EFFECT OF NITROGEN AND PHOSPHORUS FERTILIZATION ON THE PERFORMANCE OF THREE SUGARBEET (*Beta vulgaris.L*) Cultivars

By

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DEDICATION

To:

My Father

My Mother

……..

My Uncle

……..

My Brothers

And

My Sisters

To

My Darling

ACKNOWLEDGMENT

I wish to express my sincere gratitude to Dr. Tag El-Din El-Sheikh Musa Hago, for his guidance, assistance and providing all the facilities during the course of investigation.

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My pest wishes, sincere to Dr Awd El-haj Mohammed and Mr. Seif El.negay

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ABSTRACT

A field experiment was carried out for one season (2004 – 2005) in the Experimental Farm of the Faculty of Agriculture at Shambat to study the effect of nitrogen and phosphorus fertilizer on the growth and yield of three sugar beet (*Beta vulgaris.L*) cultivars under irrigation.

The experiment was laid out in randomized complete block design with three replicates. Treatments were nitrogen (0-100-200 kg N /ha) designated as (N_0, N_1, N_2), phosphorus (0-100 kg P_2 O_5/ha) designated as (P_0, P_1) and three sugar beet cultivars Tomba, Possada and Monza Designated as (CV_1, CV_2, CV_3) respectively.

The results showed that nitrogen applications tend to increase in leaf number, leaf area index shoot and root dry weigh but the effect was not significant. Phosphorus application also led to increase in growth attributes.

Addition of nitrogen had positive effect on roots weigh /plot and root yield /ha .but the effect was not significant. Also phosphorus application on sugar beet cultivars had no significant effect on root weigh /plot and roots yield /ha but had negative effect on sugar content (pol%) .

Nitrogen and phosphors fertilizer lead to positive effect on brix % fiber %, and purity % of juice and increase nitrogen, phosphorus, potassium and sodium content on roots.

Nitrogen and phosphorus application tend to increase moisture content in root. Moreover, interactions between the treatments were not significant.

ملخص الأطروحة

أجريت ربة حقلية وسم واحد (2004 – 2005م) ا قل التجري لكلية الزراعة بشمبات لدراسة أثر اد النتروج و الفسفور على و وإنتاجية ثلاثة أصناف من البنجر السكري ت ظروف الري.

صممت التجربة بواسطة القطاعات كاملة العشوائية بثلاثة مكررات ، لت ا عاملات ثلاث مستويات من الناتروج (0 - 100 – 200 كجم نتروج للهكتار) (N_2 , N_1 , N_0) ومستوي من الفسفور (0- 100كجم فوسفور للهكتار) P1 , P0 وثلاث اصناف تومبا , بوسادا ومونزا (CV3,CV2, CV1) .

أظهرت النتائج بأن إضافة النتروج أدت إ زيادة عدد الأوراق , دليل مساحة الورقة , ا موع ا ضري وا ذري ولكنها زيادة غ معنوية.

إضافة الفسفور إ البنجر السكري أيضا أدت إ زيادة غ معنوية مؤشرات النمو أما إضافة النتروج والفسفور أثرت سلبيا على توي السكر ولكن التأث يكن معنوياً.

إضافة النتروج أظهرت تأث اً إ ابيا ولكن غ معنوي على وزن وإنتاج ا ذور كذلك إضافة الفسفور إ أصناف البنجر السكري يكن ا تأث ا معنويا على وزن وإنتاج ا ذور و لكن أثرت سلبيا على توي السكر.

التسميد الناتروجي والفسفوري أديا إ تأث إ ا على نسبة الألياف وا واد الصلبة غ الذائبة كما أثرا على نقاء العص . كما أدت إ زيادة توي الناتروج والفسفور والبوتاسيوم والصوديوم العص .

إضافة الناتروج والفسفور أدت إ زيادة ا توي الرطو ا ذور. يكن التفاعل ب ا عاملات معنويا

CHAPTER ONE

INTRODUCTION

Sugar beet (*Beta vulgaris.L)* is a member of the family *Chenopodiaceae*. Sugar beet is a crop of temperate regions grown as a summer crop but proved to be a success in sub-tropical area as winter crop. It ranks second to sugar cane as the second most important sugar crop in the world according to FAO production year book (1995).

Total world production of sugar beet is 266 million tons from a production area of 7.8 million /ha.In the Arab region the area under sugar beet is 123000 hectares with a total production of 5 – 6 million tons.

