SUITABILITY OF SUL-PO-MAG AS A POTASSIUM CUM MAGNESIUM FERTILIZER FOR BANANA IN KERALA

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled "**Suitability of Sul-Po-Mag as a potassium cum magnesium fertilizer for banana in Kerala**" 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 to me of any degree, diploma, fellowship, associateship or other similar title, of any other university or society.

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Introduction

INTRODUCTION

Banana is one of the most important remunerative tropical fruit crops occupying 20 per cent of the total area under fruit crops in India. In respect of area and production, it ranks second to mango in our country. Considering the fruit value and nutritive value, it is popularly called as poorman's apple. It is also non seasonal and cheaper and has become an inevitable necessity in the households of India.

Now in India, Kerala ranks second to Tamil Nadu for banana cultivation accounting to an area of 72,000 ha and a production of 6 lakh tonnes whereas in Tamil Nadu, the total area is 73,000 ha and the production is 30 lakh tonnes.

Nendran is the most popular commercial variety of banana cultivated in the state covering nearly 30 per cent of the total area under banana. The main reason for the low production and productivity in Kerala can be attributed to the lack of proper fertilization. Moreover, intensive cropping of highly leached soils has resulted in depletion of plant nutrients, both primary and secondary, from the soil. So the addition of fertilizers is of much importance for richer and satisfactory yields. Also there can be an improvement in quality with good physical and chemical characters. It is estimated that an average crop removes 300 kg N, 80 kg P_2O_5 and 800 kg K_2O from a hectare of land (Veeraraghavan, 1972).

Generally speaking, banana is a heavy feeder of nutrients. Increased uptake of potassium has resulted in marked improvement in quality and quantity of bunches and also biometric characters as reported by a number of scientists. Many reports are available stating the beneficial effect of magnesium on yield and yield parameters in banana. Being a constituent of chlorophyll molecule, it is very essential for photosynthesis. In Kerala, muriate of potash and magnesium sulphate are the most commonly used potassium and magnesium fertilizers.

Another fertilizer, Sulphate of Potassium Magnesia short named as Sul-Po-Mag introduced by S.L.Dev and Co., New Delhi, contains the three essential nutrients required for the growth of the plants ie. potassium, magnesium and sulphur. Sul-Po-Mag is a naturally occurring mineral called Langebeinite with a nutrient content of 22 per cent K_2O, 18.5 per cent MgO and 22 per cent S. All these nutrients are present in water soluble forms and so they are easily available to the crop. This fertilizer is used all over the world for crops like tobacco, vegetables, horticultural fruit crops, coconut, palm oil, rubber, tea, banana, tapioca, coffee, citrus, sugarcane, soya bean, pineapple and cereal crops. So it is proposed to test the suitability of Sul-Po-Mag as a substitute for potassium and magnesium fertilizers in banana which is a heavy feeder of potassium.

The present study was undertaken to evaluate the suitability of Sul-Po-Mag as a source of K, Mg and S in the acid soils of Kerala using banana as a test crop. The objectives of the study were to bring to light:

1. The effect of Sul-Po-Mag on the yield and yield characters of banana.
2. The effect of Sul-Po-Mag on the quality of banana.
3. The changes in the nutrient contents of soil and plant by the application of Sul-Po-Mag.
4. Comparison of the effect of Sul-Po-Mag on yield and yield characters, quality of banana and changes in the nutrient contents of soil and plant with the treatments in which MOP is supplemented with magnesium or sulphur and magnesium together with sulphur.

Review of Literature

REVIEW OF LITERATURE

1 Potassium

1.1 Potassium status of soil

Potassium is a major component of earth's crust and its concentration in soil normally varies from 0.5 to 2.5 per cent (Tisdale *et al.*, 1985). The total K_2O content of Kerala soils ranged from 0.04 to 0.54 per cent (Praseedom, 1970). Also Nambiar (1972) gave the total potassium content in lateritic soils of Tamil Nadu and Kerala as 0.04 to 0.27 per cent respectively. Values of water soluble potassium, available potassium and nitric acid soluble potassium were 0.028 to 0.248, 0.166 to 0.969 and 0.440 to 2.041 meq 100 g^{-1} of soil respectively. The K content of Indian soils varied from 0.5 to 3.0 per cent (Tandon and Sekhon, 1988).

1.2 Sources of potassium

Main sources of K fertilizer are muriate of potash and potassium sulphate. Chloride form of K fertilizer is used extensively for all crops except where no chlorine is desired such as potato, tomato and tobacco (Biswas and Mukherjee, 1987).

Since 1985, field experiments have been conducted with Sul-Po-Mag in Southern China on more than 20 different crops and significant response in yield and quality occurred in most of the crops. Sul-Po-Mag was used to supply a portion of the K need of crops and also Mg and S (Hagstrom, 1989).

1.3 Factors affecting the availability of potassium in soil

Potassium reserves and availability mainly depend on mineralogy and the degree of weathering and that in turn determines the dynamic equillibrium between water soluble, exchangeable and nonexchageable forms (Brady, 1974). High contents of potassium present in the coarser fractions of low level laterites can be released by better soil management practices (Sreedevi and Aiyer, 1975). The magnitude of potassium fixation by the soil was in the decreasing order of alluvial, black, red and lateritic soils in South India (Ramanathan, 1978). Positive correlation of available K was noticed with CEC, base saturation and exchangeable Ca, Mg and Na (Joseph and Saifudeen, 1994).

1.4 Effect of potassium on yield and yield parameters

Pseudostem growth was greatly increased by K as represented by Chu (1960) and Sheela (1982). Marked increase in bunch weight was noted by Decunha and Fraga (1963) by the application of K in sandy soils.

Significant increase in number and weight of fruits in Nendran in Kerala was reported with 228 g N, 228 g P_2O_5 and 456 g K_2O per plant per year (Veeraraghavan, 1972). According to Lahav (1972) K starvation significantly reduced leaf area, size and longivity and pseudostem height and circumference.

Singh *et al.* (1977) reported an increased yield of 5.75 kg $plant^{-1}$ when applied with 168 g N, 845 g P and 336 g K per plant. Potassium application increased the weight, volume and density of fruits in Robusta variety. Jambulingam *et al.* (1975) reported that the increase in K level in leaves of Robusta was significant only after soil application of 360 g K_2O $plant^{-1}$. This significantly increased the pseudostem height, girth, leaf area, sucker production and enhanced early flowering and maturity with good graded bunches.

Nitrogen and potassium application to Nendran banana exerted a significant positive influence on fruit number and bunch weight. Potassium content corresponding to maximum yield of fruit was 301 g plant^{-1} (Pillai *et al.*, 1977). But no effect on the growth of plant, weight of bunch, number of hands and fingers in Robusta variety of banana was reported by Vadivel and Shanmugavelu (1978).

Studies conducted by Venkatarayappa *et al.* (1978) on the effect of post shooting application of potassium dihydrogen phosphate revealed that the treatments significantly increased the volume and weight of fruits. The volume of fruits increased by 26.88 and 32.6 per cent respectively in Giant Cavendish and Dwarf Cavendish bananas. Per cent increase in fruit weight was 62.5 and 32.6 per cent respectively.

Application of half the dose of N and K at flower initiation stage created a more favourable condition for the plant to get maximum nutrients leading to enhanced productivity in Nendran banana (Nambiar *et al.*, 1979). In Periyar river command area, 100 g N, 40 g P_2O_5 and 350 g K_2O plant^{-1} was found optimum for cv. Poovan as planted crop and 200 g N, 40 g P_2O_5 and 350 g K_2O plant^{-1} for ratoon crop and 100:40:350 g plant^{-1} for Vayal Vashai for getting good yield (Nanjan *et al.*, 1980). Pillai and Khader (1980) revealed that in Robusta, the fertilizer recommendation of 250:100:1000 kg NPK ha^{-1} produced significantly heavier bunches of 26.6 kg.

Studies on the effect of potassium nutrition in rainfed banana cv. Palayankodan revealed that the yield increased linearly with the increased doses of K (Sheela, 1982).

1.5 Potassium distribution and uptake in banana

Studies conducted on the quantities of nutrients taken up by banana plants and incorporated into new growth over a 12 month period indicated high requirement of nitrogen and potassium and a low requirement of phosphorus (Turner, 1969). According to Shanmugam (1973) the nutrient removal by a 27 tonne crop was to the tune of 74 kg N, 16 kg P_2O_5 and 93 kg K_2O respectively and that by a 30 tonne crop was to the tune of 50-75 kg N, 15-29 kg P_2O_5 and 175-225 kg K_2O ha^{-1} respectively.

Uptake studies conducted with Robusta variety revealed that at the sucker stage, the K content of the corm was higher than that of pseudostem. At the early and late vegetative stages, pseudostem was always the richest store house of K followed by leaves and corm. At shooting, pseudostem and leaves had the highest K with corm and usually the internal fruit stalk the next. At harvest, fruits contained the maximum K content and pseudostem comes the next (Twyford and Walmsky, 1974).

Robusta required N, P_2O_5 and K_2O at the rate of 325, 75 and 1195 kg ha^{-1} respectively, while the requirement of poovan was 408, 35 and 1285 kg N, P_2O_5 and K_2O respectively (Nambisan *et al.*, 1980). Nitrogen and potassium absorbed more in preflowering stage in Robusta. There was continuous and steady uptake of N and K and the quantities were almost equal before and after flowering in Poovan (Veerannah et al., 1976).

Based on the studies conducted on the nutrient removal by bananas, the optimum level of nutrients determined by foliar analysis for various clones were reported as follows:

Robusta - 2.8-3.0 per cent N, 0.45-0.45 per cent P_2O_5 and 3.8-4.0 per cent K_2O and

Gros Michel - 2.6-2.9 per cent N, 0.29-0.48 per cent P_2O_5 and 3-8 per cent K_2O (Nambisan *et al.*, 1980).

The element K was taken up by banana cv. Palayankodan in the largest amount followed by N. Crop removal of K was accounted as 343.48 kg ha^{-1} (Rajeevan, 1985).

Studies on the nutrient content and uptake of the 'Vayal Vazhai' banana revealed that marked increase in the uptake of N, P, K, Ca and Mg was noticed at the late vegetative phase. It indicated a greater assimilation of the plant nutrients at the peak of the vegetative phase. This trend continued upto shooting stage. The N, P, K, Ca and Mg uptake of the crop at harvest was recorded as 267.5, 24.5, 729.7, 5.99 and 21.15 kg ha^{-1} respectively (Buragohain and Shanmugavelu, 1986).

The potassium concentration in the dry matter of leaves at preshooting, shooting and harvest stages of banana variety 'Jahaji' was given as 2.65, 2.13 and 2.5 per cent respectively (Baruah and Mohan, 1986).

Potassium uptake was rapid and the maximum was at the 15th leaf stage and at flowering which declined thereafter. About the distribution of K, it was found that pseudostem was the richest store house in all the cultivars at flowering and harvest. At shooting, whole corm ranked second in K contribution whereas at harvest, fruits ranked second. Lamina also contained appreciable amount of K (Shanmugavelu *et al.*, 1992).

1.6 Effect of potassium on crop yield and quality

It was observed that in Taiwan the increasing supplies of K increased the number of hands and weight of fingers, rind thickness and finger length and circumference. Increased dose of K improved fruit conditions as observed after 20 days of storage. Potash at 450-600 g or more per plant was recommended for Taiwan (Ho, 1968).

Optimal yield of high quality fruits were obtained with an annual application of 370 g potassium ammonium nitrate along with 450 g KCl per plant. Yield and fruit quality were lowered by higher application rates or when the latter treatment was supplemented with 250 g $MgSO_4$ (Koen, 1976). Studies on the effect of post shooting application of potassium dihydrogen phosphate revealed that the treatments with potassium dihydrogen phosphate significantly increased the volume and weight of fruits with respect to the control. Treatment in general found to have lower acidity (Venkatarayappa *et al.*, 1979).

The increase in levels of K_2O significantly increased reducing, non reducing, total sugars as well as total soluble solids whereas acidity was reduced. Also sugar-acid ratio was enhanced (Vadivel and Shanmughavelu, 1978). Such pronounced effect of K on fruit quality parameters was reported by Jambulingam *et al.* (1975); Sheela (1982) and Barauh and Mohan (1986). Barauh and Mohan (1986) observed that sugar acid ratio was maximum at highest level of K. Fruits receiving the highest K ie., 330 g had the lowest acidity while the highest acidity was with the control ie., 0 g K per plant.

Studies on the variation in dry matter, starch, sugar, ascorbic acid and acidity of banana fingers in cv. Nendran during development revealed that 80 to 90 days after shooting the starch per cent was 30.05 to 32.01, total sugars 1.2 to 1.29 per cent, ascorbic acid 16.24 to 18.0 mg 100 g^{-1}, acidity 0.08 to 0.096 per cent of fresh pulp and pulp-peel ratio 2.88 to 3.09 (Aravindakshan, 1981). But Chellappan (1983) found the starch content of Nendran at full physiological maturity as 48.64 per cent, total sugars as 2.57 per cent and acidity as 0.62 per cent. The fruit characteristics of Nendran variety of banana is reported as TSS 29.3 $\pm$ 0.45 per cent, total sugars 15.94 $\pm$ 0.75 per cent, reducing sugars 13.22 $\pm$ 13 per cent, non-reducing sugars 1.27 $\pm$ 0.08 per cent, sugar- acid ratio 55.34 $\pm$ 2.2 and good keeping quality (Valsalakumari, 1985).

Studies on the effect of spacing on biomass production, dry matter partitioning, yield and fruit quality in tissue culture Nendran revealed that the fruit quality is decided by the amount of acidity and total sugar content of the fruit. The fruit characteristics were reported as TSS 17.4-24.5 per cent, acidity 0.4-0.53 per cent, total sugars 26.8-17.7 per cent, reducing sugars 7.0-8.7 per cent, nonreducing sugar 10.7-18.1 per cent, ascorbic acid 9.4-14.1 mg 100 g^{-1} and sugar acid ratio 33.7-68.7 (Anil *et al.*, 1995).

2 Magnesium

2.1 Magnesium status of soil

Magnesium, the only mineral constituent of chlorophyll, forms the eighth most common element of the lithosphere. Jacob in 1958 reported that the average concentration of Mg lies in the range of 0.05 per cent for sandy soils to 0.5 per cent for clayey soils of Kerala.

The mean values of total Mg in different soil types of South India was reported as 0.22, 0.09, 0.11 and 0.03 per cent respectively in the black, red, alluvial and lateritic soils (Loganathan, 1973). Studies on the exchangeable base content of different soils of Kerala showed that the base content was generally in the decreasing order of Ca, Mg, K and Na and the maximum exchangeable Mg was in black soil (Venugopal and Koshi, 1976).

Based on the studies conducted on the Mg status of acid soils of Kerala, Prema (1992) reported that the soils of Kerala are deficient in total magnesium reserves with a mean value of 963.7 ppm. In general, about 24 per cent of the total Mg reserves in the soil was considered available and 11 per cent of the total Mg was considered exchangeable. The total Mg reserves in Kerala were found to be poor and Mg could be considered as a critical element in acid soils of Kerala.

2.2 Factors affecting magnesium availability to crops

There are a lot of factors such as soil type, rainfall, pH, organic matter content, particle size distribution and other cations that affect the availability of magnesium in soil. Magnesium occurs in soil as water soluble, exchangeable, lattice and primary mineral forms (Brady, 1974)

Kirkby and Mengel (1976) found that the Podzols and lateritic soils are low in Mg. Schweder (1983) observed soils rich in dolomite and clay minerals had high Mg content whereas residual soils rich in quartz and feldspar contained low Mg.

Excessive rainfall caused Mg deficiency in light textured soils (Mc Martrey, 1947 and Prince *et al.*, 1947) and Mg is highly susceptable to leaching (Goswami and Sahrawat, 1982). Kabeerathumma (1969) and Prohaszka (1980) reported a positive correlation between Mg uptake and pH. Similarly Simpson in 1983 also observed that the low pH promoted Mg deficiency in plants. Magnesium deficiency is more in coarse textured soils than in heavy textured soils (Bolton, 1973).

A synergestic effect was observed between K and Mg by Fageria (1983). But Jayaraman (1988) observed no effect of added Mg in the availability of K.

2.3 Importance of magnesium in plants

Magnesium is found to increase the chlorophyll content of leaves and is also involved in the activation of many enzymes in carbohydrate metabolism (Tisdale *et al.*, 1985).

Magnesium promotes N uptake (Ananthanarayana and Rao, 1982; Subramanian *et al.*, 1975) and also P uptake and its utilisation by crops (Varghese and Money, 1965).

2.4 Crop response of magnesium

Kerschherger *et al.* (1986) observed the yield response to magnesium is in the order cereals > forage plants > potatoes.

Application of 2 per cent $MgSO_4$ increased the grain yield of rice by 17 per cent (Mahapatra and Gupta, 1978). Positive response to Mg application was shown by many crops in Kerala such as rice (Padmaja and Varghese, 1972; Thomas and Koshy, 1977 and Varghese, 1992), soybean (Kabeeruthumma *et al.*, 1977) coconut (Varkey *et al.*, 1979 and Kamalakshiamma and Pillai, 1980) and groundnut (Tajuddin, 1970).

2.5 Magnesium in banana nutrition

The resistance to the bunchy top disease of banana is correlated to CaO + MgO/K_2O in the leaf (Nair and George, 1960). A similar effect was noticed by Nambiar also in 1963. The CaO/MgO ratio is reported to have a role in delaying the bunchy top disease incidence in banana (Pillai, 1965). Various ratios such as K/Ca, K/Mg and K/Ca + Mg in banana midribs were positively and significantly correlated with the yield (Nambiar, 1972).

Sub-optimal levels of Mg in leaves was found to cause a disease 'blue' of banana ie., chlorosis and appearance of purple brown spots (Lahav and Turner, 1983). Increase in the supply of K and Mg to banana increased the dry matter production and uptake of most elements with the exception of Mg whose uptake remained unaffected by K supply (Barkus and Turner, 1983).

According to Prema (1992) the effect of Mg on growth and yield parameters of banana was not significant in acid soils of Kerala. The magnesium treatments failed to influence the vegetative characters, viz. height of plant, girth of plants, total number of leaves, total number of suckers, days to flower, days to mature and total duration of the crop. The effect of treatments on yield and yield characteristics such as weight and length of bunch, number of hands per bunch and weight and girth and length of finger was not significant. As far as the nutrient content of leaves was concerned, no significant difference in the percentage of N and P was found. The magnesium content of leaf was decisively influenced by the treatments at the late vegetative phase and at shooting. The available Mg content of soil and also the uptake by the plant were found to increase with the increased levels of MgO supplied as $MgSO_4$.

2.6 Nutrient content and uptake of magnesium

Magnesium is distributed uniformly all over the organs in the banana varieties like Poovan and Robusta (Hewitt, 1955). He reported the nutrient contents of whole plant at harvest as 0.26 per cent Ca and 0.25 per cent Mg in Robusta and 0.16 per cent Ca and 0.16 per cent Mg in Poovan. Also high accumulation of Mg in Dwarf Cavendish was reported by Martin Pravel (1964).

The N, P_2O_5, K_2O, CaO and MgO removal by banana which yielded 30 t ha^{-1} were found as 50-75, 15-20, 175-225, 10-20 and 25-30 kg ha^{-1} respectively (Shanmugam, 1973).

The adequacy level of leaf nutrients ranged from 3.18-3.14 per cent for N, 0.46-0.54 per cent for P, 3.36-3.76 per cent for K, 2.1-2.4 per cent for Ca and

0.25-0.28 per cent for Mg (Arunachalam *et al.*, 1976). The concentration of Ca and Mg of Vayal Vazhai banana at shooting and at harvest were reported as 1.536 and 0.466 per cent and 1.158 and 0.545 per cent respectively (Burogohain and Shanmugavelu, 1986). According to Rajeevan (1985) the Ca and Mg contents at shooting varied from 0.20-0.45 per cent an d 0.24-0.46 per cent respectively irrespective of accessions. Differences with regards to Mg concentration were not significant in any of the parts. Maximum content was recorded in leaves followed by pseudostem. Nutrient removal was 45.17 and 22.79 g plant^{-1} for Ca and Mg respectively.

