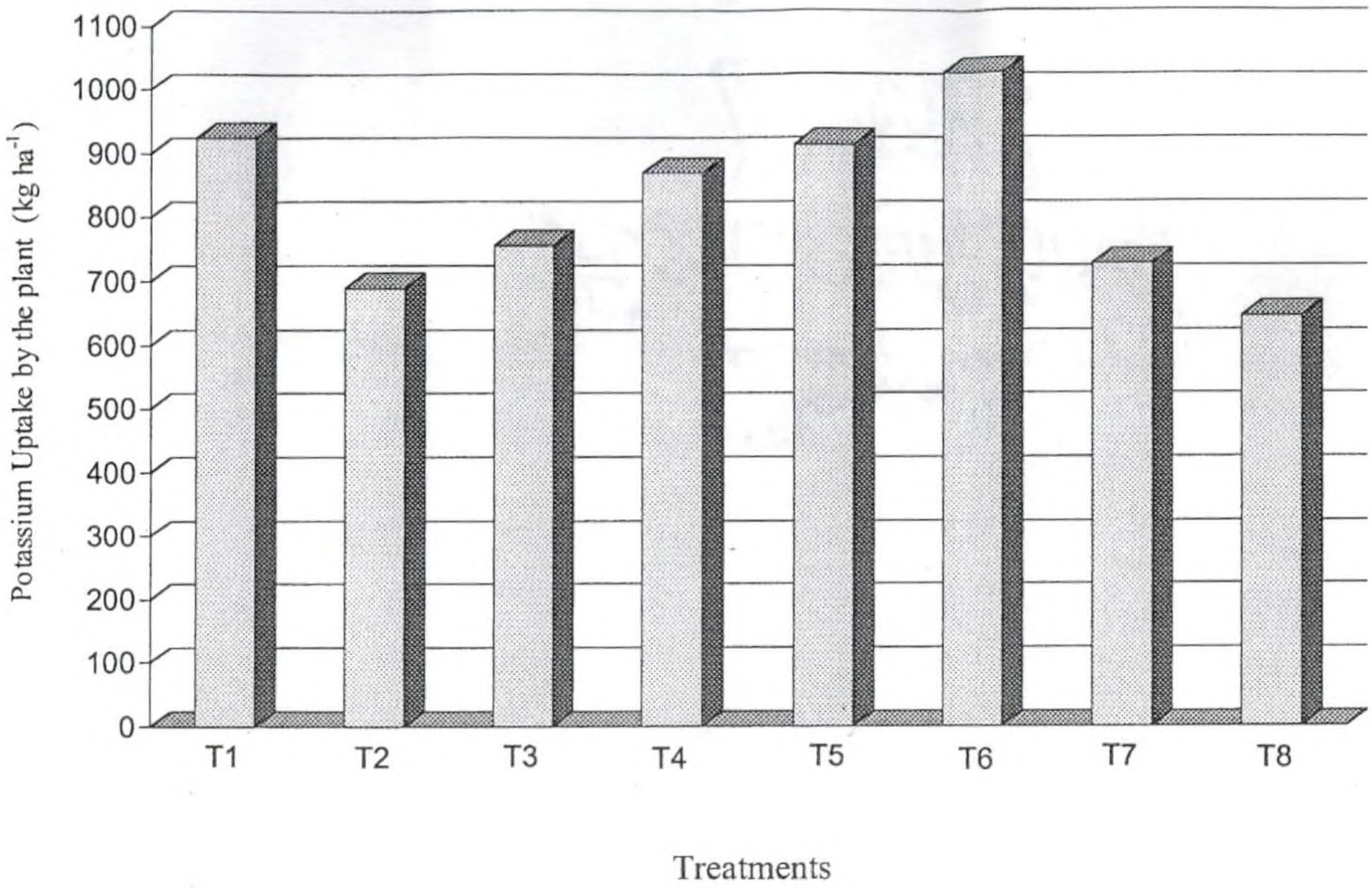


**Fig. 9 Potassium Uptake (kg ha$^{-1}$) by plants as influenced by different treatments**

Sodium content in the plant and uptake by the plant were significantly higher in the treatments receiving Na as a substitute for K.

Chloride uptake (Fig. 11) in treatments $T_6$ (50% K + 50% Na), $T_1$ (100% K) and $T_5$ (75% K + 25% Na) were on par and significantly higher than the uptake in the other treatments.