The leading beet producing Arab country is Morocco which produces about 49% of total production of all Arab countries. In Egypt, the crop was introduced on commercial scale very recently. Its cultivation is expanding rapidly, being a more efficient user of water. The government policy now is discouraging further cane area expansion (Afifiy 1996).

Sudan has no experience in beet production although scientific research on the crop had started nearly seventy years ago. The first trials recorded were carried out at Gazera Research Farm during the depression of the 1930s when a substitute for cotton was being actively sought. It was considered a possible source of sugar during the war at that time.

Sugar beet, like most of the members of the family *Chenopodiaceae*, is a salt tolerant plant and in this respect may be a suitable crop for Northern Sudan. Being an easy rotational crop which farmers can grow in the winter season, the inclusion of sugar beet in the rotation facilitates crop diversification and could lead to spread of small factories for sugar extraction at the village level. Besides providing self-sufficiency in sugar commodity, it will add an extra income to small farmers. Moreover the by-products of beet culture and manufacturing are a good feed for animals.

Research on sugar beet nutrition has a high priority wherever the crop is introduced and grown and there are several reasons for this. Firstly, the correct addition of nutrients to soil has the greatest effect on crop performance, which is within the grower's control. Secondly, fertilizers have historically been the most expensive item in growing the crop on nearly all soil types, although currently insecticides and herbicides often top the bill. Thirdly much attention is paid to the correct nutrition of the crop, and concern about straw burning and nitrate in under ground water stimulated research into nutritional strategies which minimize adverse effects on the environment.

Nitrogen is in short supply in nearly all arable soils and is the most important element applied to sugar beet wherever the crop is grown and when virgin soils are brought into intensive farming.

Phosphorus is also important for growth and productivity of sugar beet. However, the continued use of fertilizer containing this element has meant that many arable soils now contain large reserves of phosphorus and fresh applications give little or no increase in sugar beet yield.

Research on sugar beet in Sudan is scarce, but some preliminary research on the crop has been conducted (AM, 1984, Karouri, 1984. Alhj, 1995 and FAO 1995). Therefore the objectives of this work are to:

- Study the effect of nitrogen and phosphorus on the growth and yield of three sugar beet cultivars.

- Investigate the effects of the treatments on quality characteristics of beet sugar.
- To see whether three is a differential response of the different cultivars to the treatments.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction:

Sugar beet is one of two most important Sugar crops, the other being sugar cane which constitutes the only important sources of sucrose a product with sweetening and preserving properties that make it a major component of, or additive to a vast range of foods, beverages and pharmaceuticals.

Sugar, as sucrose is almost invariably called, has been a valued component of the human diet for thousands of years. For the great part of that time the only source of pure sucrose was the sugar cane plant, varieties of which are all species or hybrids within the genus *Saccharum*. However, the expansion of cane production, particularly in the Caribbean area, in the late seventeenth and the eighteenth centuries, meant that sugar became available to an increasing proportion of the world population.

2.2 History of sugar beet crop:

2.2.1 Origin of beet:

In ancient times different varieties of the beet plant have already been cultivated on the shores of the Mediterranean as a garden-vegetable, they were grown mainly for their leaves.

The first detailed description of different forms of beet were given by Caesalpinus (1538) and Dalschamp (1587) who recognized four varieties, one of them red-colored, and by then it was the root rather than the leaves of some beet varieties, especially the red colored types which were preferred as a vegetable. In the sixteenth century these "Burgundian beets" (the precursors of today's table beet or red beet) with a sweet taste and red flesh, were widely used as a vegetable in European agriculture. Tops and roots of various forms of field-grown beet were used mainly as fodder for cattle in the cooler regions of central Europe. Some varieties with white flesh were cultivated mainly for storage and used as fodder during the long winter. By the middle of the 18^{th} century, varieties of this kind were grown in Germany. The crop was known by about 40 different names in the countries of northern Europe.

2.2.2 Evolution of cultivated *Beta* sp:

The taxonomy of *Beta* is confused, with little consistency in the reports concerning the number of species within the genus.

In 1753 Linnaeus named a single sp, *Beta vulgaris*, comprising three varieties: *var perennis* (wild type), *var rubra* (garden beet) and *var cicla* (foliage beet). In 1763 he added a new sp *Beta maritime* (wild maritime beet).