Mean value of nutrient uptake of Ca and Mg by Nendran variety of banana were 68.56 g plant^{-1} and 9.082 g plant^{-1} respectively. Only the uptake of calcium by the leaves is found to have positive correlation with yield. The average Mg content and uptake by the rhizome, pseudostem, fingers and leaves were 0.143 per cent and 1.56 g plant^{-1}, 0.137 per cent and 1.398 g plant^{-1}, 0.051 per cent and 1.475 g plant^{-1} and 0.121 per cent and 4.657 g plant^{-1} respectively. The calcium content of rhizome, pseudostem, finger and leaf of Nendran banana was 0.336, 0.329, 0.123 and 1.568 per cent respectively and the corresponding uptake was 2.848, 3.194, 3.576 and 58.94 g plant^{-1} respectively (Prema, 1992).

3 Sulphur

Sulphur is one of the 16 essential nutrient elements which all plants must have for normal growth development. Sulphur is being recognised as the fourth major plant nutrient after N, P and K. Crops, in general, require as much sulphur as they need P.

3.1 Sulphur status of soil

The main source of sulphur for plants is soil where its concentration ranges widely from 0.02 to 0.20 per cent (Jacob, 1966). Since India is a sub continent with a wide variety of tropical climate and soils supporting different agro ecosystems, the S content among and within soil types as well as regions varies to a greater extent. The low soil S reserves in tropical Indian soils appears to have resulted largely from their poor organic matter status (Takkar, 1988). Similarly, effect of organic C content in the S content of soil was described by Palaniappan *et al.* (1978).

Plants absorb S as SO_4^{-2} and it comprises largely of water soluble, adsorbable and easily releasable S from soil organic matter. Available S content of Indian soil is generally less than 40 ppm (Naik and Das, 1964). In general, SO_4^{-2} S content of Indian soils ranged from 3.4 to 81 ppm and water soluble content ranged from 12 to 1161 ppm (Sureshlal and Mathur, 1985).

Morgan's reagent extractable S is 40 ppm in soils of Mannuthy, Kerala (George, 1989). Sulphur deficiency ranged from 20 per cent in Trivandrum to 55 per cent in Palghat as reported by Tandon (1991).

3.2 Crop response of sulphur

Sulphur deficiency could reduce the crop yields by 10 to 30 per cent as observed by Sallbach (1973) even without any external symptoms. Sulphur improves the crop quality also. It is important for protein synthesis, oil production and optimising the N:S ratio of fodders and forages (Tisdale *et al.*, 1985).

Sulphur is found to increase the starch content of potatoes (Ramamurthy and Devi, 1981), improve the quality of sugarcane juice (Saroha and Singh, 1979) and reduce the HCN content and increase the starch content by 6.7 per cent of cassava by applying 50 kg S ha^{-1} (Mohankumar and Nair, 1983). An uptake of 6 kg per tonne of food grain produced has been taken as the average for tropical countries (Kanwar and Mudahar, 1985). Sulphur uptake can range from 5 to 80 kg ha^{-1} under field conditions (Tandon, 1991).

3.3 Sulphur nutrition in banana

Application of S at 0.5 kg $plant^{-1}$ increased the growth and earliness, particularly in the presence of supplementary N (Melin, 1970).

The critical content of S in dry matter of lamina of banana was observed as 0.20 per cent to 0.23 per cent (Lahav and Turner, 1983). Stover and Simmond (1987) observed S deficiency in banana caused thickening of secondary veins and yellowing of whole leaves.

Rajeevan (1985) in his study on banana found that quantity of S removal was 208.8 mg $plant^{-1}$ which accounted for a removal of 10.29 kg ha^{-1}. The uptake of S was significant only in the fruits. The leaves contained 2.72 g of S which accounted for 58.28 per cent of the total uptake in the aerial parts and peduncle showed the maximum uptake of S. Highest percentage was recorded in the peduncle and leaves contained 2.72 g of sulphate S which accounted for 58.28 per cent of the total uptake in the aerial parts.

The nutritional imbalance of S with other elements can cause banana disorder yellow pulp (Martin-prevel, 1964). Tandon in 1991 observed chlorosis, necrosis and growth retardation in S deficient banana plants.

4 Interaction of potassium, magnesium and sulphur

According to Nair and George (1960), resistance to the bunchy top disease may really be correlated to the ratio of CaO + MgO/K_2O and not merely to CaO/MgO ratio in the leaf.

The content of K in the banana leaf has a depressing affect on the Mg content. Potassium application lowered leaf Ca, Mg and N contents (Ho, 1968). Fernandez *et al.* (1973) found that K was negatively correlated with Ca and Mg in all stages. Synergism of K and P and antagonism between K and Na was observed by Lahav (1972) in banana.

Balakrishnan (1980) studied on the nutrient uptake of eight cultivars of banana and found that there was preferential uptake of K during the initial stages of growth so that the K/Ca + Mg increased upto flowering and at harvest phase the ratio decreased considerably indicating the uptake of secondary elements in preference to K. Similar trend was noticed by Tandon 1991 also.

Synergistic effect between Mg and S was reported by Nad and Goswami (1984) but antagonistic effects was reported by (Aulakh and Parskcha, 1988).

Materials and Methods

MATERIALS AND METHODS

The present study was carried out to evaluate the suitability of Sul-Po-Mag as a source of K, Mg and S in the acid soils of Kerala using banana as a test crop.

1 Experimental site

The experiment was conducted at the College of Horticulture, Vellanikkara during the period of September 1994 to August 1995.

2 Climate

The location enjoys a typical tropical climate.

3 Soil

The soil was well drained, acidic and lateritic sandy loam. The basic characteristics of the soil is presented in Table 1.

4 Planting and management practices

Healthy suckers of uniform size and age (3 months old) were selected from disease and pest free plots and pseudostems were cut back retaining 15-25 cm from the base. The suckers were dipped in solution of cowdung and carbofuran and dried. The treated suckers were stored in partial shade for about 15 days before planting.

Table 1. General characteristics of the soil selected for field experiment

Soil type	: Laterite
Texture	: Sandy loam
Sand %	: 77.5
Silt %	: 5.0
Clay %	: 17.5
pH	: 5.2
Specific conductance dS m^{-1}	: 0.07
Organic carbon %	: 0.98
Available P kg ha^{-1}	: 29.04
Available K kg ha^{-1}	: 156.00
Exchangeable Ca cmol(+) kg^{-1}	: 10.00
Exchangeable Mg cmol(+) kg^{-1}	: 0.40
Available S ppm	: 13.44

The experimental area was cleared, ploughed, levelled and pits of 50 cm^3 were dug at a spacing of 2 m x 2 m. Farmyard manure and green leaves at the rate of 10 kg pit^{-1} were applied in the pits and allowed to decay. As a prophylatic measure, 25 g each of furadan was applied in each pit and suckers were planted on 30th September 1994. The cultural operations and management practices were followed uniformly as per the Package of Practices Recommendations issued by the Kerala Agricultural University (KAU, 1993). The fertilizers were applied as per the treatments. The crop was irrigated on alternate days for 5 months from December to May.

5 Experimental design and layout

The experiment was laid out in randomised blocks with 14 treatments and 3 replications using the Nendran variety of banana. Each row contained 4 plants. Out of the total of 16 plants in a plot, the central 4 plants comprised the observation plants and all the remaining kept as border plants. The lay out of the experiment is given in Fig.1.

6 Treatments

The treatments included in the investigation were:

T_1 - Control (no fertilizer)

T_2 - Recommended dose of NPK as urea, diammonium phosphate and muriate of Potash

T_3 - N and P as urea and diammonium phosphate respectively and Sul-Po-Mag to supply 100 per cent K_2O requirement

T_4 - N and P as urea and diammonium phosphate respectively. Sul-Po-Mag to supply 50 per cent K_2O requirement and remaining 50 per cent K_2O as MOP

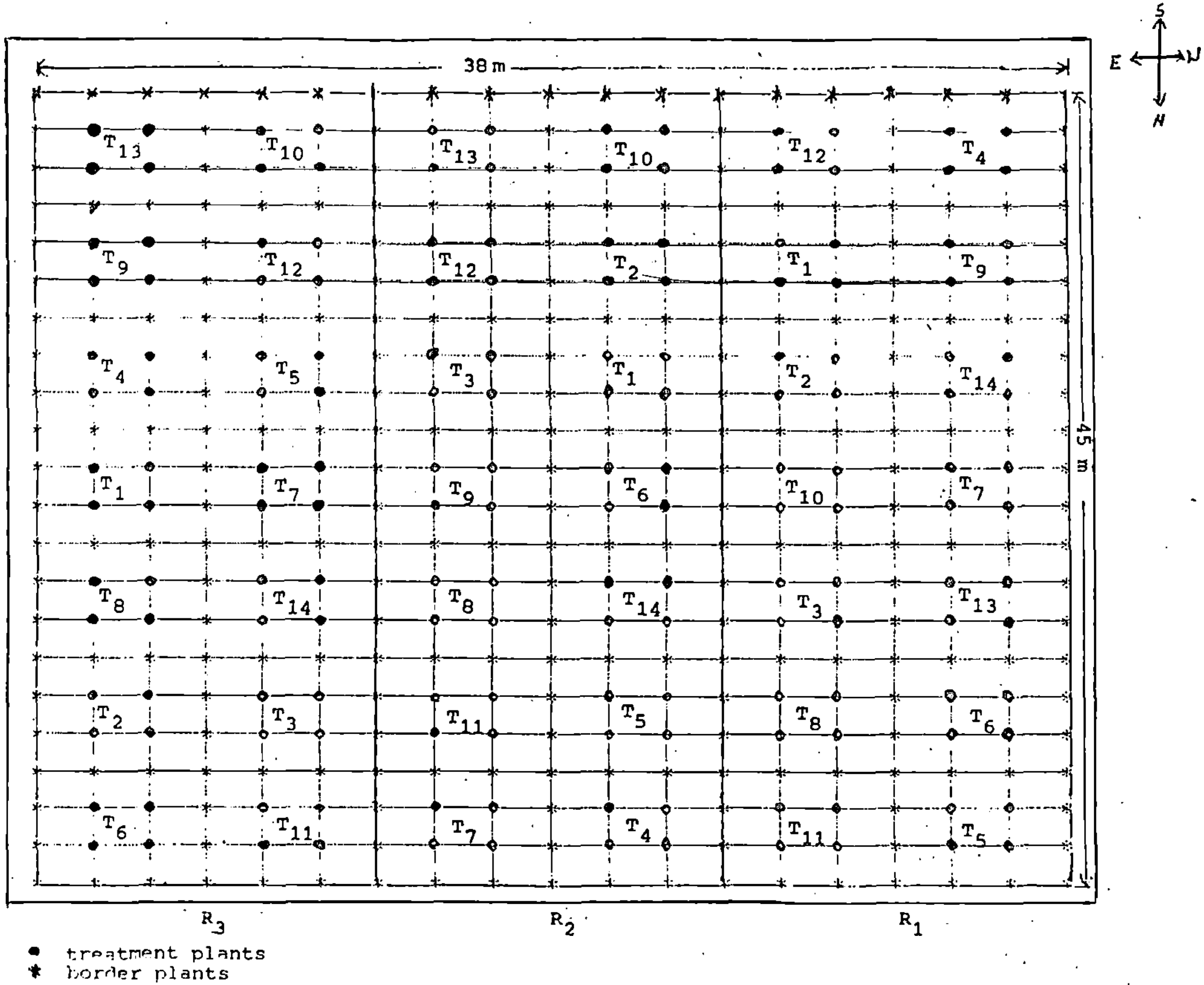

Fig. 1 Lay out of the experimental plot

T_5 - N and P as urea and diammonium phosphate respectively. Sul-Po-Mag to supply 25 per cent K_2O and the remaining 75 per cent K_2O as MOP

T_6 - Recommended dose of NPK as urea, diammonium phosphate and muriate of potash + MgO equivalent to that in Sul-Po-Mag supplied in treatment 3

T_7 - Recommended dose of NPK as urea, diammonium phosphate and muriate of potash + MgO equivalent to that in Sul-Po-Mag supplied in treatment 4

T_8 - Recommended dose of NPK as urea and diammonium phosphate and MOP + MgO equivalent to that in Sul-Po-Mag supplied in treatment 5

T_9 - Recommended dose of NPK as urea, diammonium phosphate and MOP + S equivalent to that supplied in Sul-Po-Mag in treatment 3

T_{10} - Recommended dose of NPK as urea, diammonium phosphate and MOP + S equivalent to that supplied by Sul-Po-Mag in treatment 4

T_{11} - Recommended dose of NPK as urea, diammonium phosphate and MOP + S equivalent to that in Sul-Po-Mag applied in treatment 5

T_{12} - Recommended dose of NPK as urea, diammonium phosphate and MOP and MgO + S equivalent to that supplied by Sul-Po-Mag in treatment 3

T_{13} - Recommended dose of NPK as urea, diammonium phosphate and MOP and MgO + S equivalent to that supplied by Sul-Po-Mag in treatment 4

T_{14} - Recommended dose of NPK as urea, diammonium phosphate and MOP and MgO + S equivalent to that supplied by Sul-Po-Mag in treatment 5

Magnesium and sulphur were applied as magnesite and gypsum respectively. The NPK fertilizers at the rate of 190 g N, 115 g P_2O_5 and 300 g K_2O per plant per year were supplied in 6 splits as basal, one month after planting, two months after planting, three months after planting, four months after planting and just after complete emergence of the bunch.

Sul-Po-Mag marketed by the International Minerals and Chemical Corporation, U.S.A. is a naturally occurring fertilizer material and is a mixture of potassium sulphate and magnesium sulphate containing 22 per cent K_2O, 18.5 per cent MgO and 22 per cent sulphur.

7 Biometric observations

Biometric observations were recorded at 4 growth stages of the crop i.e., during early vegetative phase, late vegetative phase, at shooting and at harvest as suggested by Yang and Pao (1962).

7.1 Plant characters

7.1.1 Height of pseudostem

The height from the base of the pseudostem to the axil of the youngest leaf was measured and recorded in cm.

7.1.2 Girth of pseudostem

The girth was measured in cm at a height of 20 cm from the ground level.

7.1.3 Total number of leaves per plant

Leaves were counted and recorded at different stages.

7.1.4 Duration of crop

The number of days from planting to shooting and the number of days from shooting to harvest were recorded.

7.1.5 Number of suckers per plant

The number of suckers produced per plant was recorded. They were not allowed to grow till shooting as it might affect the yield of the crop.

7.1.6 Bunch characters

The bunches were harvested at full maturity stage when they are "full round" (Simmonds, 1959). The observations made were:

7.1.6.1 Weight of the bunches

The weight of the bunches including the exposed peduncle portion was recorded in kg.

7.1.6.2 Number of hands and fingers per bunch

The total number of hands per bunch and fingers per bunch were recorded.

7.1.6.3 Weight of fingers

The middle fruit in the top row of the second hand from the base of the bunch was selected as the representative finger to find the mean weight of the fingers.

7.1.6.4 Girth and length of finger

The girth of finger was measured at the midportion and the length from the point of attachment to the tip using a thread and a tape.

8 Chemical analysis

8.1 Studies on the nutrient status of plants

Leaf samples were collected at vegetative stage, at shooting and at harvest for the analysis of N, P, K, Ca, Mg and S contents. The central portion including both lamina and midrib from the middle portion of the third leaf was taken for chemical analysis.

At the time of harvest K, Mg and S contentsof different plant parts were determined to find out the total nutrient uptake.

Nitrogen content of the plant sample was estimated by microkjeldahl digestion and distillaton method (AOAC, 1960).

Phosphorus content of the digested extract was found out using Vanado molybdo phosphoric yellow colour method (Jackson, 1958).

Potassium content was estimated using a flame photometer (Jackson, 1958).

Calcium and magnesium contents were determined using versenate titration method (Hesse, 1971).

Sulphur content was determined using turbidimetric method (Jones *et al.*, 1972 and FAO, 1988).

8.2 Studies on the nutrient status of soil

Soil samples were collected by using soil auger to a depth 15 cm from the surface of the soil. Samples were taken from the basins of 4 plants in a plot. For each plant 4 samples were collected from the four sides. Thus 16 samples were taken, mixed and composited. Samples were analysed for organic carbon, available P, K, Mg and S and exchangeable Ca, pH and EC.

The different methods used for soil analysis were:

For the estimation of organic carbon Walkley and Black titrimetric method (Piper, 1942) and for available P ascorbic acid blue colour method after extracting with Bray No.1 (Watanabe and Olsen, 1965) were used.

For available K estimation, direct reading in a flame photometer (Jackson, 1958) was followed. The exchangeable Ca and Mg contents in solution were determined by using versenate titration method (Hesse, 1971). Available S was found out using spectro photometer using the turbidimetric method (Hesse, 1971).

The pH was read using a pH meter (Jackson, 1958), Electrical conductance of the supernatent liquid of soil-water suspension used for the determination of pH was read with the help of a conductivity bridge (Jackson, 1958).

8.3 Studies on the quality of fruits

The fruits collected from well ripe bunches were used for quality analysis. The middle fruit in the top row of the second hand was selected as the representative sample. The top, middle and bottom portion of each fruit was taken and pooled and macerated using a fruit pulper. The plant samples were analysed for sugar content, total soluble solids, ascorbic acid and titratable acidity.

Total reducing and non reducing sugars in the sample were determined as per the method described by AOAC (1960).

Total soluble solids was found out by an Erma pocket refractometer and was expressed in percentage.

Ascorbic acid content was determined using 2,6-dichlorophenol indophenol dye and was expressed in mg 100 g^{-1} sample.

Titratable acidity was found out using O.IN NaOH using phenolphthalein as the indicator. This was expressed as percentage of citric acid (AOAC, 1960).

Sugar : acid ratio was arrived at by dividing the total sugar with titratable acidity and this was reckoned as a measure of fruit quality.

After removing the peel, the weight of pulp and peel were recorded separately.

Pulp-peel ratio on weight basis was obtained by dividing the weight of pulp by the weight of peel.

9 Statistical analysis

The data were analysed using the analysis of variance method for randomised block design (Panse and Sukhatme, 1985).

Results and Discussion

RESULTS AND DISCUSSION

The results obtained in the present study are presented and discussed in this chapter.

1 Effect of Sul-Po-Mag on biometric characteristics

1.1 At vegetative stage

Data presented in Table 2 represents the values on height, girth and number of leaves of the plants as influenced by the application of Sul-Po-Mag.

1.1.1 Height of plants

The height of plants did not vary considerably due to the influence of the treatments. The maximum height of 72.25 cm was recorded by the treatment T_9, the treatment with S equivalent to that in full dose of Sul-Po-Mag along with K_2O supplied as MOP. The lowest value of 58.33 cm was recorded by T_{12}.

Most of the treatments have shown higher values compared to T_2 and this indicates that application of Sul-Po-Mag or Mg or S alone or along with KCl has shown some favourable influence on the height of plants.

1.1.2 Girth of plants

The girth did not differ significantly under the influence of the treatments. The maximum value of 20.17 cm was recorded by T_9 the treatment in which S equivalent to that in full dose of Sul-Po-Mag was added as gypsum along with

Table 2. Biometric observations at early vegetative phase

Treatments	Mean height of plants (cm)	Mean girth of plants (cm)	Mean number of leaves
T_1	59.75	17.67	5.50
T_2	61.67	17.75	6.31
T_3	71.67	19.97	5.94
T_4	65.00	18.67	6.25
T_5	66.67	19.08	6.25
T_6	67.67	18.92	6.67
T_7	68.75	19.42	6.25
T_8	65.83	19.33	6.67
T_9	72.25	20.17	6.36
T_{10}	60.83	16.00	5.42
T_{11}	65.17	19.00	5.81
T_{12}	58.33	17.44	5.39
T_{13}	65.83	18.42	5.75
T_{14}	68.92	19.67	6.18
CD 5%	NS	NS	NS
Sem±	59.319	2.852	0.566

MOP and the minimum value (16.00 cm) was recorded by T_{10} which was also a gypsum treatment in which half the dose of S applied in T_9 was added. Almost all the treatments with Sul-Po-Mag application and Mg application have recorded higher values compared to application of MOP alone.