**5.6 Changes in physical and chemical properties of soil due to substitution of K with Na**

The pH of the soil has increased significantly due to substitution of K by Na at first and second stages of fertilizer applications but the variations seemed to be not significant at the harvest stage. The treatments did not influence the EC of the soil significantly. These results indicated that increase in pH at the early stages would be temporary and the effect of Na would have disappeared due to leaching of sodium in the drainage water at the harvest stage.

The organic carbon contents of the soil increased from the initial stage and was higher after first fertilizer application than in the other stages. This may be due to the addition of FYM at the time

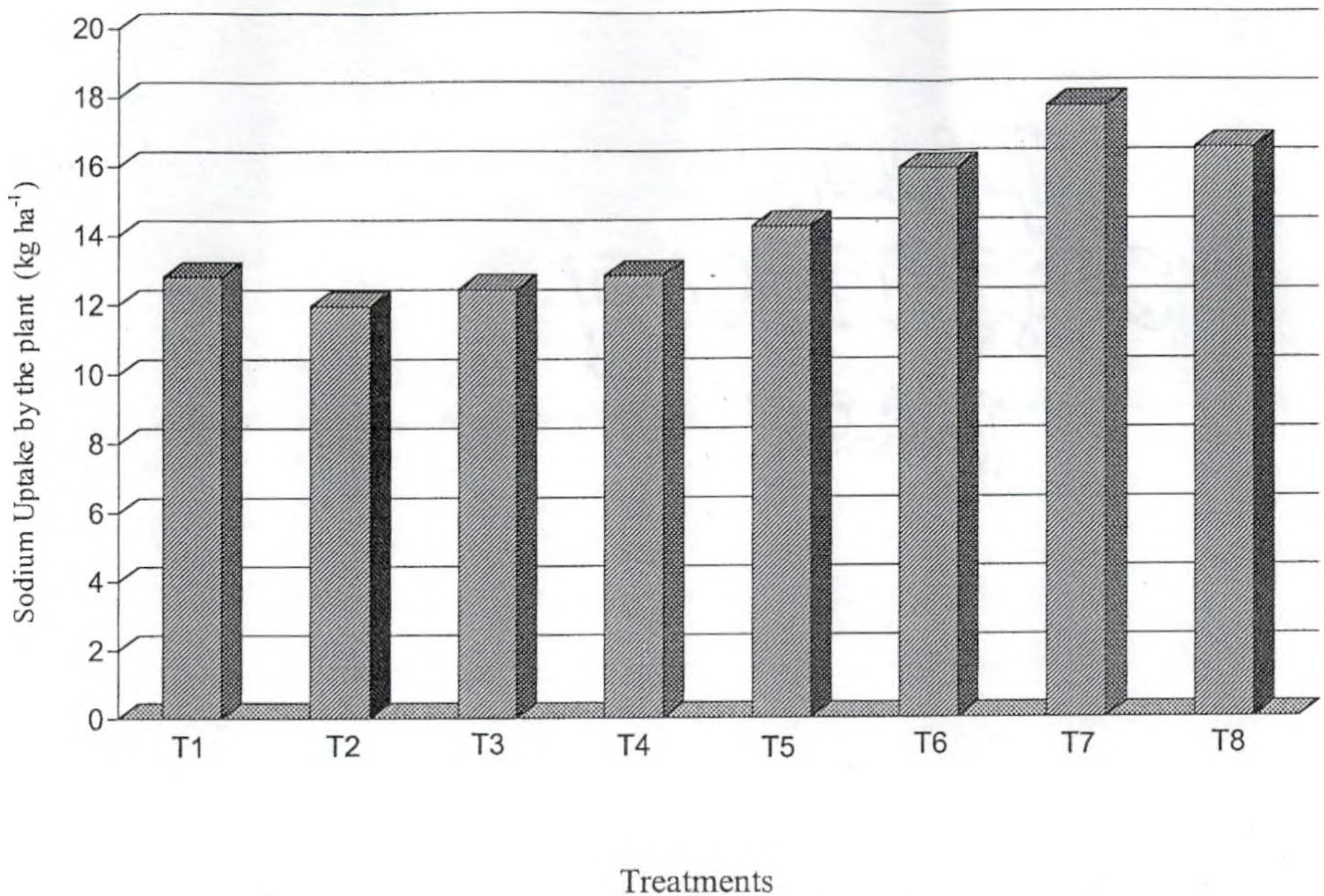


**Fig. 10 Sodium uptake (kg $ha^{-1}$) by plants as influenced by different treatments**

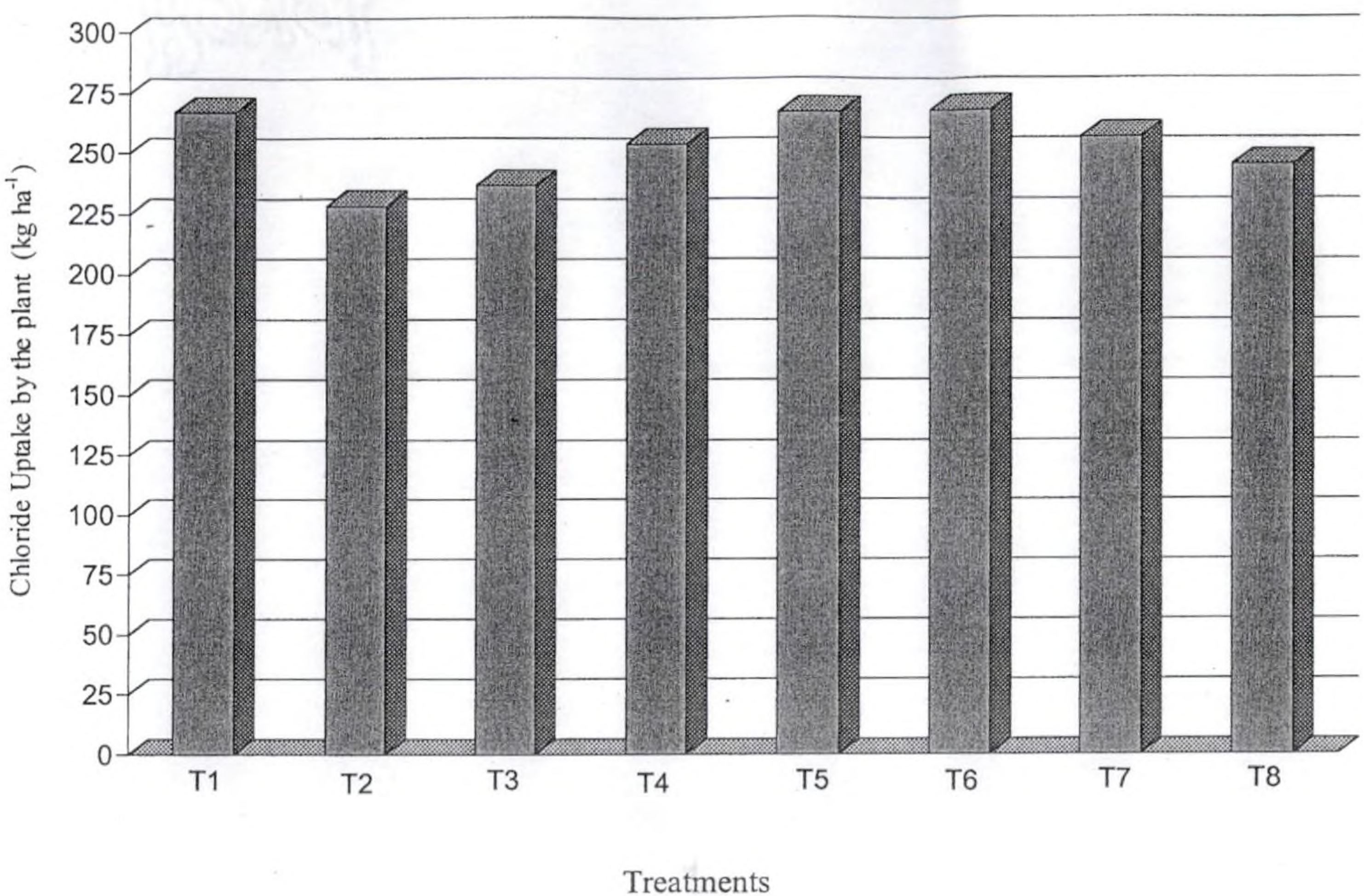


**Fig. 11 Chloride uptake (kg $ha^{-1}$) by plants as influenced by different treatments**

of planting. But the treatments did not have any significant influence on the organic carbon content.

Soil available N values differed significantly only after first and second fertilizer applications. At these stages the difference in growth obtained by plants in different treatments favoured N uptake in different rates.