Cultivated beets all fall into *Beta vulgaris* and can be separated into four groups, mainly on basis of external features (Gill and Vear, 1958):

1. Leaf beets or "foliage beets": this group comprises two separate types, spinach beet and Swiss chard or seakale beet.
2. Garden beets: these are grown as root vegetables for human consumption, with the red beet as the best-known example.
3. Fodder beets: these are used exclusively as stock feed and are characterized by their enlarged hypocotyls, and crowns.
4. Sugar beets: the most recent and widely grown product of man's breeding work within *Beta vulgaris*.

2.3 Biology and physiology of sugar Beet:

2.3.1 Germination and vegetative growth:

Sugar beet is a biennial plant. In the first year, apogeal germination leads to the development of a rosette of glabrous, dark green, glossy leaves with prominent midribs and strong petioles.

Once the seedling has become established, the plant enters a period of leaf initiation, during which there is very little root growth and leaf production continues throughout the first season. Thus, at six weeks age, the plant has 8 – 10 leaves but only a small root (Milford, 1973. Scott *et al.*,1974). When the plant is in about leaf 12 stages, mature leaves become progressively larger, but later-formed leaves achieve smaller final size. Early leaves die in the order in which they are produced, and leaf area index reaches maximum value close to the time at which the largest leaf reaches its full size. Thereafter leaf area index declines. Leaves appear and expand in a linear relationship with thermal time from the 8 – 10 leaf stage onward. Leaf and root growth occur simultaneously, with the root making up an increasing proportion of total plant dry weight.

2.3.2 Storage root growth:

The true root and the hypocoty both contribute to the storage organs of the sugar-beet plant. The increase in girth of this structure results from the activity of the cambium.

Sucrose enters the root via the phloem and is stored in the vacuoles of parenchyma cells both in the vascular zone and in the parenchymatous zone itself (Giaquinta, 1979). Sucrose concentration is greatest in the center of the section of the root with the largest diameter and it falls off above, below and outside this region.

2.4 Reproductive Growth:

2.4.1 Vernalization:

Sugar beet is a biennial plant, and its complete life cycle comprises a period of vegetative growth, cold-induced vernalization, production of the upright extended flowering stems and seed production.

In order for the plants to flower during their second year, vernalization is necessary. This normally takes place in the winter at the end of the first year but it can also occur when seedlings experience a late frost soon after establishment. In such cases, "bolters" are produced which have a sufficiently low vernalization requirement to cause them to flower in the first year (Fick *et al.*, 1975).

The storage roots of these flowering plants lose sucrose and become heavily lignified, so that large numbers of "bolters" in root crops decrease both harvesting efficiency and sugar yield. The shoots of univernalized sugar-beet plants continue to produce new leaves, without elongating for several years (Ulrich, 1954). In common with many other species which require vernalization, the optimum temperature for beet plants is 5 – 10 ^{o}C (Stout, 1946).

De-vernalization of sugar-beet plants seems possible over a long period as long as the plants have not advanced too far in the direction of actual stem elongation (Smith, 1983).

2.4.2 Bolting and flowering:

During bolting the stem elongates to give a tall, angular structure. Several new leaves are produced the first being large and petioled and similar in size to those produced in the first year. As stem elongation proceeds, successive leaves produced towards the top of the plant are smaller and with shorter petioles and eventually are sessile. The shoot is actively photosynthetic and does not appear to depend upon reserves laid down in the root. Shoots develop in the axils of leaves and these develop quickly to produce second and third order inflorescences.

Each flower has five green-yellow perianth members, one-stamen opposite each segment and an inferior ovary usually with three styles. Flowering period extends for three to ten weeks. Pollination is principally by wind with a small contribution by insects. Cross-fertilization is general because of lack of synchrony between release of pollen and receptivity of the stigma. The weather plays a very important part in successful pollination.

2.5 seed Production:

The seed is one of the most important factors in the production of the sugar-beet root crop, particularly since the change from multigerm varieties sown at high seed rates to monogerm varieties which are usually planted to stand without subsequent thinning. Sugar beet is a biennial plant, and although the root crop which provides the raw material for sugar production is grown in a single season, seed production requires a second year for reproductive growth.

Seed is produced by two methods:

a - Indirect method:

In this method the seed producing plants, small plants known as "stecklings", are produced in the first season of vegetative growth and these are grown to produce seeds in the second. This method has the following advantages:

1. High adaptability to geotechnical and breeder's requirements.
2. Low rotational risk.
3. Reduced risk from adverse winter weather conditions.
4. Favorable propagation ratios.