1.1.3 Number of leaves

The number of leaves of the plants was not influenced significantly due to treatments. Maximum value 6.67 cm was recorded by treatments 6 and 8. They were the treatments with application of Mg along with muriate of potash. The minimum value 5.39 cm was recorded by T_{12} which was a Mg cum S treatment along with KCl. The results indicate that the effect of Mg is more compared to S in increasing the number of leaves also.

The results obtained indicate that the effect of treatments was not significant for all the three biometric characters studied at early vegetative phase and this may be due to the comparatively higher content of the magnesium and sulphur in the soil.

1.2 At late vegetative phase

Data relating to the height of plants, girth of plants and number of leaves at late vegetative stage are presented in Table 3.

1.2.1 Height of plants

The variation due to treatments was not significant at late vegetative phase. Maximum height of 190.93 cm was recorded by T_9 i.e., the treatment with MOP + S in full dose. The same treatment recorded the highest value at the early

Table 3. Biometric observations at late vegetative phase

Treatments	Mean height of plants (cm)	Mean girth of plants (cm)	Mean number of leaves
T_1	152.75	38.08	16.42
T_2	170.58	42.67	18.08
T_3	190.50	47.50	19.00
T_4	188.08	48.25	19.33
T_5	186.33	48.33	19.50
T_6	181.75	46.25	18.50
T_7	183.83	45.83	19.08
T_8	181.67	45.67	18.52
T_9	190.93	47.40	19.42
T_{10}	144.75	37.00	16.67
T_{11}	181.17	45.42	19.33
T_{12}	183.17	46.25	19.33
T_{13}	168.92	42.75	18.50
T_{14}	180.83	45.58	19.08
CD 5%	NS	3.912	1.348
Sem±	116.333	5.431	0.645

vegetative phase also. The lowest value was recorded by T_{10} (144.75 cm) as against T_1 at the early vegetative phase. All the treatments which have received Sul-Po-Mag alone (T_3, T_4, T_5) and Mg with muriate of potash (T_6, T_7 and T_8) have recorded higher values compared to T_2.

Same trend was recorded at the early vegetative phase too. This indicates that effect of Mg was more in increasing the height of banana plant compared to S at the early periods of growth.

1.2.2 Girth of plants

Application of various treatments has influenced the girth of plants significantly. Maximum value of 48.33 cm was recorded by T_5 where three fourth of the quantity of K was applied as MOP and the remaining quantity as Sul-Po-Mag. This was followed by T_4 and T_3. The recommended practice i.e., the application of MOP alone (T_2) was significantly lower than all the treatments with Sul-Po-Mag application. All treatments supplemented with Mg alone or with Mg and S have also recorded higher values compared to T_2.

Almost the same trend was noted at the early vegetative phase although the treatment effects were not significant.

1.2.3 Number of leaves

Statistical analysis of the data revealed that the application of various treatments influenced the number of leaves significantly. Maximum value 19.50 was recorded by T_5 i.e., application of three fourth dose of K as MOP and one fourth as Sul-Po-Mag. Treatment 5 was on par with all the other treatments except T_2, T_1 and

T_{10}, where T_2 was the application of MOP alone at the recommended dose, T_1 was the control and T_{10} was the application of S along with K.

In short, though the effect of treatments on the vegetative characters was not significant at the early vegetative phase, it became significant for the girth of plants and the number of leaves at the late vegetative phase. All the treatments with Sul-Po-Mag application have recorded significantly higher values compared to T_2 for girth of plants. In the case of number of leaves, the treatment 5 which recorded the highest value was significantly higher compared to T_2.

1.3 At shooting

Data relating to height, girth and number of leaves at shooting are presented in Table 4.

1.3.1 Height of plant

There was no considerable variation in the height of the plants due to application of various sources of fertilizers. The maximum value of 288 cm was recorded by treatment T_{12} which was a Mg cum S treatment equivalent to full dose of Sul-Po-Mag and minimum value of 204.97 cm was recorded by the control. All the treatments have recorded higher values as compared to the application of MOP alone (248.7 cm).

1.3.2 Girth of plants

Mean girth of plant was influenced significantly due to the application of various treatments as in the late vegetative stage. The highest value 64.85 cm was recorded by T_2 and is on par with T_3, T_4 and T_{14}. The treatments T_3 and T_4 were

Table 4. Biometric observations at shooting (7 MAP)

Treatments	Mean height of plants (cm)	Mean girth of plants (cm)	Mean number of leaves
T_1	204.97	49.17	25.08
T_2	248.07	64.85	30.15
T_3	271.58	64.13	29.47
T_4	249.33	64.25	29.97
T_5	250.92	60.13	29.40
T_6	261.50	60.59	29.25
T_7	279.57	59.30	27.83
T_8	256.67	61.17	26.87
T_9	265.43	62.07	26.87
T_{10}	268.83	59.83	26.47
T_{11}	272.17	62.17	27.23
T_{12}	288.00	59.20	27.57
T_{13}	270.67	60.90	29.87
T_{14}	257.98	62.75	28.00
CD 5%	NS	2.626	NS
Sem±	136.599	2.447	2.782

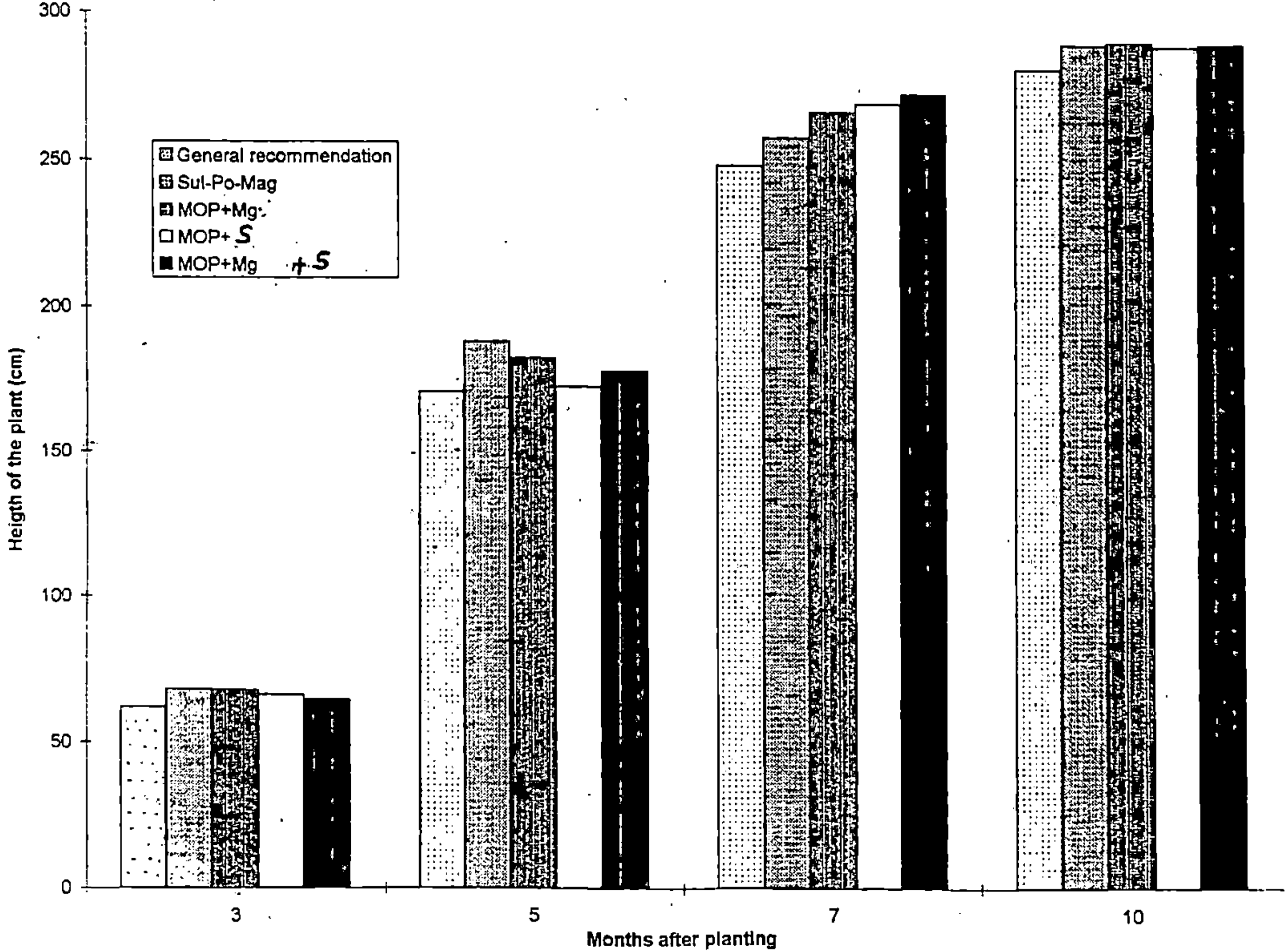

Fig . 2 Trend in the height of the plant during the various growth phases application of Sul-Po-Mag in full and half doses respectively and T_{14} was a treatment supplement with Mg and S. The control recorded the least girth of 49.17 cm.

1.3.3 Number of leaves

Not much difference was noticed in the number of leaves. Maximum value of 30.15 was shown by T_2 and lowest value 25.08 was exhibited by the control.

1.4 At harvest

Table 5 presents data on biometric observation of the plants at harvest.

1.4.1 Height of plants

The effect of treatments on plant height was not significant as in the earlier stages. The lowest height 232.75 cm was recorded by T_1 i.e., the control. All the treatments recorded higher values than T_2 except T_1.

1.4.2 Girth of plants

The influence of treatments was significant. The maximum girth 55.83 cm was recorded by T_7 and it is on par with all the other treatments except T_1 and T_2. Though T_2 showed a considerable increase in girth at shooting, that did not keep the pace till harvest.

1.4.3 Number of leaves

Significant difference was noticed in the number of leaves at harvest.

Table 5. Biometric observations at harvest

Treatments	Mean height of plants (cm)	Mean girth of plants (cm)	Total number of leaves (mean)	Total number of suckers (mean)	Days to flower	Days to mature	Total duration (days)
T_1	232.75	45.37	25.08	7.07	224.33	85.23	309.57
T_2	280.42	52.58	30.58	10.47	241.13	79.90	320.80
T_3	297.08	55.00	29.90	8.77	227.77	79.23	307.00
T_4	283.67	55.67	31.00	11.10	227.53	81.33	308.87
T_5	285.83	54.45	29.60	9.43	230.03	80.00	310.03
T_6	287.42	55.28	29.40	7.23	238.27	77.27	316.20
T_7	297.92	55.83	28.20	6.77	237.60	80.00	317.60
T_8	283.60	54.25	27.10	8.70	231.20	81.33	312.53
T_9	288.03	55.62	27.00	7.97	226.30	82.13	308.43
T_{10}	285.83	54.00	26.80	9.37	244.70	77.67	322.37
T_{11}	290.25	54.43	27.50	7.57	235.27	77.60	312.93
T_{12}	287.92	54.25	28.20	12.10	229.87	78.43	308.30
T_{13}	291.07	54.53	30.20	11.73	248.03	80.00	327.93
T_{14}	287.42	53.67	28.20	9.06	226.93	76.23	303.17
CD 5%	NS	2.760	2.620	2.497	NS	NS	NS
Sem±	115.113	2.712	2.431	2.213	57.09	8.761	54.779

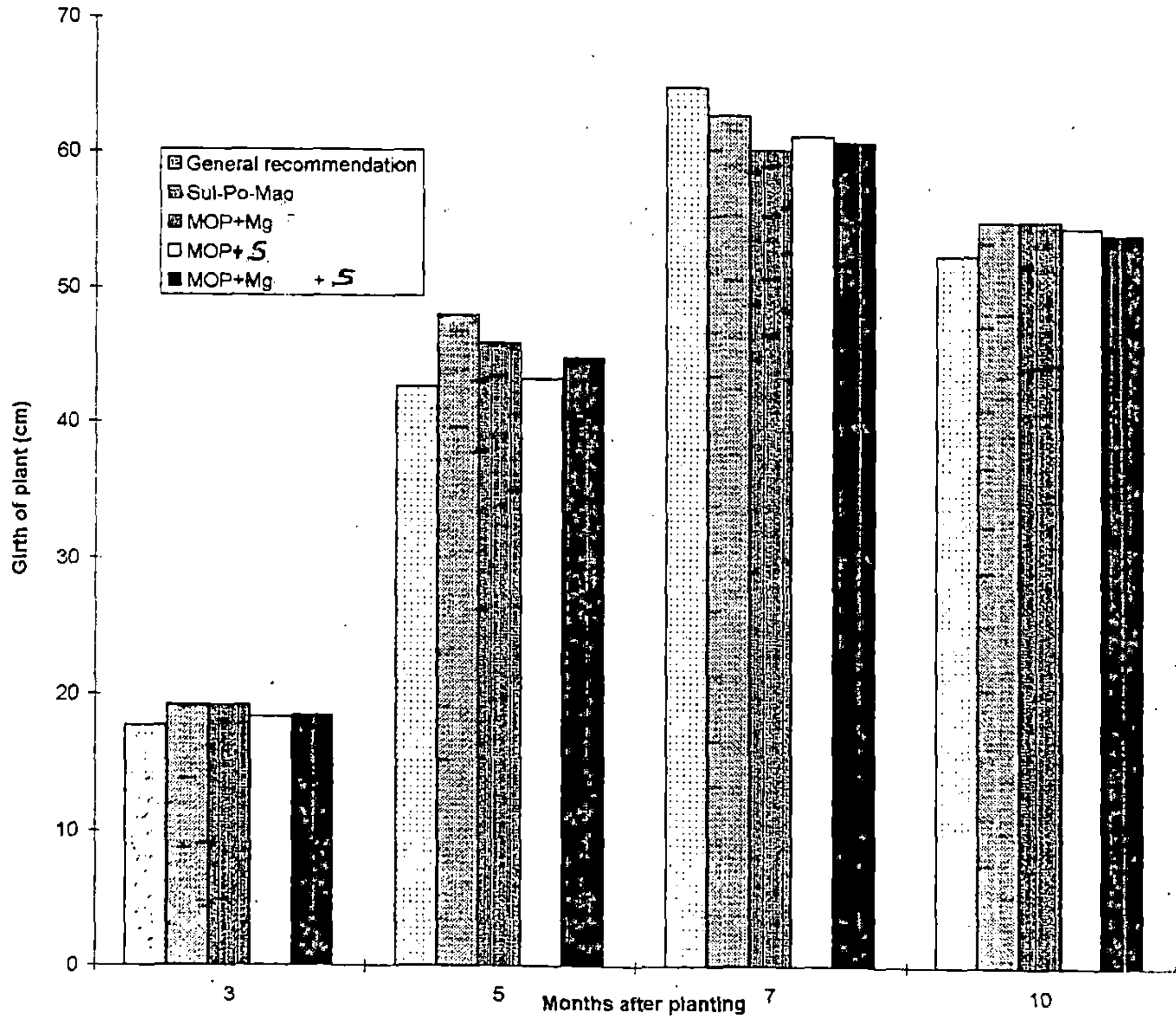

Fig .3 Trend in the girth of the plant during the growth phases

Maximum value of 31.00 was recorded by T_4 where K was supplied equally as MOP and as Sul-Po-Mag and is on par with T_2, T_{13}, T_3, T_5 and T_6. All the treatments which have received Mg alone or S alone in addition to MOP have recorded lower values compared to Sul-Po-Mag treatments.

These results on the vegetative characters at different stages of growth of the crop in general reveal that at the early vegetative stage there was no significant difference due to the treatments in any of the charactersstudied. This may be due to the reason that the soil contained sufficient nutrients to meet the initial requirements and the addition of fertilizers could not influence the growth of the plant at this stage. But at later stages namely at late vegetative stage and at harvest, the girth and number of leaves differed significantly under the influence of treatments and application of Sul-Po-Mag showed a favourable effect on these characters. Probably, the increased absorption of nutrients from the soil for plant utilization would have resulted in a decrease in the level of nutrients and so the plants responded to various treatment effects.

A similar pattern of increase in vegetative characters due to the increment in the supply of potassium fertilizers was reported by various workers (Jambulingam *et al.*, 1975; Singh *et al.*, 1977; Rajeevan, 1985). But according to Prema (1992) there was no significant effect on the vegetative characters due to application of Mg fertiliser.

1.4.5 Number of suckers

Data on the number of suckers produced presented in Table 5 indicated that the effect of treatments was significant. Maximum number of 12.10 was

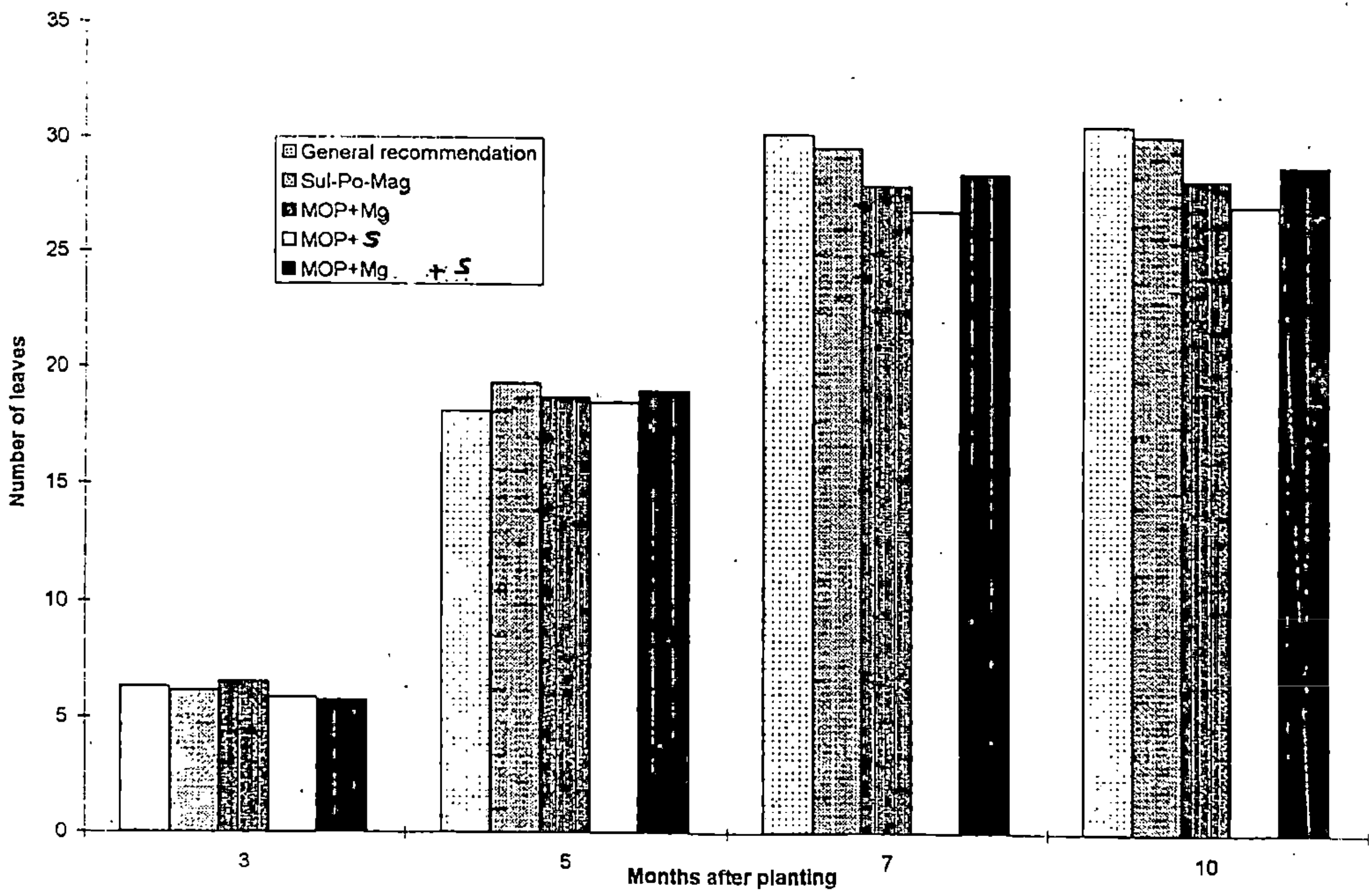

Fig . 4 Trend in the number of leaves during the growth phases

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recorded by T_{12}, where Mg and S were applied equivalent to that contained in full dose of Sul-Po-Mag along with MOP. But this treatment is on par with T_2 and this indicates that the application of S and Mg failed to increase the number of suckers produced. Similar result due to application of Mg has been reported by Prema (1992).