Soil available P, K and Na values differed significantly at all stages due to treatments. In the first two stages there was increase in soil available P, K and Na but the values decreased at harvest stage. This decrease may be due to the increased uptake by plants.

**5.6 Correlation Studies**

Plant girth at 2 MAP showed significant positive correlation with yield. The girth of pseudostem and yield of plants in banana is positively correlated as reported by Mathew (1980). Other growth parameters like LAI, total chlorophyll content and total dry matter yield also showed significant positive correlation with yield. A high LAI is the result of the production of more number of functional leaves which contribute to a high photosynthetic efficiency leading to accumulation of more quantity of dry matter. This type of relationship has already been reported by several workers (Ghosh *et al.*, 1988; Devi, 1995).

**5.7 Economic analysis**

Economic analysis showed that 50 per cent substitution recorded maximum benefit:cost ratio of 1.99. There was a net profit of Rs. 98955 by the combined application of K and Na in 50:50 proportion. The savings in fertilizer cost is Rs. 572 $ha^{-1}$ in $T_6$ (50% K +50 Na) treatment. This is about 11.57 per cent of the cost of MOP when full recommended dose of K is applied as MOP.

Hence it is seen that if half the recommended dose of K in banana is replaced as Na of CS, the farmers can save the fertilizer cost as well as can have more savings due to higher crop yield.

# SUMMARY

# 6. SUMMARY

A field experiment was conducted at the Instructional farm attached to the College of Agriculture, Vellayani during the period August 1999 to June 2000 to study the extent of substitution of K by Na in banana variety Robusta. The treatments consisted of application of K alone at graded levels of 25, 50, 75 and 100 per cent and treatments with the substitution of K by Na as CS at 25, 50, 75 and 100 per cent. The experiment was conducted in randomized block design with three replications.

The results of the investigation are summarised as follows:

1. The various growth parameters like plant height, girth of pseudostem, number of functional leaves and Leaf Area Index (LAI) varied significantly due to treatments at all stages of growth. The values of these parameters in the treatments receiving 100 per cent K and 50 per cent K plus 50 per cent Na were on par at all the growth stages. A general reduction in these parameters was observed when the substitution of K with Na was done above 50 per cent.

2. Total chlorophyll contents in treatment receiving full recommended dose of K as MOP and K and Na in 50:50 proportion were on par, suggesting the possible role of Na in chlorophyll biosynthesis. Among the treatments which were given K alone, chlorophyll content increased with increase in K application. At all stages treatment receiving 25 per cent K alone recorded the least chlorophyll content.

3. Relative Leaf Water Content (RLWC) in general increased in all the Na supplied treatments.

4. Fifty per cent substitution of K by Na produced significantly higher bunch yield and the yield decreased at higher degree of substitution. Length of bunch, bunch weight, number of fingers per bunch and length of fingers were significantly higher in the treatment receiving 50 per cent K plus 50 per cent Na. Number of hands per bunch and girth of fingers were on par in the treatments receiving 100 per cent K and 50 per cent K plus 50 per cent Na.

5. Application of Na along with K significantly increased the dry matter production of plants. Fifty per cent substitution of K by Na produced highest dry matter yield. With further increase in the substitution, dry matter production decreased significantly.

6. Quality of the fruit, as reflected in TSS, total sugars, sugar/acid ratio and shelf life was as good in the treatment receiving 50 per cent K plus 50 per cent Na as in the treatment receiving 100 per cent K.

7. Shelf life of fruits did not vary significantly due to Na application. Maximum shelf life was recorded in the treatment that received 100 per cent K.

8. Pulp/peel ratio was significantly higher in the treatment that received 50 per cent K plus 50 per cent Na followed by $T_1$ (100% K) with a comparable value. It decreased drastically in the treatments in which K was substituted by Na more than 50 per cent. The ratio decreased with increase in substitution above 50 per cent level.

9. Though the contents of N, P and K did not vary significantly in the fruit, the total uptake of these nutrients were significantly higher in the treatment that received 50 per cent K plus 50 per cent Na than in the 100 per cent K treatment due to significantly higher drymatter yields in the 50 per cent K plus 50 per cent Na treatment.

10. Uptake of Na increased with increase in Na substitution upto 75 per cent and then decreased. Maximum uptake of Na occurred at 75 per cent substitution of K by Na.

11. Chloride uptake in the treatments that received 100 per cent K, 75 per cent K plus 25 per cent Na and 50 per cent K plus 50 per cent Na were on par and significantly higher than the uptake in the other treatments.