But it has disadvantages:

1. The need for irrigation to establish the "steckling" bed in the first year.
2. The high cost of transplanting.

b - Direct Method:

The direct method of seed production can be mechanized more easily than the indirect method and thus entails less labor cost. It differs from the indirect method in several aspects, in particular because of the special rotational requirements.

2.6 Soil management and crop establishment:

2.6.1 Primary tillage:

Sugar beet is usually grown as spring crop in temperate and as a winter crop in sub-tropical and tropical regions. Stubble cultivation is carried out mainly to control weeds. Annual weeds and volunteers of previous crop are also destroyed, and weed seeds in the soil are induced to germinate so that the weeds can be removed later. Disc plough and tine cultivators are the most commonly used implements for carrying out this operation. Heavy disc tillers are usually able to work through the whole surface in one pass, whereas two passes at an angle to each other are usually needed when using tine cultivators, unless they are equipped with duck- foot shares (Kritz, 1986).

Another objective of stubble cultivation is to mix straw and other crop residues more uniformly into the soil. If the straw is buried in a layer and the soil is wet, microbial decomposition may create anaerobic conditions which hamper root growth. On the other hand, in dry and compact soil, root growth is limited and may be largely restricted to the least dense parts of the soil where the straw is concentrated. The stubble cultivation increases both biological activity and soil water content in cultivated layer. (Kunze, 1985).

Mould-board ploughing is an expensive operation and may not be justified in areas with soil erosion problems. Ploughing depth has gradually increased in recent decades,but is normally about 25 cm. Deeper ploughing improved weed control, and on some sites, increasing the ploughing depth by 6 cm increased the yield of various crops by 1- 6 % (Kritz, 1987). Decreasing the ploughing depth to about 15 cm increased yield, probably because it increased the concentration of organic matter near the surface.

2.6.2 Secondary tillage, sowing and post-sowing tillage:

Most sugar beet crops are grown in humid or sub humid temperate regions where the soils are wet at the end of winter, but where dry periods occur during the spring.

Early sowing increases the risk of soil compaction and damage by many soil-inhabiting anthropoid pests, and late sowing may lead to poor germination due to drought, and increase damage from pests or diseases, with high optimum temperatures. The beet seed coat is relatively impervious to water and gases. In the first phase of germination, oxygen has to enter through a small basal pore and intake rate can be reduced by excess water. Some initial water uptake facilitates the further uptake of water and gases and the emergence of the root and seedling. The germination process, therefore, is sensitive to overwet as well as to overdry conditions.

A temperature of at least 3 ^{o}C is required to start the germination process, and 90 day degrees above that temperature are needed for the attainment of 50% emergence under favorable conditions.

Sugar-beet seeds must be sown with great care and the drill must be well maintained and adjusted to suit the field conditions. It is crucial to set the right depth, normally 2.3 cm and with correct alignment. The speed of the drill must be regulated with regard to the properties of the machine and the seedbed.

2.6.3 Plant establishment and spacing:

For radiation interception to be maximized it is crucial that establishment and spacing are right. If there are gaps not covered by foliage when plants are fully grown then yield is lost (Scott, 1964). Many experiments show that on mineral soils population of 75000 plants/ha are the minimum required for maximum sugar yield. Usually, biomass yields have increased progressively with increased population. The failure of population above 75000 to give extra yield arises because overlapping of leaves from adjacent plants occurs early and as it becomes more extensive individual plants trap less light. In consequence the individual plant produces less dry matter, its leaves expand more slowly and light interception, on a ground area basis, from additional plants is reduced. From some studies the optimum plant spacing was found to be 25 cm. Beyond this sun light interception is reduced and exploitation of the soil profile by roots may also be incomplete.(Dray Cott, 1972).

When crops are drilled to a stand, the spacing and arrangement of the plants is constrained by the requirement of the harvester and controlled by the proportion of seeds which become established.

2.6.4 Fertilizer application:

The fertilizer application to sugar beet aims to mainly maximize the interception of light and maintain the efficiency of its conversion to dry matter and sugar.