1.4.6 Number of days to flower

The data recorded in Table 5 revealed that the effects of treatments were not significant on the number of days to flower. The least number of days to flower was found with the control. All the Sul-Po-Mag applied treatments and treatments in which Mg was applied required lesser number of days to flower compared to the treatment received application of MOP alone.

1.4.7 Days to mature

Results indicated that the effect of treatments was not significant in the number of days required to mature and it was found to be the highest with the control i.e., 85.23 days. Though the control without fertilizer application flowered earlier, it recorded the maximum time to mature. There was not much variation in the number of days required to mature between the treatments other than the control.

1.4.8 Total duration of crop

All the treatments have recorded lower values when compared with T_{10} and T_{13}. But the difference due to treatments was not significant.

These results indicate that application of either Sul-Po-Mag or Mg or S in addition to MOP has failed to influence the days to flower, days to mature and the total duration of the crop. This shows that Sul-Po-Mag is as efficient as M O P in supplying the requirement of potassium. Further the results also indicate that application of Mg and S has no influence on the duration of crop. Therefore it can be inferred that the soil contained sufficient quantities of S and Mg to meet the requirements of crop.

Contradictory to the results obtained in the study, Sheela (1982) reported that higher levels of potassium reduced the total duration of crop. The works of Singh *et al.*, (1977) and Valsamma Mathew (1980) were also on similar lines. But no effect of Mg on total duration of crop has been reported by Prema (1992).

1.4.9 Bunch characters at harvest

Data on bunch characters at harvest are presented in Table 6.

1.4.9.1 Bunch weight

The data revealed that the effect of treatments was significant in the bunch weight. All the treatments have recorded significantly higher values compared to T_1 (4.19 kg). The maximum yield was recorded by T_4 (8.77 kg) where potassium is supplied equally by Sul-Po-Mag and MOP.

Treatment 4 is on par with all other treatments in which Sul-Po-Mag was applied. Among the Mg supplemented treatments, T_7 has recorded significantly lower yield compared to T_4. Treatment 10 which was a treatment supplemented with S has also recorded significantly lower yield compared to T_4. Treatment 14 which has received Mg and S together has recorded significantly lower yield compared to T_4. The results therefore indicate that Sul-Po-Mag application is better than MOP

Table 6. Bunch characters at harvest

Treatments	Mean bunch weight kg/plant	Mean No. of hands	Mean No. of fingers	Mean weight of fingers (g)	Mean length of fingers (cm)	Mean girth of fingers (cm)
T_1	4.19	4.03	30.25	97.20	19.41	11.03
T_2	7.72	4.82	41.43	175.83	26.99	13.47
T_3	8.59	5.00	43.33	182.75	28.00	13.25
T_4	8.77	5.00	41.67	192.92	26.67	13.63
T_5	8.66	4.93	44.58	180.42	26.65	13.33
T_6	7.89	4.94	40.33	156.37	26.10	12.78
T_7	7.54	5.00	42.20	167.08	25.75	13.18
T_8	8.19	5.00	42.85	166.75	26.13	13.13
T_9	7.75	5.00	41.68	150.47	25.43	12.63
T_{10}	6.78	4.42	34.50	149.67	25.00	13.27
T_{11}	8.07	4.83	40.85	164.67	25.67	12.81
T_{12}	8.50	5.08	42.58	172.92	25.63	13.67
T_{13}	7.87	5.00	41.21	172.23	27.76	13.16
T_{14}	7.63	4.92	41.92	154.83	25.09	12.92
CD 5%	1.091	0.547	NS	NS	2.59	0.84
Sem±	0.422	0.106	11.81	258.226	2.385	0.25

supplemented with Mg or S or both Mg and S together. Moreover the values of treatments which received S in addition to MOP (T_9, T_{10} and T_{11}) showed a decreasing trend and this may be due to the adverse effect of S on yield.

Yield increase due to potassium application in cv. Nendran was reported by many workers, Veeraraghavan (1972), Pillai *et al.* (1977) and Nambiar *et al.* (1979). But no favourable effect on yield due to application of Mg was reported by Prema (1992).

1.4.9.2 Number of hands

The variation between treatments was significant. But there was no significant variation between T_2 and and Sul-Po-Mag applied treatments. Treatments with S alone in addition to K_2O have recorded lower values compared to Sul-Po-Mag treatments, Mg applied treatments (T_6, T_7 and T_8) and Mg + S applied treatments (T_{12}, T_{13} and T_{14}). This again indicates that S application has an unfavourable influence on the number of hands also as in the case of bunch weight.

1.4.9.3 Number of fingers

No significant difference was observed between the treatments. The control recorded the lowest number of fingers (30.25). There was not much variation between the other treatments.

1.4.9.4 Weight of fingers

The influence of treatments on the weight of fingers was not significant. All treatments which have received Sul-Po-Mag i.e., T_3, T_4 and T_5 have recorded

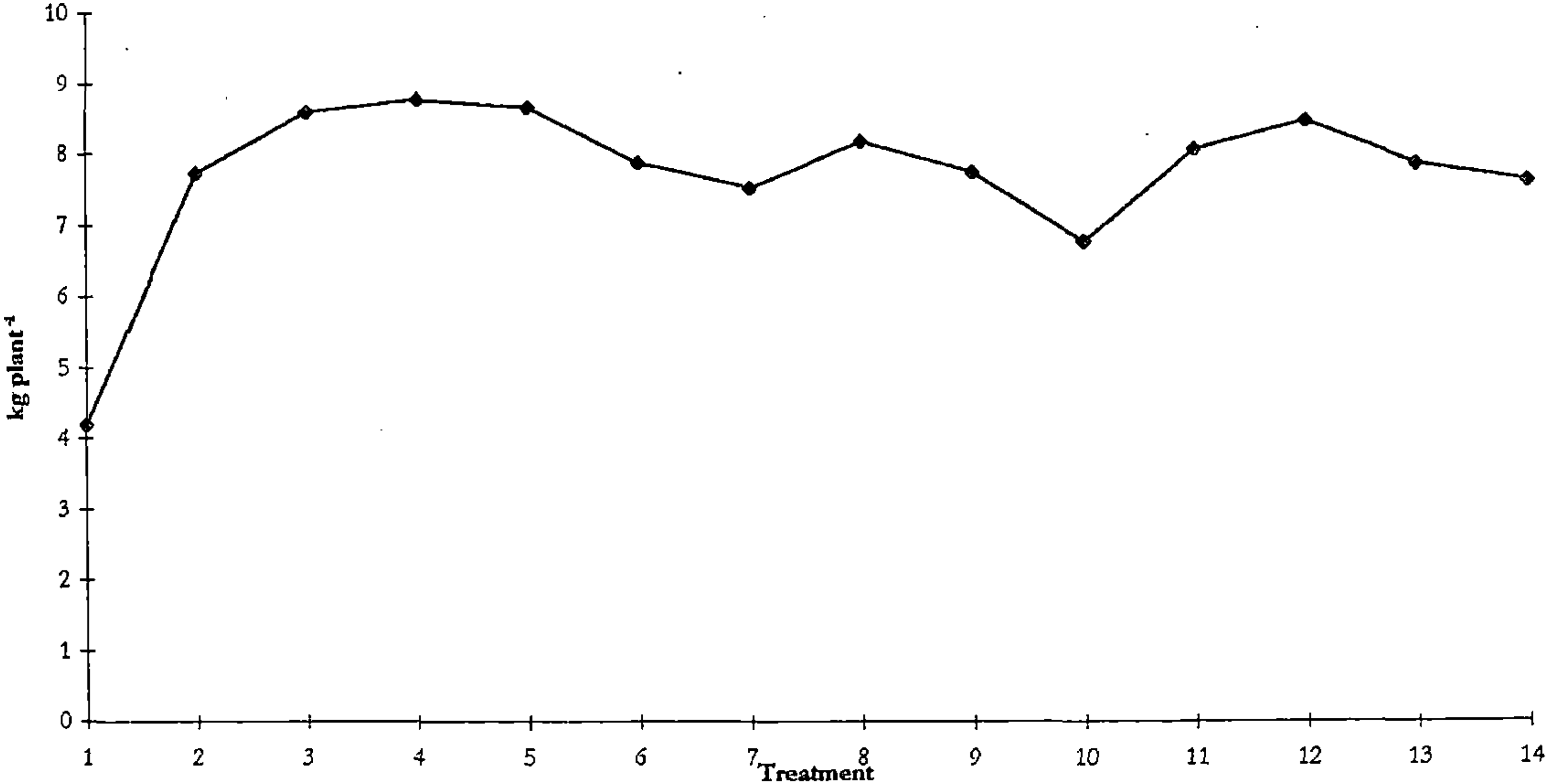

Fig . 5 Mean bunch weight

higher values compared to T_2 where as all the other treatments have recorded lower values compared to T_2. The maximum weight was with T_4 i.e., 192.92 g and the minimum with the control 97.20 g.

1.4.9.5 Length of fingers

Length of fingers was influenced significantly due to application of treatments. Control plot, has recorded the lowest value i.e., 19.41 cm and all other treatments have recorded significantly higher values. No significant variation was recorded between T_2 and other treatments, even though treatments of Sul-Po-Mag recorded higher values compared to other treatments. This shows that Sul-Po-Mag is as good as MOP and application of S and Mg separately has not much influence on the yield of banana.

1.4.9.6 Girth of fingers

Result showed that girth of fingers was also influenced significantly due to the effect of treatments. As in the case of other yield characters, the lowest value was recorded by T_1, 11.03 cm and all other treatments were superior to T_1. The mean girth of fingers recorded by T_2 (13.47 cm) and all other treatments are statistically on par and this again indicates that Sul-Po-Mag is as good as MOP and application of S and Mg in addition to MOP has no favourable influence on the yield.

1.4.10 Quality parameters

Data relating to quality parameters as influenced by the application of MOP, Sul-Po-Mag, Mg and S are presented in Table 7.

Table 7. Quality parameters

Treatments	TSS (%)	Ascorbic acid (mg/100 g)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Acidity (%)	Sugar:Acid ratio	Weight of pulp (g)	Weight of peel (g)	Pulp:Peel ratio
T_1	20.40	8.79	15.13	0.88	16.02	0.46	35.21	86.67	35.00	2.39
T_2	22.40	16.19	14.17	1.50	15.72	0.34	46.23	141.67	55.00	2.53
T_3	25.53	14.34	15.10	0.56	15.66	0.39	40.93	128.33	56.67	2.27
T_4	24.73	16.66	16.17	1.38	17.55	0.44	40.21	136.67	46.67	3.08
T_5	23.13	14.34	15.14	1.02	16.16	0.42	38.48	120.00	43.33	2.75
T_6	19.23	10.64	12.00	0.63	12.63	0.45	28.35	138.33	50.67	2.74
T_7	21.93	13.42	12.57	0.52	13.09	0.35	37.40	121.67	51.67	2.40
T_8	20.60	15.27	14.25	0.66	14.91	0.34	44.01	134.00	45.67	2.99
T_9	26.13	15.27	15.10	0.18	15.28	0.23	68.21	80.67	34.00	2.41
T_{10}	24.13	11.10	14.30	1.06	15.36	0.32	48.00	101.67	35.00	2.90
T_{11}	25.89	9.72	12.50	0.59	13.09	0.24	54.54	125.00	38.33	3.37
T_{12}	22.60	9.25	13.13	0.70	13.84	0.33	42.99	126.67	38.33	3.30
T_{13}	23.20	9.72	12.49	0.30	12.70	0.24	53.29	105.00	36.67	2.99
T_{14}	24.87	15.27	11.37	1.38	12.74	0.24	52.59	128.33	46.67	2.78
CD 5%	1.286	3.721	NS	0.658	NS	0.178	NS	NS	NS	0.936
Sem±	0.587	4.916	2.766	0.154	3.129	0.011	214.8	841.321	83.985	0.311

1.4.10.1 Total soluble solids

The content of total soluble solids was influenced significantly due to the application of fertilizers. The treatment T_6 i.e., application of Mg along with MOP has recorded the lowest value 19.23 and it is on par with the control plot. Application of gypsum has shown a tendency to increase the content of TSS as all the three treatments (T_9, T_{10} and T_{11}) with gypsum application have recorded significantly higher values as compared to application of MOP alone. Similarly all the treatments with Sul-Po-Mag application and the treatments with Mg and S application along with MOP have also shown a favourable influence on the TSS. But application of Mg has shown a tendency to decrease the soluble solid contents. The values recorded varied from 19.23 to 26.13 and these are in accordance with the results reported by Anil *et al.* (1995).

But the values recorded by Valsalakumari (1985), Aravindakshan (1981) and Chellappan (1983) are much higher and the values recorded by them are 29.3, 31.03 and 48.64 per cent respectively.

1.4.10.2 Ascorbic acid

The influence of treatments was significant in ascorbic acid content also. The lowest value (8.79) was recorded by T_1 and the highest value (16.66) was recorded by T_4. The results reveal that Sul-Po-Mag application has not affected the ascorbic acid content as there is no significant difference between T_2 and Sul-Po-Mag applied treatments. Most of the treatments with Mg or S separately and Mg + S together reduced the ascorbic acid content compared to T_2. Values

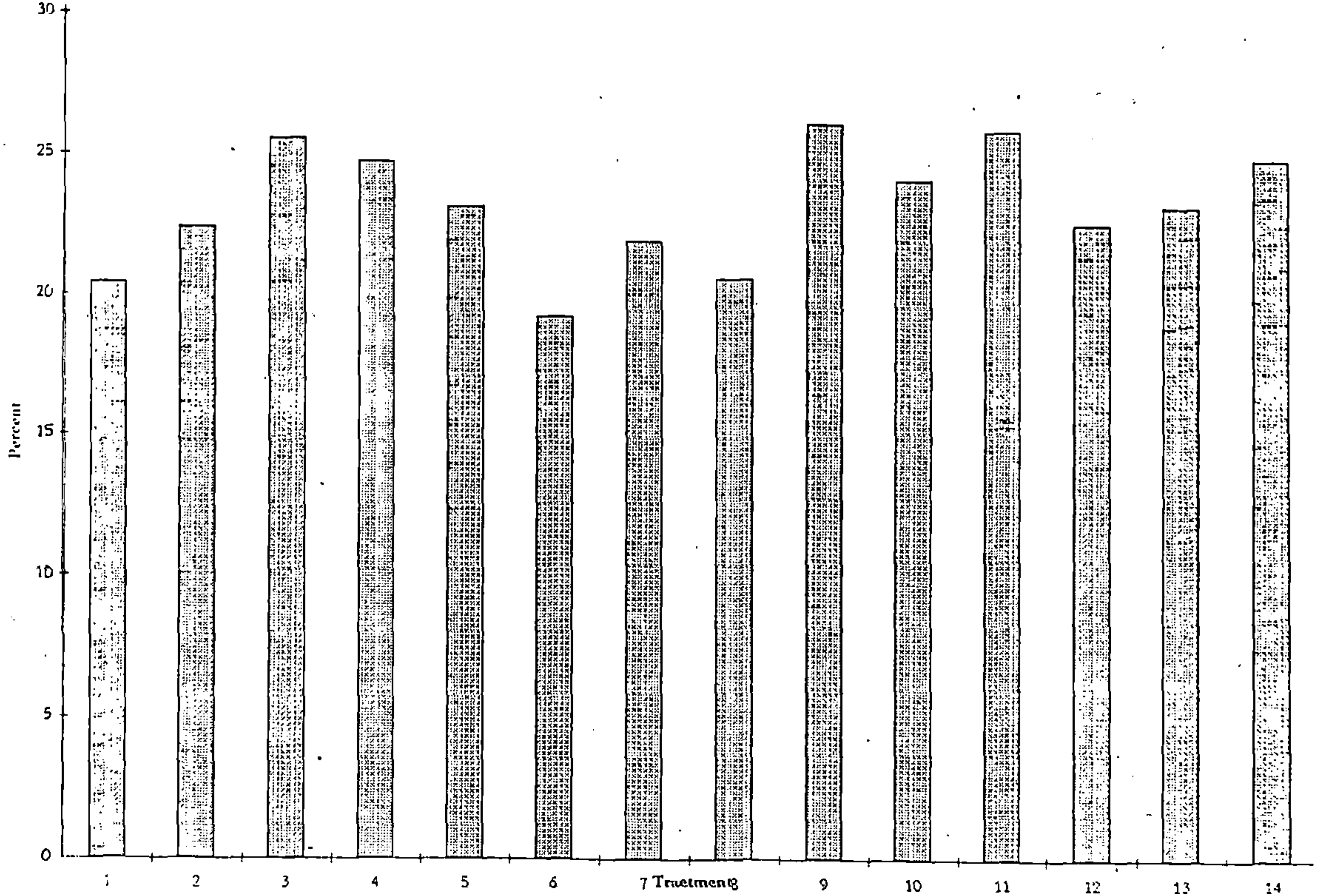

Fig. 6 Total soluble solids for variuos treatments

recorded are in accordance with that reported by Aravindakshan (1981) and Anil *et al.* (1995).

1.4.10.3 Reducing Sugar

The variation in the content of reducing sugar due to treatment differences was not significant. The highest value of 16.17 was recorded by T_4 which was a treatment having half dose of K as MOP and half as Sul-Po-Mag. Lowest value was observed with T_{14} which was Mg cum S supplemented treatment (11.37). The general trend observed is that application of Sul-Po-Mag showed a tendency to increase the content of reducing sugar whereas supplementing MOP with Mg and S showed a tendency to decrease it. The values reported by Anil *et al.* (1995) were much lower compared to the values obtained in the present investigation as the values reported by them varied from 7.0 to 8.7.

1.4.10.4 Non reducing sugar

The non reducing sugar content which decides the taste and sweetness of fruit showed a significant difference among the treatments applied. The treatment which received the general recommended dose of NPK (T_2) has got the highest non reducing sugar content of 1.50. The least value was recorded for T_9 where gypsum equivalent to S contained in full dose of Sul-Po-Mag was applied. Application of Sul-Po-Mag, Mg and S showed a tendency to decrease the content of non reducing sugar.

1.4.10.5 Total sugar

The total sugar content was not affected significantly due to treatments.