12. Partial substitution of K by Na did not have much influence on soil pH and available nutrient status of soil.

13. Plant girth (2 MAP), LAI, total chlorophyll content and dry matter production recorded significant positive correlation with the bunch yield.

14. Fifty per cent substitution of K by Na recorded maximum B:C ratio followed by 100 per cent K.

From the results, it can be concluded that in soils having low to medium status of K, K of MOP can be substituted upto 50 per cent by Na of CS for banana to get maximum yield without affecting the quality of fruits.

**Future line of work**

The results obtained in the study points out the necessity of detailed studies on the following aspects of banana cultivation.

1. Role of Na or $Cl^-$ in improving the chlorophyll content of plant should be studied in detail.

2. Possibility of substitution of K by Na needs to be tested in other crops also.

3. The long-term effects of such substitution of K by Na on the physical, chemical and biological properties of the soil should be studied.

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# REFERENCES

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* Original not seen

# APPENDIX

# APPENDIX – 1

**Data on weather parameters during cropping period**

| Month | Relative humidity (%) | Temperature (°C) | | Rainfall (mm) (Monthly total) |
|---|---|---|---|---|
| | | Maximum | Minimum | |
| August 1999 | 84.63 | 29.7 | 23.7 | 108.4 |
| September 1999 | 78.6 | 31.1 | 23.9 | 10.4 |
| October 1999 | 86.8 | 28.96 | 23.3 | 375 |
| November 1999 | 80.6 | 29.8 | 23.2 | 156 |
| December 1999 | 79.1 | 30.7 | 21.7 | 6.2 |
| January 2000 | 77.95 | 30.9 | 21.8 | 18.3 |
| February 2000 | 75.25 | 29.85 | 21.9 | 98.9 |
| March 2000 | 76.66 | 31.12 | 23.4 | 9.3 |
| April 2000 | 79.65 | 31.85 | 23.58 | 80.4 |
| May 2000 | 74.46 | 32.4 | 24.6 | 14.26 |
| June 2000 | 83.25 | 29.3 | 22.7 | 84.9 |

# SUBSTITUTION OF MURIATE OF POTASH BY COMMON SALT IN BANANA *Musa* (AAA group CAVENDISH subgroup) 'ROBUSTA'

By

SUNU, S.

ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT
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COLLEGE OF AGRICULTURE
VELLAYANI
THIRUVANANTHAPURAM.

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## ABSTRACT

A field experiment was conducted in the College of Agriculture, Vellayani during August 1999 to June 2000 to study the extent of substitution of K of muriate of potash by Na of common salt in banana cv. Robusta. Four treatments involving four levels of K at 25, 50, 75 and 100 per cent of recommended dose and four treatments substituting K with Na at 25, 50, 75 and 100 per cent were tried in RBD with three replications.

The plant growth parameters like plant height, pseudostem girth, number of functional leaves and LAI varied significantly due to treatments at all growth stages. These parameters in the 100 per cent K and 50 per cent K plus 50 per cent Na treatments were on par at all growth stages. Chlorophyll content and RLWC showed an increase with the addition of Na along with K.

Highest bunch yield was recorded in the 50 per cent K plus 50 per cent Na treatment followed by the yield in the 100 per cent K treatment. The yield attributes like length of bunch, number of hands per bunch, number of fingers per bunch, length and girth of fingers reflected similar trends.

The quality of fruits as reflected in the total soluble solid content, total sugar content and acidity was as good in 50 per cent K plus 50 per cent Na treatment as in 100 per cent K treatment. With increase in the levels of substitution above 50 per cent there was reduction in total soluble solids and sugar content.

Shelf life of fruits did not vary significantly due to treatments.

Pulp/peel ratio in the 100 per cent K and 50 per cent K plus 50 per cent Na treatments were on par. Pulp/peel ratio decreased significantly with increase in substitution of K by Na above 50 per cent level.

The uptake of nutrients except Na was higher at the 50 per cent K plus 50 per cent Na treatment and decreased with increase in substitution of K by Na above this level. Na uptake increased upto 75 per cent substitution of K by Na and decreased at 100 per cent substitution.

The treatments did not have any influence on the soil physical and chemical properties.

Bunch yield was positively and significantly correlated to plant girth (2MAP), chlorophyll content and LAI.

It can thus be concluded that upto fifty per cent of the K requirement of Robusta banana, grown in soils of low K status, can be replaced by Na of common salt.