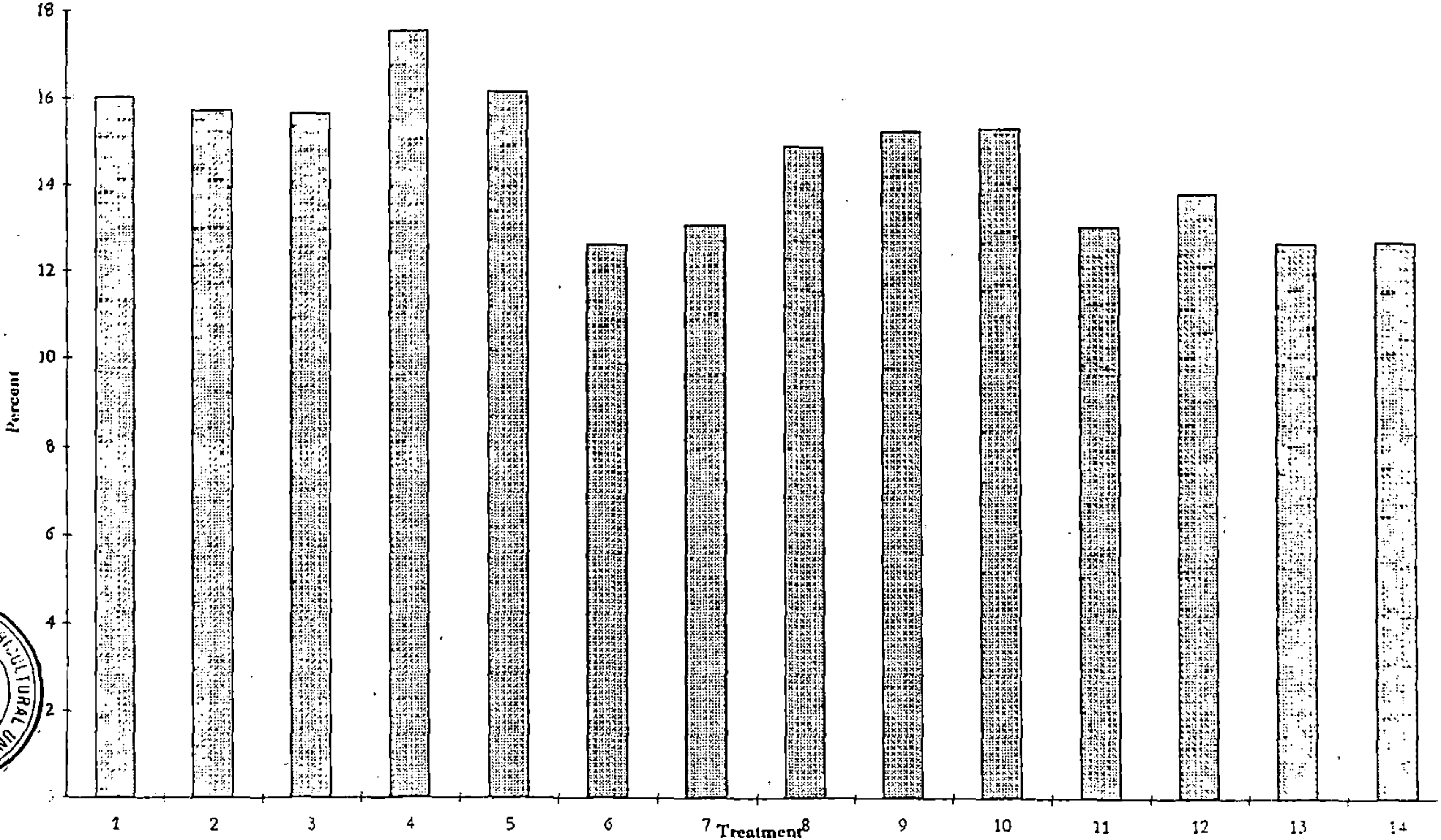

Fig . 7 Total sugar content variation due to various treatments

Maximum value was found with T_4 which was a treatment with Sul-Po-Mag application (17.55) and minimum with T_6 (12.63) which was a treatment with Mg application in addition to MOP. Sugar content of the treatments with Sul-Po-Mag showed a slight increase compared to treatments with application of Mg or S or Mg and S together. The values recorded are in accordance with that reported by Valsalakumari (1985) but much lower than that reported by Anil *et al.* (1995).

1.4.10.6 Acidity

The influence of treatments on the acidity of banana was significant. The control recorded the highest acidity (0.46). The acidity recorded for all the other treatments were low compared to control. Application of S singly and in combination with Mg in addition to MOP showed a tendency to decrease the acidity of fruits. The values obtained are in conformity with those reported by Anil *et al.* (1995).

1.4.10.7 Sugar acid ratio

This ratio was also not affected considerably due to treatments. Application of NPK fertilizer alone and application of Sul-Po-Mag increased the ratio compared to the control. In general, the treatments with S alone and in combination with Mg showed a tendency to increase the ratio and this is mainly due to the decrease in acidity. Similar values have been reported by Anil *et al.* (1995).

1.4.10.8 Weight of pulp

The treatments failed to make any significant difference in the weight of pulp. Highest value 141.67 g was recorded by T_2 and lowest value of 86.67 g by the control.

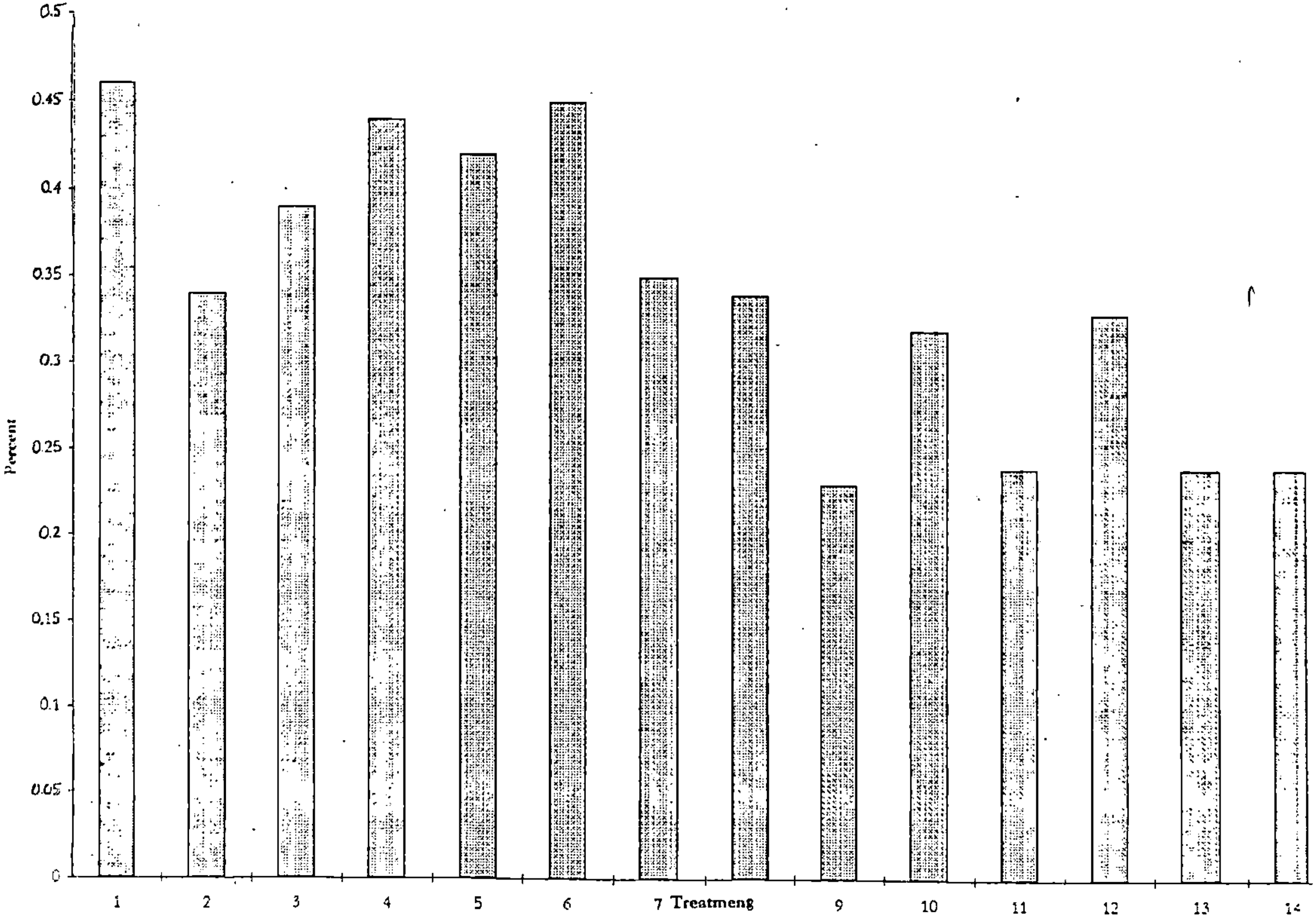

Fig . 8 Acidity of fruits for various treatments

1.4.10.9 Weight of peel

Result revealed that weight of peel was also not influenced by the treatments. The maximum value was recorded by T_3 where MOP was substituted by Sul-Po-Mag and the minimum by T_9 where gypsum was applied with MOP.

1.4.10.10 Pulp-peel Ratio

There was significant difference among the treatments for the characteristic pulp-peel ratio. The highest value 3.37 was with T_{11} and the lowest value 2.27 was with T_3. The treatment 2 is found to be on par with all the treatments indicating that the fertilizers applied have no influence on the pulp peel ratio which affects the keeping quality during storage and transport.

2 Soil reactions and nutrient content of soil

2.1 Soil reaction and nutrient contents at vegetative phase

Data relating to soil reaction and nutrient contents at vegetative phase are presented in the Table 8.

2.1.1 Soil reaction (pH)

The result indicated that applications of treatmentshas influenced the soil reaction significantly. The maximum value 5.5 was recorded by T_2, and the lowest value was recorded by T_4, T_6, T_7 and T_{11} (4.9). The pH of the control plot is on par with T_2. All the Sul-Po-Mag applied treatments and treatments supplemented with Mg have recorded significantly lower values compared to T_2.

2.1.2 Specific conductance

Specific conductance of the soil solution was influenced significantly due to treatments. Electrical conductivity of all the treatments except the control (0.07 dS m^{-1}) was higher than T_2. The highest value was recorded by T_6 1.41 dS m-1 where Mg in full dose is applied along with MOP.

2.1.3 Organic carbon

There was no considerable variation in the organic carbon content of soil due to treatments. The highest value was recorded by T_4 and the lowest by T_9. There was no difference between treatments in the quantity of organic matter applied and that may be the reason for the nonsignificant difference noticed. The organic carbon content of the original soil was high. At the vegetative phase also, all the treatments have recorded relatively higher values.

2.1.4 Available P

In the case of available P also, there was no significant variation and this is expected as there was no difference in the P content of the treatments. In general, the values are alike and the soil is rich in P content. The control has also recorded a value similar to that of the treatments which received P fertilizer and this may be due to the high P content of the soil and the same was indicated by the original data.

2.1.5 Available K

No decisive difference was observed in available K content of soil among the treatments. Maximum value 548.32 kg ha^{-1} was observed in T_5 where K is

Table 8. Soil reactions and nutrient contents in soil at vegetative phase

Treatments	pH	E.C. dS m^{-1}	Organic C (%)	Available P kg ha^{-1}	Available K kg ha^{-1}	Exchangeable Ca cmol(+)kg^{-1}	Exchangeable Mg cmol(+) kg^{-1}	Available S ppm
T_1	5.3	0.07	0.81	18.47	160.66	9.07	3.20	58.67
T_2	5.5	0.10	1.00	18.42	493.34	8.27	3.20	20.00
T_3	5.0	0.22	0.83	20.62	346.66	6.13	8.80	167.33
T_4	4.9	0.29	1.10	15.75	470.66	7.73	8.20	87.33
T_5	5.0	0.34	0.96	24.10	548.32	6.67	8.60	210.00
T_6	4.9	1.41	0.88	20.00	380.00	4.53	7.60	113.33
T_7	4.9	0.33	0.88	22.85	333.32	4.27	7.90	96.67
T_8	5.1	0.35	0.86	18.03	366.66	5.07	4.40	40.00
T_9	5.3	0.24	0.80	18.77	243.32	41.60	8.40	580.00
T_{10}	5.3	0.18	0.82	23.02	308.32	17.87	2.40	236.67
T_{11}	4.9	0.14	1.01	18.27	305.00	17.07	2.00	206.67
T_{12}	5.2	0.68	0.97	20.25	255.00	34.13	5.20	326.67
T_{13}	5.2	0.55	1.05	18.79	388.34	28.80	8.00	400.00
T_{14}	5.1	0.18	0.85	20.10	295.00	12.80	6.00	66.67
CD 5%	0.332	0.320	NS	NS	NS	10.231	2.543	NS
Sem±	0.039	0.036	0.025	353.32	2846.50	37.15	2.295	2878.64

2.1.2 Specific conductance

Specific conductance of the soil solution was influenced significantly due to treatments. Electrical conductivity of all the treatments except the control (0.07 dS m^{-1}) was higher than T_2. The highest value was recorded by T_6 1.41 dS m^{-1} where Mg in full dose is applied along with MOP.

2.1.3 Organic carbon

There was no considerable variation in the organic carbon content of soil due to treatments. The highest value was recorded by T_4 and the lowest by T_9. There was no difference between treatments in the quantity of organic matter applied and that may be the reason for the nonsignificant difference noticed. The organic carbon content of the original soil was high. At the vegetative phase also, all the treatments have recorded relatively higher values.

2.1.4 Available P

In the case of available P also, there was no significant variation and this is expected as there was no difference in the P content of the treatments. In general, the values are alike and the soil is rich in P content. The control has also recorded a value similar to that of the treatments which received P fertilizer and this may be due to the high P content of the soil and the same was indicated by the original data.

2.1.5 Available K

No decisive difference was observed in available K content of soil among the treatments. The maximum value 548.32 kg ha^{-1} was observed in T_5 where K was supplied 3/4th as MOP and 1/4th as Sul-Po-Mag and the minimum

160.66 kg ha^{-1} was recorded by the control. All the other treatments are in the medium to high level of potassium.

2.1.6 Exchangeable Ca

The effect of treatments on exchangeable Ca content of soil was found to be significant. The treatments 9, 12 and 13 which have received S as gypsum along with K_2O gave significantly higher values compared to T_2. The Sul-Po-Mag treatments i.e., T_3, T_4 and T_5 and the Mg alone supplied treatments i.e., T_6, T_7 and T_8 were found to be on par with T_1 and T_2.

2.1.7 Exchangeable Mg

Exchangeable Mg content of soil was influenced significantly by the treatment effects. The maximum value, 8.8 cmol(+) kg^{-1}, was recorded by the treatment 3 where Sul-Po-Mag was applied in full dose and the minimum value, 2.00 cmol(+) kg^{-1} was recorded by treatment 11 where gypsum was supplied along with MOP in dose equivalent to that in treatment 5. The treatments T_3, T_4, T_5, T_6, T_7, T_9, T_{13} and T_{14} were found to be superior to T_2.

2.1.8 Exchangeable S

In the case of exchangeable S difference due to treatments was not significant. All those treatments which have received S either as Sul-Po-Mag or as gypsum have recorded higher values compared to the treatments T_1 and T_2 and the Mg received treatments.

2.2 Soil reaction and nutrient contents in soil at harvest phase

Data on nutrient content in soil at harvest phase are presented in Table 9.

2.2.1 Soil Reaction

The influence of treatments was significant at harvest phase. Similar results were obtained at vegetative phase also. As at early vegetative stage, all treatments which have received either Sul-Po-Mag. Mg and S either alone or Mg + S in combination have recorded lower valuesof pH compared to T_1 and T_2.

2.2.2 Specific conductance

The statistical analysis of the data showed that the treatments differed significantly in their influence in specific conductance as at the vegetative phase. The overall mean value was found to decrease at harvest stage compared to that at vegetative phase.

2.2.3 Organic carbon

The difference due to treatments was significant. The highest value of 0.88 per cent was recorded by both T_2 and T_9. Most of the treatments have recorded values significantly lower than T_2. Organic carbon content at harvest was much lower than that recorded at vegetative phase and this may be due to the rapid decomposition of organic matter and the exhaustive uptake of nutrients by the crop during the growth phase.

Table 9. Soil reactions and nutrient content in soil at harvest phase

Treatments	pH	E.C. dS m^{-1}	Organic C (%)	Available P kg ha^{-1}	Available K kg ha^{-1}	Exchangeable Ca cmol(+)kg^{-1}	Exchangeable Mg cmol(+) kg^{-1}	Available S ppm
T_1	5.2	0.08	0.77	17.60	402.00	6.00	11.53	36.30
T_2	5.2	0.07	0.88	18.50	556.60	6.23	12.30	37.50
T_3	4.9	0.07	0.80	18.00	246.00	4.33	12.80	95.30
T_4	4.6	0.08	0.76	17.30	244.00	5.63	10.40	99.70
T_5	5.2	0.07	0.77	22.37	354.60	5.57	12.00	135.75
T_6	5.1	0.09	0.82	17.40	353.00	6.90	14.53	58.00
T_7	5.2	0.09	0.71	19.87	273.60	7.13	13.10	160.30
T_8	4.9	0.07	0.78	18.49	273.60	6.27	11.93	55.87
T_9	5.1	0.09	0.88	18.90	288.00	8.67	13.80	244.70
T_{10}	5.0	0.06	0.68	20.50	305.00	6.10	10.53	210.30
T_{11}	4.8	0.07	0.76	17.17	202.00	6.00	11.20	111.00
T_{12}	4.9	0.09	0.85	20.90	243.00	8.13	11.30	185.70
T_{13}	5.1	0.08	0.64	21.43	321.00	7.80	11.10	97.00
T_{14}	4.9	0.08	0.75	20.11	395.60	5.03	11.20	141.00
CD 5%	0.395	0.008	0.100	NS	NS	1.823	1.53	NS
Sem±	0.055	0.000	0.004	52.27	256.81	1.18	0.828	885.72

2.2.4 Available P

There was not much difference in the available P content in soil due to the treatments at harvest. The available P content of the original soil was high. Moreover there was no significant difference in the quantity of P applied to plots except in control. That may be the reason for the nonsignificant difference between the treatments.

2.2.5 Available K

In the case of available K also there was not much difference due to the treatments. The highest value 556.60 kg ha^{-1} was recorded by T_2 and the lowest value of 202.00 kg ha^{-1} was recorded by T_{11}. There was not much difference in the K content of soil at harvest compared to that at vegetative phase. The K content of the original soil was in the medium range and this level was maintained till harvest.

2.2.6 Exchangeable Ca

The difference in the exchangeable Ca content of soil at harvest was significant. Maximum value was recorded by T_9 (8.67 cmol(+) kg^{-1}) followed by T_{12} (8.13 cmol(+) kg^{-1}). No regular pattern could be identified in the exchangeable Ca content of soil at harvest due to the treatments. Exchangeable Ca content at harvest was found to be lesser than that recorded at vegetative phase. This indicates the utilization of Ca in the vegetative growth stage.

2.2.7 Exchangeable Mg

The difference due to the treatments was significant at harvest phase too.

The highest value was recorded by T_6 i.e., 14.53 cmol(+) kg^{-1} and the lowest value was recorded by T_4 (10.40 cmol(+) kg^{-1}). No regular trend was observed due to the application of treatments. Magnesium content of soil at harvest stage was found to be higher than that at the vegetative phase.

2.2.8 Exchangeable S

The influence of treatments on the exchangeable S content of the soil was found to be nonsignificant. No regular pattern was noticed in the S content due to treatments at harvest and at vegetative phase. All the treatments have recorded higher values compared to T_1 (control) and T_2 (recommended practice).

3 Nutrient content of leaves

The nutrient content of leaves was analysed at vegetative phase, at shooting and at harvest phase.

3.1 Nutrient content of leaves at vegetative phase

Data relating to the major and secondary nutrient content of leaves as influenced by treatments are presented in Table 10.

3.1.1 Nitrogen

Not much variation was noticed in the N content. The highest value 3.41 per cent was recorded by T_6 and the lowest 2.52 per cent by T_{13}. The non significant effect may be attributed to the availability of N in the soil in optimum quantities as revealed by the organic carbon content.

Table 10. Nutrient content of leaves at vegetative phase

Treatments	N %	P %	K %	Ca %	Mg %	S %
T_1	2.94	0.39	1.52	2.48	1.83	0.50
T_2	3.08	0.37	1.70	1.68	1.63	0.52
T_3	3.13	0.45	2.54	1.92	1.87	0.60
T_4	2.61	0.41	2.35	2.08	1.83	0.56
T_5	2.75	0.42	2.51	1.52	1.55	0.59
T_6	3.41	0.37	2.36	1.60	1.54	0.50
T_7	2.99	0.42	2.42	1.44	1.87	0.71
T_8	3.03	0.38	2.22	1.52	1.59	0.74
T_9	3.22	0.37	2.33	2.32	1.30	0.61
T_{10}	3.08	0.35	2.42	2.32	0.63	0.57
T_{11}	3.03	0.40	2.21	1.92	1.27	0.52
T_{12}	2.71	0.33	2.29	2.32	1.97	0.49
T_{13}	2.52	0.36	2.27	1.76	1.58	0.51
T_{14}	2.71	0.35	2.79	1.68	1.44	0.46
CD 5%	NS	NS	1.042	0.468	0.363	NS
Sem±	0.222	0.002	0.385	0.078	0.047	0.05

3.1.2 Phosphorus

The effect of treatments was not significant on the P content also. The plants from the control plot without P application (T_1) have also recorded values almost similar to other treatments. This may be inferred as due to the high content of soil P.

3.1.3 Potassium

The effect of treatments was significant in the K content of the plant. The highest value 2.79 per cent was recorded by T_{14} which is a S + Mg treatment along with MOP. The lowest value, 1.52 per cent was recorded by the control. Application of Sul-Po-Mag, MOP + Mg, MOP + S and MOP + Mg + S have recorded superior values compared to T_2 where MOP alone is applied. All these treatments contained either Ca or Mg and these elements are known to enhance the availability of K and this may be the reason for the increased content of K in these treatments.

3.1.4 Calcium

The calcium content of plants also differed significantly due to the influence of treatments. The highest value, 2.48 per cent was recorded by the control. The treatments which have received gypsum in addition to MOP (T_9, T_{10} and T_{11}) have recorded comparatively higher values followed by treatments which have received S along with Mg in addition to MOP. The increased content of Ca in these treatments may be due to the higher content of Ca applied to the above treatments as $CaSO_4$.

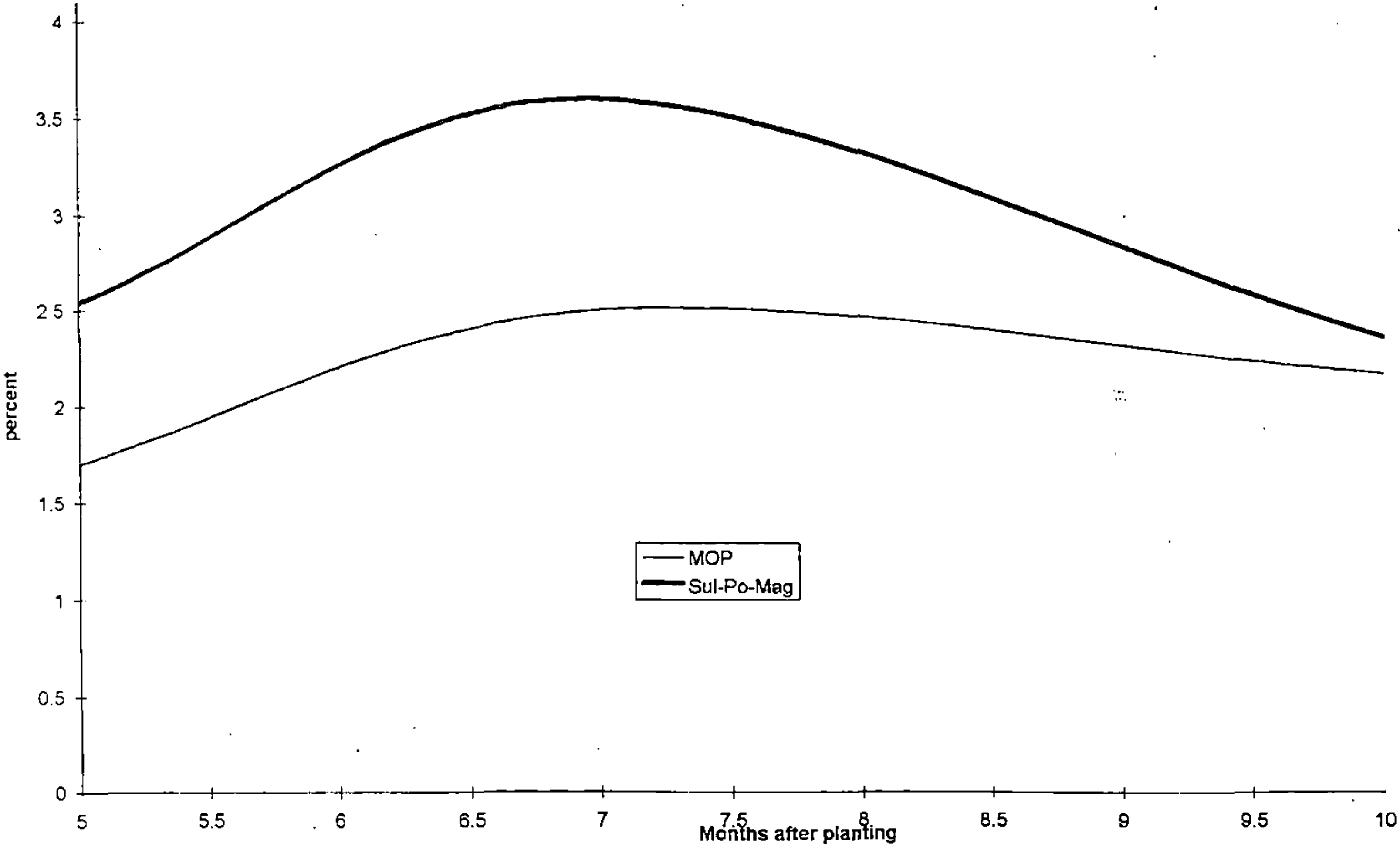

Fig . 9 Comparison of potassium content of leaves by application of MOP and Sul-Po-Mag

3.1.5 Magnesium

The influence of treatments on Mg content of plants was also significant. In this case also the control plot T_1 has recorded higher value 1.83 per cent compared to T_2, 1.63 per cent. The low content of magnesium in T_2 may be due to dilution effect. Though the influence of treatments on the Mg content of plants was significant, no regular trend due to application of treatments could be identified. The treatments with application of S in addition to MOP showed a tendency to decrease the Mg content.

3.1.6 Sulphur

The influence of treatments on the S content of plants was not significant. The maximum value of 0.74 per cent was recorded by T_8 and the minimum by T_{14}, 0.46 per cent. Treatment 8 is a Mg treatment and Treatment 14 is a S applied treatment. This indicates that supply of S has no significant influence on the content of S in plants.

3.2 Nutrient content of leaves at shooting

Data relating to the nutrient content of leaves as influenced by treatments are presented in Table 11.

3.2.1 Nitrogen

The effect of treatments on the nitrogen content of leaves at shooting was found to be significant. The maximum value was given by T_{12} i.e., 4.15 per cent which was a Mg and S treatment along with K and the minimum with T_{10} which

Table 11. Nutrient content of leaves at shooting

Treatments	N %	P %	K%	Ca %	Mg %	S %
T_1	3.58	0.39	1.95	3.29	0.46	0.19
T_2	3.66	0.37	2.50	2.40	0.37	0.23
T_3	3.78	0.31	3.60	1.60	0.67	0.29
T_4	3.77	0.35	3.35	1.89	0.86	0.35
T_5	3.94	0.36	2.20	1.44	1.07	0.57
T_6	4.05	0.36	3.05	1.76	0.77	0.29
T_7	4.06	0.35	3.30	1.44	0.58	0.19
T_8	4.06	0.32	3.20	1.67	0.55	0.40
T_9	3.48	0.32	3.25	1.92	0.77	0.46
T_{10}	3.33	0.34	3.65	1.60	0.99	0.29
T_{11}	3.54	0.31	2.80	1.40	0.96	0.31
T_{12}	4.15	0.36	3.00	1.77	0.67	0.65
T_{13}	4.07	0.38	3.30	1.68	0.56	0.61
T_{14}	3.83	0.40	2.60	1.53	0.48	0.57
CD 5%	0.333	0.055	0.385	0.695	0.340	0.270
Sem±	0.039	0.001	0.053	0.171	0.040	0.025

was a treatment with S alone along with K. All the Sul-Po-Mag treatments are found on par with T_2. All magnesium treatments are found superior to T_2 indicating the enhancement of N content in leaves by application of Mg. All the S supplied treatments are found to be on par with T_2 indicating that S is not of much importance in the uptake of N. Not much difference was noticed in the N content of the plants at vegetative phase and at shooting.

3.2.2 Phosphorus

The results revealed that the treatments showed significant difference with respect to P content in leaves at shooting. The highest value was recorded by T_{14} i.e., 0.4 per cent and the next by T_1 i.e., 0.39 per cent. Treatment which has received the recommended dose of N, P and K (T_2) is found to be on par with all the Sul-Po-Mag treatments, Mg treatments, and all S treatments except for T_{11}. This indicates that potassium, magnesium and sulphur have no influence on the P content of leaves. There was not much difference in the P content of leaves at the vegetative phase and at shooting.

3.2.3 Potassium

The treatment effects were significant. All the treatments showed significantly higher values compared to the control indicating the uptake of potassium applied in the soil. Significantly higher contents were noticed in Mg supplemented treatments. It may be inferred as the positive effect of Mg on K content of leaves at shooting. The K content of leaves showed a tendency to increase during shooting compared to that at vegetative phase.

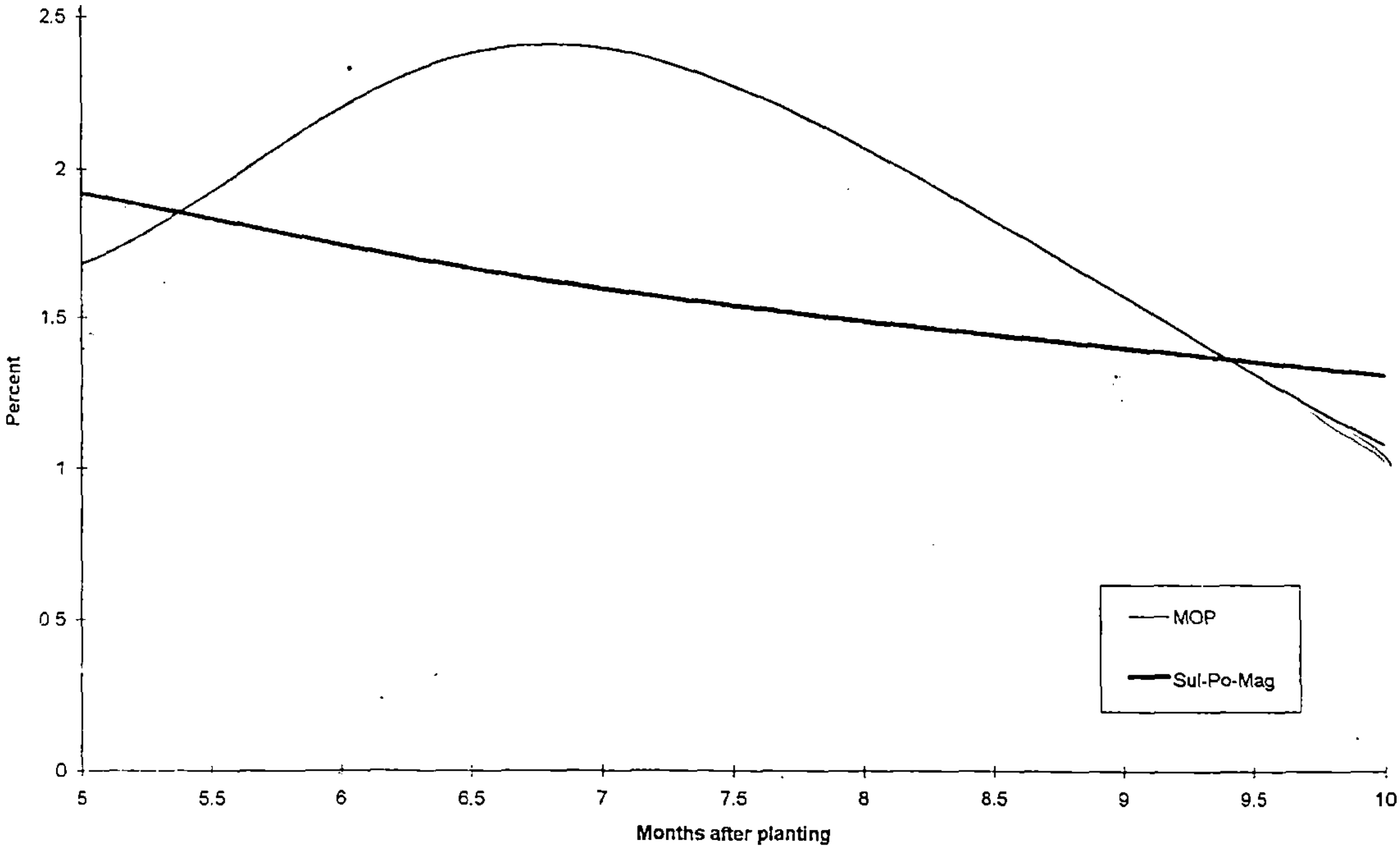

Fig . 10 Comparison of calcium content of leaves by the application of MOP and Sul-Po-Mag

3.2.4 Calcium

Calcium content of leaves at shooting also showed significant difference. But no regular trend was noticed in its content due to treatments. Maximum value, 3.29 per cent was given by the control followed by the treatment 2. All the other treatments have recorded significantly lower values compared to control and this may be due to the dilution effect. Not much difference was noticed in the calcium content at vegetative phase and at shooting.

3.2.5 Magnesium

The results revealed the significance of treatment effects in the Mg content of leaves. Maximum content was found with T_5 1.07 per cent which is a Sul-Po-Mag treatment and minimum with T_2, 0.37 per cent which is the general recommendation. All the treatments with Sul-Po-Mag, Mg, S and Mg + S together have recorded higher values compared to T_2. Magnesium content was found to be lower at shooting compared to that at vegetative stage.

3.2.6 Sulphur

The effect of treatments on sulphur content of leaves at shooting was found to be significant. All the treatments with S application either as Sul-Po-Mag or as gypsum have recorded higher values for S. This shows that soil application of S has influenced the leaf content of S.

3.3 Nutrient content of leaves at harvest

Data presented in Table 12 represents the nutrient content of leaves at harvest.

Table 12. Nutrient content of leaves at harvest

Treatments	N %	P %	K%	Ca %	Mg %	S %
T_1	2.91	0.25	2.17	1.11	0.06	0.11
T_2	3.19	0.27	2.19	1.02	0.12	0.05
T_3	3.11	0.27	2.36	1.31	0.15	0.09
T_4	2.91	0.26	2.93	1.36	0.24	0.06
T_5	3.32	0.33	2.86	1.03	0.15	0.07
T_6	3.05	0.27	2.65	1.13	0.15	0.06
T_7	3.03	0.25	3.27	1.06	0.22	0.09
T_8	2.91	0.27	3.10	1.28	0.24	0.11
T_9	2.71	0.25	2.15	1.53	0.24	0.06
T_{10}	2.67	0.24	1.74	1.52	0.27	0.09
T_{11}	2.65	0.26	2.45	1.17	0.15	0.07
T_{12}	2.75	0.29	2.96	1.29	0.16	0.05
T_{13}	3.07	0.27	2.31	1.21	0.15	0.06
T_{14}	2.95	0.24	3.05	1.10	0.18	0.13
CD 5%	NS	NS	0.890	0.297	0.060	0.024
Sem±	0.116	0.001	0.281	0.031	0.001	0.000

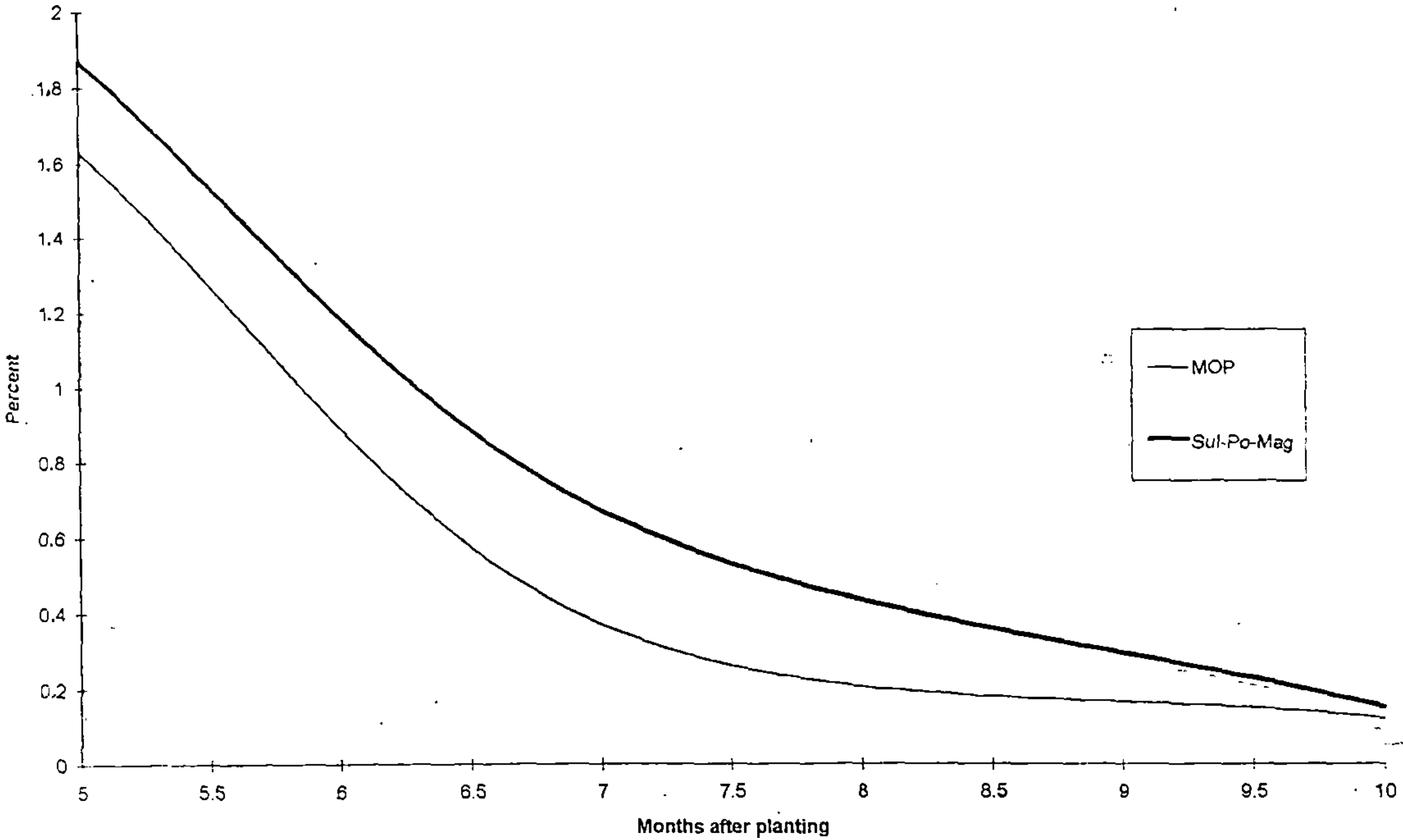

Fig . 11 Comparison of magnesium content of leaves by the application of MOP and Sul-Po-Mag

3.3.1 Nitrogen

The effect of treatments on the nitrogen content of leaves was found to be non significant. The highest value was noted with T_5, 3.32 per cent and the lowest value with T_{11}, 2.65 per cent. All the treatments showed a decrease in nutrient content compared to the early stages. This may be due to the translocation of nutrient to fruits at shooting.

3.3.2 Phosphorus

Phosphorus content was also found to be not significant irrespective of treatment difference. But the P content decreased from shooting and this may be due to the translocation of nutrients to fruit.

As in the earlier stages, the control without P fertilizer showed no difference with other treatments and this may be due to the high availability of P in the soil.

3.3.3 Potassium

There was significant difference due to the variation in treatments. As in the earlier stages of growth, application of Sul-Po-Mag or Mg alone or Mg + S along with K_2O showed a tendency to increase the K content.

3.3.4 Calcium

The influence of treatments was significant in the calcium content of plants. In general, the treatments with S application have recorded higher values.

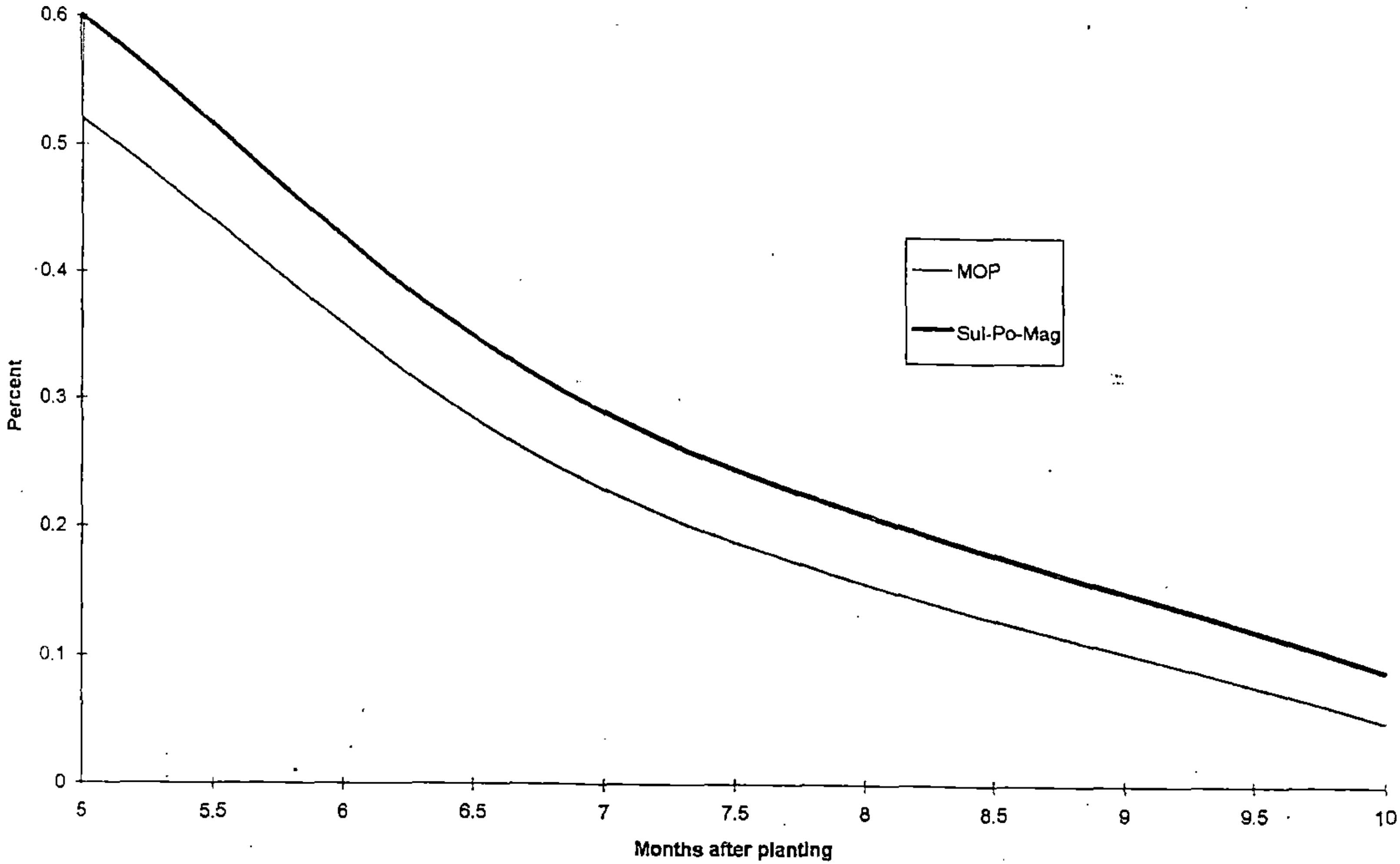

Fig . 12 Comparison of sulphur content of leaves by the application of MOP and Sul-Po-Mag

3.3.5 Magnesium

In the case of Mg all treatments have recorded higher contents compared to T_1 and T_2. A similar trend was noticed at shooting also. The higher content in the treatments containing Sul-Po-Mag, Mg and Mg along with S may be due to the higher content of Mg in those treatments. The treatments T_9, T_{10} and T_{11} in which gypsum alone was added in addition to K_2O has also recorded higher contents of Mg and this may be due to synergistic effect of Ca in plant.

3.3.6 Sulphur

Sulphur content showed a tendency to decrease at harvest compared to the content at early stages. All the treatments containing Sul-Po-Mag, Mg, S and Mg + S have recorded higher values compared to T_2.

4 Content and uptake of nutrients by different plant parts at the harvest phase

4.1 Potassium

Data relating to the content and uptake of potassium by the various plant parts and the total uptake are presented in Table 13.

4.1.1 Leaves

There was significant difference in the percentage of potassium in banana leaf with respect to the various treatments but uptake recorded no significant difference. Maximum percentage (3.27) was recorded with T_7 and minimum (1.74) was recorded with T_{10}. The treatment which received the general recommended

Table 13. Content and uptake of potassium by different plant parts of banana and total uptake at harvest

Treatments	Leaf		Pseudostem		Fruit		Rhizome		Total uptake (g plant^{-1})
	Percentage	Uptake (g)	Percentage	Uptake (g)	Percentage	Uptake (g)	Percentage	Uptake (g)	
T_1	2.17	33.75	5.55	136.01	1.50	44.69	2.10	39.06	253.49
T_2	2.19	58.06	5.10	107.27	1.83	134.08	2.46	45.74	345.14
T_3	2.36	57.13	5.83	126.28	1.80	142.18	2.18	44.91	365.26
T_4	2.93	61.73	5.80	110.57	1.63	132.23	2.85	56.66	361.19
T_5	2.86	51.50	5.97	111.62	1.57	123.60	2.77	55.58	342.30
T_6	2.65	51.53	6.38	135.00	1.37	81.55	2.49	57.45	325.70
T_7	3.27	46.61	5.87	127.00	1.43	101.52	2.36	59.15	336.58
T_8	3.10	50.39	5.40	110.00	1.45	105.21	2.41	53.36	318.96
T_9	2.15	42.85	5.93	97.00	1.43	91.43	2.11	34.26	265.55
T_{10}	1.74	37.38	5.82	100.00	1.00	56.65	2.01	27.03	221.06
T_{11}	2.45	42.93	5.70	111.33	1.35	91.17	2.85	41.76	287.19
T_{12}	2.96	49.94	5.89	125.33	1.60	118.16	2.74	53.13	346.56
T_{13}	2.31	56.36	6.06	140.00	1.37	89.82	2.38	45.22	331.37
T_{14}	3.05	41.11	5.56	110.33	1.39	85.90	2.23	53.55	290.90
CD 5%	0.890	NS	0.629	NS	0.461	NS	0.649	NS	NS
Sem±	0.281	56.857	0.141	135.90	0.075	470.29	0.149	40.443	675.104

dose of fertilizers (T_2) is found to be on par with all the treatments except for T_7 and T_8 which were Mg treatments in addition to MOP.

Though there was significant difference in the potassium content in the leaves, it was not reflected in the uptake and this may be due to the nonsignificant difference in the weight of leaves. Maximum uptake 61.73 g $plant^{-1}$ was recorded by T_4 which was a Sul-Po-Mag treatment in which 50 per cent of the K_2O was received as Sul-Po-Mag.

The results obtained in the present study are in conformity with the work of Baruah and Mohan (1986) and they reported the potassium concentration in leaves at harvest stage as 2.5 per cent.

4.1.2 Pseudostem

The data showed that the difference in treatments has significant effect on the percentage of potassium of pseudostem but no significant difference was observed with its uptake. All the Sul-Po-Mag treatments have recorded significantly higher values compared to T_2. Higher levels of Mg, S and Mg + S treatments have also recorded significantly higher values compared to T_2.

The uptake of potassium showed no significance difference between treatments, though there was significant difference in the content of potassium. This may be due to the non-significant difference in the pseudostem weight.

The highest percentage (5.78) of potassium was recorded with pseudostem compared to other parts of the plant. This is in accordance with the report of Shanmugavelu *et al.*, 1992.

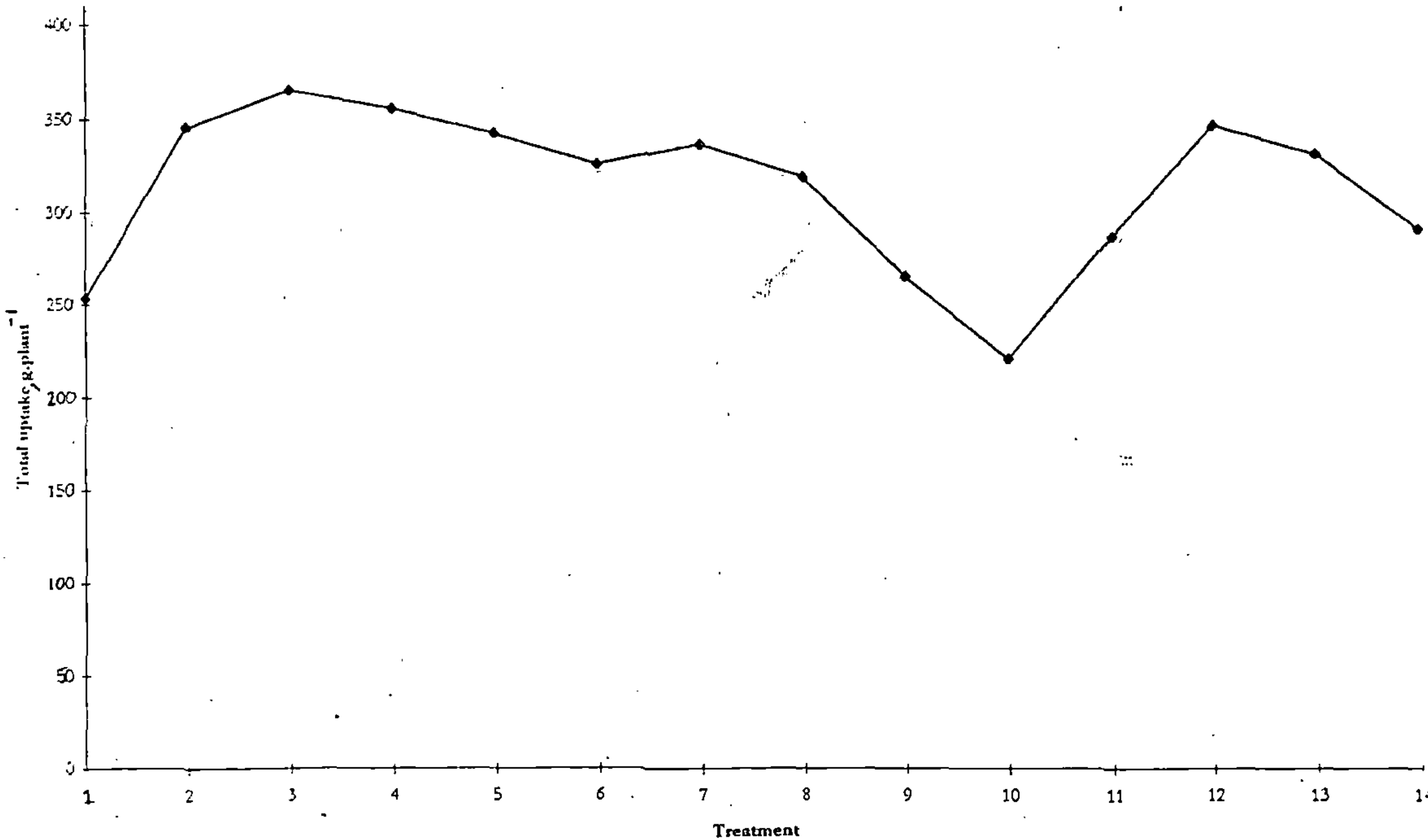

Fig 13 . Total uptake of potassium

4.1.3 Fruits

Results of the data revealed that the effect of treatments on the percentage of potassium content of fruit was significantly different. The highest value was given by T_2 as 1.83 per cent where as T_{10} was with the lowest value of 1.00 per cent. Treatment 2 is on par with all the Sul-Po-Mag treatments whereas most of the treatments with S alone found inferior to T_2. This shows that Mg has no effect on the percentage of K content in fruits but S has some unfavourable effects.

Uptake of K by fruits was found to be independent of treatment effects. The highest value was found with T_3 (142.18 g plant^{-1}) and the minimum with T_1 (44.69 g plant^{-1}).

4.1.4 Rhizome

Here also percentage was found to be significant and uptake of K non-significant. Comparison of the treatments showed that the maximum value of 2.85 per cent was shown by T_4 and T_{11} and the minimum value of 2.01 per cent was given by the T_{10}.

Uptake was found to be the maximum for T_7 and the minimum for T_{10}, but they were not significantly different. The values ranged from 27.03 to 59.15 g plant^{-1}.

4.1.5 Total uptake of potassium by the plant

Results indicated that the effect of treatments on the uptake of K was not significant. Maximum value was given by T_3, 365.26 g plant^{-1}, where entire quantity of K was supplied as Sul-Po-Mag. Minimum uptake was by T_{10} 221.06 g plant^{-1}. The uptake recorded by all the treatments with S as gypsum application were considerably low compared to treatments with Sul-Po-Mag, Mg and Mg + S application. This indicates that application of S has showed a tendency to reduce the uptake of K.

The total uptake of potassium at harvest is in accordance with the reports of Buragohain and Shanmugavelu (1986).

4.2 Calcium

Data presented in Table 14 represents the content and uptake of calcium by various plant parts and the total uptake by the crop.

4.2.1 Leaf

Even though the Ca content varied significantly, uptake was not affected by the difference of treatments and this may be due to the nonsignificant variation in the weight of leaves. Uptake was found to be maximum for T_4 (27.17 g plant^{-1}) and minimum for T_1 (17.19 g plant^{-1}). Similar values were reported by Hewitt (1955) for poovan variety of banana.

4.2.2 Pseudostem

Content and uptake of Ca differed significantly with respect to treatments. Maximum content was shown by T_5 (1.84) and minimum content by T_1 (1.17). With respect to Ca content only T_5 contained significantly higher value compared to T_2.

Table 14. Content and uptake of calcium by different plant parts and total uptake at harvest

Treatments	Leaf		Pseudostem		Fruit		Rhizome		Total uptake (g plant^{-1})
	Percentage	Uptake (g)	Percentage	Uptake (g)	Percentage	Uptake (g)	Percentage	Uptake (g)	
T_1	1.11	17.19	1.17	28.73	0.32	9.43	0.17	3.20	58.62
T_2	1.02	19.61	1.46	30.73	0.43	8.58	0.16	3.04	61.29
T_3	1.31	25.14	1.46	30.83	0.32	8.45	0.15	2.74	67.16
T_4	1.36	27.17	1.79	34.00	0.32	10.11	0.11	2.29	73.57
T_5	1.03	20.08	1.84	33.87	0.32	8.54	0.12	2.44	64.92
T_6	1.13	24.43	1.65	34.73	0.32	6.72	0.13	2.93	68.65
T_7	1.06	18.62	1.56	33.70	0.32	7.52	0.12	3.39	63.24
T_8	1.28	22.41	1.49	30.17	0.32	7.62	0.12	2.67	62.88
T_9	1.53	24.64	1.57	25.50	0.32	6.66	0.12	2.17	57.97
T_{10}	1.52	23.53	1.67	28.70	0.27	6.92	0.16	2.19	61.34
T_{11}	1.17	20.09	1.61	31.23	0.27	5.90	0.16	3.01	60.32
T_{12}	1.29	23.01	1.56	33.07	0.32	7.86	0.16	3.09	67.03
T_{13}	1.21	23.63	1.25	28.89	0.27	8.64	0.13	2.52	63.64
T_{14}	1.10	19.61	1.54	30.97	0.32	8.06	0.10	2.57	61.21
CD 5%	0.297	NS	0.34	3.515	NS	NS	0.037	0.939	NS
Sem±	0.031	12.202	0.04	4.384	0.01	4.718	0.00	0.313	29.019

The maximum uptake of Ca was reported by T_6 (34.73 g plant^{-1}) which was a Mg treatment and the minimum was reported by T_9 (25.5 g plant^{-1}) which was a gypsum treatment. All the treatments with Sul-Po-Mag application have recorded higher values compared to T_2.

4.2.3 Fruit

The content and uptake of Ca were found to be nonsignificant in the fruit. Maximum content (0.43%) was given by T_2 indicating the adequacy of Ca present in soil.

The total uptake of Ca by the fruit was found to be maximum for T_4 (10.11 g plant^{-1}) and the minimum was found with T_{11} (5.90 g plant^{-1}).

4.2.4 Rhizome

The difference due to treatments was found to be significant in the content and uptake. Treatment 1 showed the highest content of Ca. In the case of uptake, T_2 is on par with all the treatments and this indicates that the Ca content of the soil was sufficient to meet the requirements of the crop.

4.2.5 Total uptake of calcium by the plant

From the results, it is inferred that the treatment effects have no significance on the uptake of Ca by the plant. Maximum value was given by T_4 i.e., 73.57 g plant^{-1} whereas the minimum by T_9 i.e., 57.97 g plant^{-1}. Even though there was no significant difference among the treatments, it was found that all the treatments that were supplied with Mg increased the uptake of Ca.

The values obtained for the total uptake of Ca by the plant is in accordance with the findings of Prema (1992).

4.3 Magnesium

Table 15 represents the content and uptake of Mg by various plant parts and the total uptake by the crop.

4.3.1 Leaf

The effect of treatments on percentage and uptake of magnesium by banana leaf was significant. All the treatments with Sul-Po-Mag, Mg and Mg + S application have recorded higher Mg content compared to T_2.

In the case of uptake also all the treatments with Mg application have recorded significantly higher values compared to T_2. Minimum percentage and uptake was given by T_1. The treatment that gave maximum yield i.e., T_4 showed high content of Mg in leaf and higher uptake. As far as the uptake was concerned, all the treatments showed higher values than T_2 and T_1. The adequacy level of leaf Mg was reported by Arunachalam (1975) as 0.25-0.28 per cent and this is in conformity with the value obtained for T_4 in the present investigation. Almost similar values of leaf content (0.12) and uptake (4.66) were obtained in the experiment conducted by Prema (1992) also.

4.3.2 Pseudostem

Both content and uptake of Mg in pseudostem were found to be significantly different. The highest value of Mg content was shown by T_4 i.e., 0.24

Table 15. Percentage and uptake of magnesium by different parts of banana and total uptake at harvest

Treatments	Leaf		Pseudostem		Fruit		Rhizome		Total uptake (g plant^{-1})
	Percentage	Uptake (g)	Percentage	Uptake (g)	Percentage	Uptake (g)	Percentage	Uptake (g)	
T_1	0.06	0.91	0.06	1.40	0.03	0.94	0.07	1.20	4.45
T_2	0.12	2.29	0.12	2.50	0.03	2.27	0.06	1.23	8.29
T_3	0.15	2.89	0.18	3.79	0.04	3.15	0.08	1.69	11.52
T_4	0.25	4.20	0.24	4.53	0.03	2.11	0.16	3.26	14.13
T_5	0.15	3.01	0.22	3.92	0.03	2.70	0.08	1.71	11.34
T_6	0.15	3.25	0.19	4.20	0.05	3.15	0.15	3.55	14.15
T_7	0.22	3.97	0.17	4.19	0.04	2.70	0.10	2.58	13.44
T_8	0.24	4.20	0.16	3.90	0.04	2.97	0.11	2.33	13.40
T_9	0.24	3.81	0.20	4.29	0.03	1.95	0.17	2.76	12.81
T_{10}	0.27	4.10	0.20	3.71	0.05	2.70	0.27	2.72	13.23
T_{11}	0.15	2.57	0.16	3.91	0.03	2.20	0.08	2.13	10.81
T_{12}	0.16	2.97	0.15	3.27	0.04	2.82	0.16	3.05	12.11
T_{13}	0.15	3.05	0.18	4.73	0.05	3.20	0.18	3.52	14.50
T_{14}	0.18	3.07	0.16	3.52	0.05	3.11	0.12	2.97	12.67
CD 5%	0.060	0.764	0.059	0.594	0.012	0.517	0.052	0.678	0.909
Sem±	0.001	0.207	0.001	0.125	0.000	0.095	0.001	0.163	0.293

per cent and the lowest by T_1 (0.06 per cent). All the treatments with Sul-Po-Mag application have recorded significantly higher values compared to T_2. Sul-Po-Mag was found to be more efficient in increasing the Mg content compared to Mg application along with MOP. The highest percentage of Mg was observed with pseudostem as reported by Prema (1992).

Uptake of Mg was maximum for T_{13} i.e., 4.73 g plant^{-1} and minimum for T_1 i.e., 1.40 g plant^{-1}. All the treatments were significantly superior to T_2 and T_1.

4.3.3 Fruit

The variation due to treatments was significant in the Mg content. But no specific trend in the Mg content of fruit due to different treatments i.e., application of Sul-Po-Mag, Mg, S or Mg + S was noticed.

In the case of uptake also, the variation due to treatments was significant. All the treatments with S + Mg application along with MOP have recorded significantly higher values compared to T_2. The results reveal that the soil application of Mg has influenced the fruit content and uptake.

4.3.4 Rhizome

The nutrient content differed significantly, so also the uptake. All the treatments showed higher values compared to T_2. The maximum was shown by T_{10} and the minimum by T_2. Like Mg content the uptake was found to be more in all the treatments compared to T_2 and T_1.

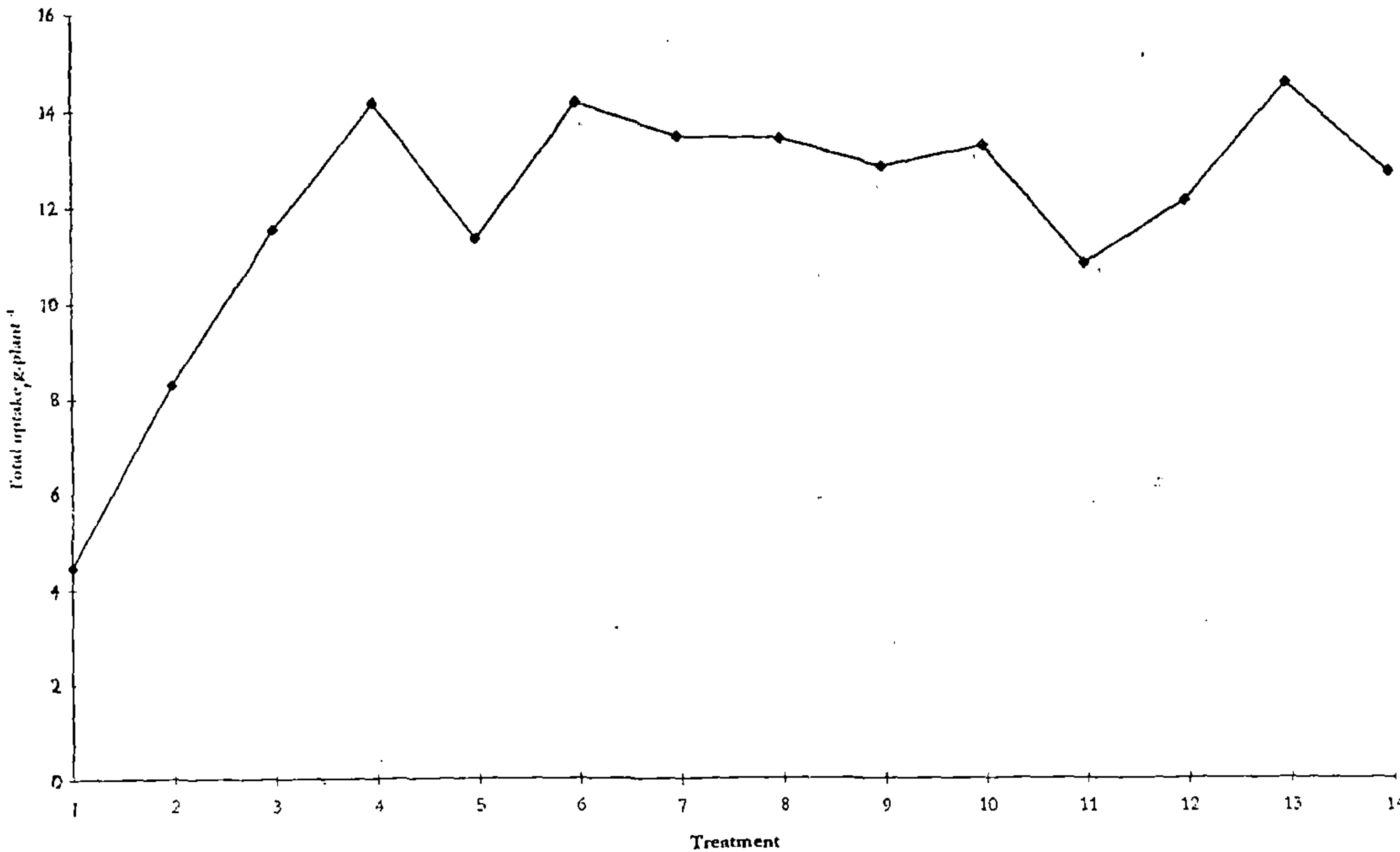

Fig 14. Total uptake of magnesium

4.3.5 Total uptake of magnesium by the plant

All the treatments were found significantly superior to T_2 and T_1 indicating increased uptake by the plant due to application of S or Mg fertilizer. Treatment 13 which is a Mg + S treatment along with K_2O showed highest uptake of Mg (14.50 g $plant^{-1}$). Compared to Sul-Po-Mag, S and Mg + S treatments, Mg alone applied treatments have recorded higher values. This indicates that application of Mg along with MOP is more efficient in increasing the uptake of Mg compared to Sul-Po-Mag application.

The total uptake of Mg obtained in this experiment is comparable with that obtained for Prema (1992).

4.4 Sulphur

Table 16 represents the content and uptake of S in the various plant parts.

4.4.1 Leaf

The variation due to treatments was significant in the S content. Most of the treatments have recorded lower values compared to T_1 and this may be due to the dilution effect.

There was significant difference in the uptake. All the treatments with Sul-Po-Mag and $MgSO_4$ application have recorded higher values compared to T_2.

Table 16. Content and uptake of sulphur by different plant parts and total uptake at harvest

Treatments	Leaf		Pseudostem		Fruit		Rhizome		Total uptake ($g\ plant^{-1}$)
	Percentage	Uptake (g)	Percentage	Uptake (g)	Percentage	Uptake (g)	Percentage	Uptake (g)	
T_1	0.11	1.62	0.09	2.09	0.003	0.09	0.02	0.35	4.15
T_2	0.05	1.05	0.09	1.90	0.005	0.36	0.02	0.40	3.71
T_3	0.09	1.70	0.07	1.59	0.009	0.75	0.02	0.42	4.46
T_4	0.06	1.20	0.11	2.09	0.004	0.42	0.03	0.65	4.36
T_5	0.07	1.30	0.11	1.98	0.004	0.32	0.02	0.29	3.89
T_6	0.06	1.37	0.09	1.74	0.005	0.31	0.02	0.39	3.81
T_7	0.09	1.60	0.14	2.49	0.006	0.43	0.02	0.41	4.93
T_8	0.11	1.90	0.07	1.50	0.004	0.34	0.02	0.39	4.13
T_9	0.06	0.97	0.15	2.45	0.012	0.80	0.04	0.53	4.55
T_{10}	0.09	1.40	0.08	1.38	0.011	0.67	0.04	0.49	3.94
T_{11}	0.07	1.20	0.10	1.96	0.009	0.67	0.02	0.31	4.14
T_{12}	0.05	0.97	0.10	2.10	0.008	0.61	0.02	0.36	4.04
T_{13}	0.06	1.20	0.11	2.53	0.009	0.67	0.03	0.43	4.83
T_{14}	0.13	1.70	0.10	1.98	0.011	0.71	0.03	0.56	4.94
CD 5%	0.024	0.335	NS	NS	NS	0.210	0.005	0.135	NS
Sem±	0.00	0.04	0.159	6.423	0.00	0.016	0.00	0.006	0.513

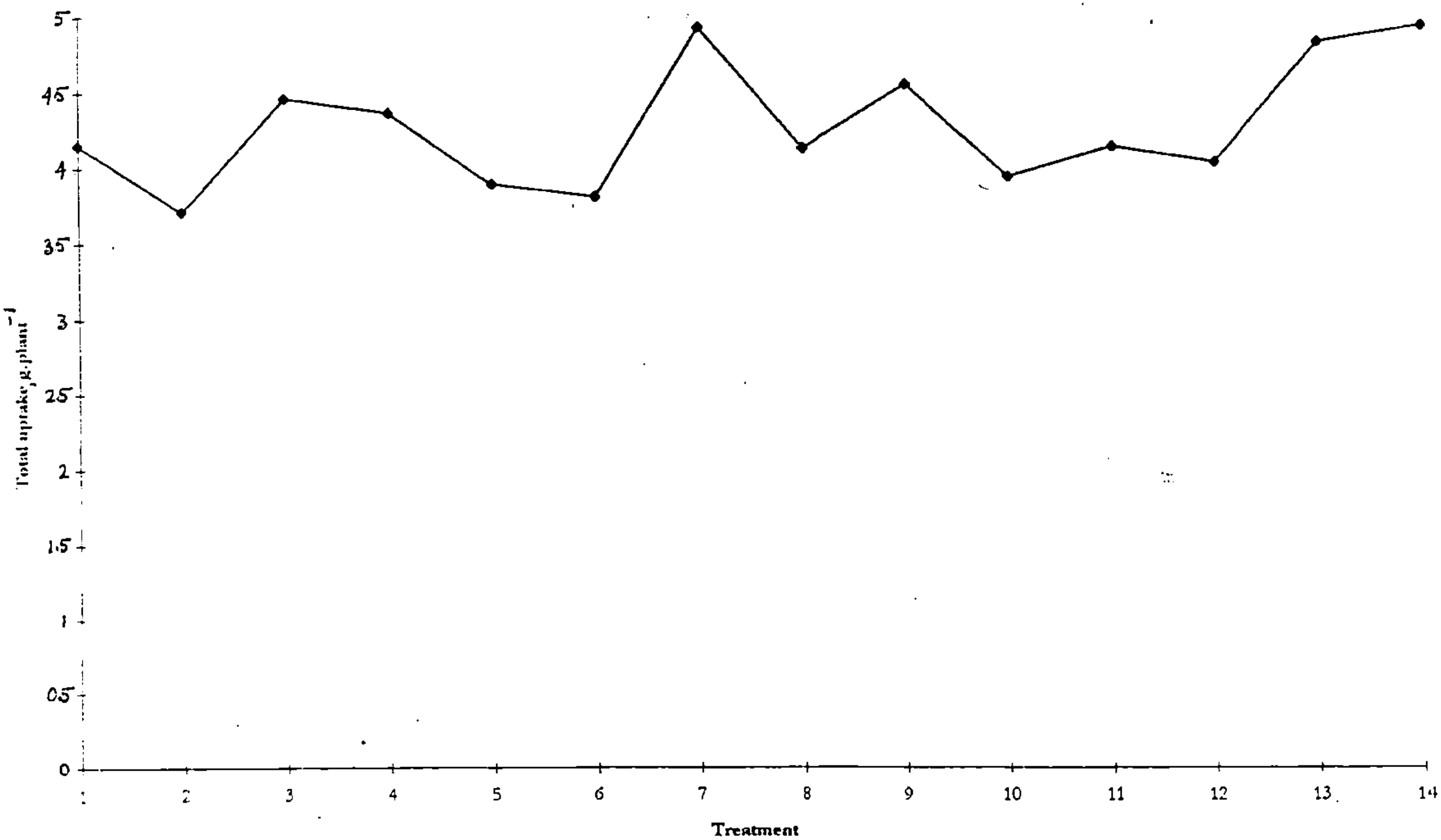

Fig 15. Total uptake of sulphur

4.4.2 Pseudostem

No regular trend due to treatments was noticed in the content and uptake and this may be due to the reason that the S content in the soil was high enough to meet the requirements of the crop. Soil content of available S at harvest phase was very high as compared to the original value.

4.4.3 Fruit

Results of the data revealed that the content of S was nonsignificant but uptake differed significantly for the different treatments. The fruit content of S was found to be very less and it varied from 0.003 to 0.012 per cent. In the case of uptake highest value of 0.80 g plant^{-1} was recorded by T_9 and the lowest value of 0.09 g plant^{-1} was given by T_1. All the gypsum applied treatments showed significantly higher values compared to T_2.

4.4.4 Rhizome

Both content and uptake differed significantly with respect to treatments. Both T_9 and T_{10} gave the highest values (0.04%) and application of gypsum showed a tendency to increase the S content in most of the treatments. With respect to uptake, only T_4 and T_{14} differed significantly from T_2 and both these treatments are on par with S application.

4.4.5 Total uptake of sulphur by the plant

Results revealed that the effect of treatments recorded no significant difference. The highest value was given by T_{14} (4.94 g plant^{-1}) which was having S application and the lowest by T_2 (3.71 g plant^{-1}) which was the general recommendation. Though there was significant difference in the uptake of S by leaves, fruits and rhizome, it was not reflected in the total uptake and this may be due to the reason that no regular trend was noticed by the treatments in the uptake by different plant parts.

Comparing with the yield, it is found that those treatments that recorded higher values of total uptake of S showed lower yields. From this may be inferred that higher content of S is detrimental to the plant.

Summary

SUMMARY

The present investigation was carried out in the Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara during the period September 1994 to August 1995. The study was aimed to find out the suitability of Sul-Po-Mag as a potassium cum magnesium fertilizer for banana in Kerala. The treatments included Sul-Po-Mag, substitute of potassium to the extent of 25, 50 and 100 per cent in the normal recommended dose of NPK as urea, diammonium phosphate and muriate of potash at the rate of 190 g N, 115 g P_2O_5 and 300 g K_2O per plant per year. Treatments of MOP supplemented with magnesium and sulphur separately and with magnesium and sulphur together are also included and they were compared with the recommended practice. The experiment was laid out in randomised block design with 3 replications.

The experimental site selected for the investigation was well drained, acidic and lateritic sandy loam. Soil had a pH of 5.2 and was rich in organic carbon and phosphorus and contained potassium in the medium range. The contents of calcium, magnesium and sulphur were relatively low.

In the early vegetative stage of growth, the treatments failed to influence the height, girth and number of leaves of the plants. This may be due to the reason that the soil contained sufficient nutrients to meet the initial requirements of the crop. But at later stages ie. at late vegetative phase and at harvest the girth and number of leaves differed significantly under the influence of treatments and application of Sul-Po-Mag showed a favourable effect on these characters. This may be due to reason that increased absorption of nutrients for the plant utilization would have

resulted in the depletion of soil nutrients and so plants responded to the applied fertilizers. No significant difference was observed in characters like total number of suckers, days to flower, days to mature and total duration of the crop between the Sul-Po-Mag applied treatments and the treatment in which muriate of potash alone was applied. Application of Mg or S in addition to MOP has not produced any significant variation in these characters.

The effect of treatments on yield characters such as number of fingers and weight of fingers was not significant. Bunch weight, number of hands, length and girth of fingers were found to be significantly different. Though the treatments differed significantly in yield from the control where no fertilizer was applied, the treatments of MOP and Sul-Po-Mag are on par indicating no pronounced influence of Mg and S in the yield.

Among the quality parameters, reducing sugars, total sugar content, sugar-acid ratio, weight of pulp and peel and pulp-peel ratio remained unaffected by the treatments whereas total soluble solids, ascorbic acid content, non reducing sugars and acidity were found to be significantly different. Application of Sul-Po-Mag, Mg or S showed a tendency to reduce the sweetness of the fruit. Sugar acid ratio was found to be highest for $CaSO_4$ applied treatments.

Available P, available K and exchangeable S content of soil were found to be nonsignificant both at vegetative and at harvest stages. Sulphate containing treatments were found to decrease the pH of soil. Organic carbon content of soil was found to be significant only at harvest stage and the values recorded were much lower than that recorded at vegetative phase. Calcium, Magnesium and Sulphur contents in the fertilizer increased their availability in soil and also the plant content.

Calcium and Magnesium were found to enhance the availability of K and uptake. Phosphorus content of leaves remained nonsignificant in all stages indicating no effect of Mg + S + K. Sulphur content of leaves at the vegetative and harvest stages remained unaffected by the treatments.

The percentage contents of potassium, calcium, magnesium and sulphur were found to be highest in the pseudostem followed by leaves.

Total uptake of potassium, calcium, magnesium and sulphur ranged between 365.26 and 221.06, 73.57 and 57.97, 4.45 and 14.5 and 3.71 and 4.94 g $plant^{-1}$ respectively.

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SUITABILITY OF SUL-PO-MAG AS A POTASSIUM CUM MAGNESIUM FERTILIZER FOR BANANA IN KERALA

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ABSTRACT OF A THESIS

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ABSTRACT

The present investigation was carried out in the Department of Soil Science and Agriculture Chemistry, College of Horticulture, Vellanikkara during the period of September 1994 to August 1995. The study was aimed to bring to light the suitability of Sul-Po-Mag as a potassium cum magnesium fertilizer for banana in Kerala. The treatments included Sul-Po-Mag substitutes of potassium to the extend of 25, 50 and 100 per cent in the normal recommended dose of NPK as urea, diammonium phosphate and muriate of potash at the rate of 190 g N, 115 g P_2O_5 and 300 g K_2O per plant per year. Treatments of muriate of potash supplemented with magnesium and sulphur separately and with magnesium and sulphur together were also included and they were compared with the recommended practice. The experiment was laid out in randomised block design with three replication.

During the early stages of growth, the treatments failed to influence the morphological characters such as height, girth and number of leaves of the plant. But at the later stages, the girth and the number of leaves differed significantly and the application of Sul-Po-Mag showed a favourable influence on these characters. No significant difference was observed in characters like total number of suckers, days to flower, days to mature and total duration of the crop among the treatments.

Among the bunch characters, numbers of hands, length and girth of fingers and bunch weight were influenced by the difference in treatments while the number of fingers per bunch and weight of fingers remained unaffected. The maximum yield was given by the treatment where potassium was supplied by Sul-Po-Mag and muriate of potash in half doses. Though the treatments differed

significantly in yield from the control, where no fertilizer was applied, the treatments of muriate of potash and Sul-Po-Mag are on par indicating that Sul-Po-Mag is as good as MOP for its capacity to meet potassium requirement of the crop.

The treatments did not differ significantly in quality parameters such as reducing sugars, total sugars, sugar acid ratio, weight of pulp and peel and pulp peel ratio. But significant difference was observed with total soluble solids, ascorbic acid content, non reducing sugars and acidity. High value of these characters were recorded with Sul-Po-Mag except for the reducing sugars and total sugars. Treatments with magnesium and sulphur were found to decrease the sugar content of fruits. High pulp peel ratio of Sul-Po-Mag treatments showed increased storage quality.

The nitrogen, phosphorus and sulphur contents of leaves remained unaffected both at vegetative and harvest phases, while potassium, calcium and magnesium differed significantly between the treatments. The contents in leaf of N, P, K, Ca, Mg and S were decisively influenced by the treatments at the time of shooting. Nutrient contents of leaves were found to increase till shooting and a drastic reduction was observed thereafter. Calcium, magnesium and sulphur contents in the fertilizer increased their availability in soil and the plant content. Treatments with Sul-Po-Mag and magnesium showed high content of potassium in leaves. The contents of potassium, calcium, magnesium and sulphur were found to be the highest in the pseudostem followed by leaves. Rhizome and fruit also showed appreciable amount of these nutrients. The total uptake of potassium, calcium, magnesium and sulphur ranged between 365.26-221.06, 73.57-57.97, 4.45-14.5 and 3.71-4.94 g plant^{-1} respectively. Only the total uptake of magnesium was decisively influenced by the treatments. The maximum values of uptake of magnesium found in treatment which was supplied with Mg equivalent to that present in half dose of Sul-Po-Mag.

Available P, available K and available S contents of the soil were found to be nonsignificant both at vegetative and harvest stages. The sulphate containing treatments were found to decrease the pH of the soil. Maximum electrical conductance was found with Mg supplied treatments. Organic carbon content was found to be significant only at harvest stage. Calcium, magnesium and sulphur contents in the fertilizer were found to increase the soil content of these elements.