Nitrogen has the most profound effect on growth and thus on the efficiency of light interception by crops. In many crop sp; particularly those in which yield is mainly foliage, there is direct relationship between the yield and the amount of N that the crop contains. There is, however, no direct relationship between nitrogen uptake and sugar yield and there are several reasons for this. First there is lack of direct proportionality between leaf area and light interception. Secondly a reletively small canopy is able to intercept much of the radiation late in the season, and thirdly N has an adverse effect on harvest index. While a certain amount of N uptake is required to produce and maintain a full canopy, the light which the canopy intercepts and the amount of sugar which it produces is then determined by the incident sunlight, the level of disease and the degree of drought. Over periods when the crop is growing at full potential the nitrogen concentration of the storage root can be as little as 5 kg/t dry matter. A properly fertilized crop can reduce the available nitrogen concentration of the top meter of soil to only 20 - 30 kg N/ha. Nitrogen starts to be lost from old leaves as soon as, or just before, they reached full size (Armstrong *et al.*, 1986).

On organic soils and where large dressings of organic manures have been applied, the crop continues to take up nitrogen. This results in less nitrogen being mobilized from old leaves, leaves being retained longer, and the production of large, late-formed leaves. However, these effects are not usually created by over-generous use of inorganic fertilizer but by growing crops in conditions where large amounts of N are being mineralized either from soils inherently rich in organic matter or from recently added manures. These are also the conditions which lead to large concentration of nitrogenous impunities in the roots. By the time the canopy of a well-grown beet crop closes; at three months age, the crop contains 150 – 170 kg/ha of nitrogen. Thereafter, the content needs to rise only slowly at less that 1 kg/ha/day, until at harvest the N uptake is approximately 200 kg N/ha. When uptake exceeds this value the concentration of nitrogenous impurities, particularly the amides and amino acids, rises rapidly to the point where they impair the crystallization of sugar in the factory process (Armstrong and Milford, 1985). Like N,the presence of sodium fertilizer in the seed bed can cause the osmotic potential of the soil solution to become increasingly negative, thereby inhibiting water uptake by seeds, slowing germination and emergence and resulting in fewer, smaller plants at the earlier stages. However, if the fertilizer is applied sufficiently early to avoid affecting seedbed water potential, then it can accelerate expansion of the leaf surface during the critical early period (Farley and Dray Cott, 1974).

For a beet crop producing 10 t/ha sugar, total N uptake is typically about l00 kg/ha. N concentration in root dry matter ranges from 0.04 to 0.11% and in top dry matter from 0.9 to 1.7%. In crops given normal fertilizer applications, typical average values for roots and tops are 0.08 and 1.4% respectively.

Sodium fertilizer affects growth and yield when it increases leaf expansion early in the growing season, increases the proportion of root to top dry-mater production, and improves sugar concentration in roots at harvest (Dray Cott and Farley, 1971). Sodium chloride increases the water capacity of the whole plant. All of these beneficial effects are reflected in sugar yield responses to sodium fertilizer. Although leaves of healthy sugar-beet plants contain large quantities of sodium, plants grown without the element do not show any deficiency symptoms. Presence or absence of sodium in the nutrient medium does, however, influence the degree to which sugar- beet leaves show potassium deficiency. Symptoms of potassium deficiency are decreased when sodium is applied, so that instead of the severe intervenal scorch, symptoms are usually confined to marginal browning.

Potassium is taken up rapidly by sugar-beet crops and is very mobile in plant tissues and found throughout the plant. It is important to photosynthesis, and the sugar which is produced relies on potassium for movement to the storage root. At harvest, plants given potassium (and sodium) have significantly greater sugar content than those given none. This has important economic implications because for a given weight of sugar, less weight of roots has to be harvested and transported which reduces cost. Moreover, the produce gives more returns for a given harvest when roots have high sugar concentration. Potassium also improves performance by increasing leaf area which allows the crop to intercept more radiation.

Potassium fertilizer is applied immediately before drilling sugar beet. This early application has several advantages:

- Better incorporation of potassium.
- No negative effect on seed germination.

Despite the low potassium concentrations in many beet- growing soils, foliar symptoms are rarely seen. When they do appear, they are typified at first by a dull olive-green appearance of the margins of the leaves followed by sclerosis. Later the whole leaf becomes dull and bronze in color, with small clusters of buff-colored spots. Brown striped lesions commonly appear on the petioles. The potassium concentration of leaf dry matter from deficient-plants is usually less than 0.6%.

Calcium plays two roles in the production of successful sugar- beet crop. First, it is an important major plant nutrient, its uptake being greater than phosphorus or magnesium, but less than nitrogen or potassium. Secondly, Calcium is present in large quantities in soil,and damage to crops normally occurs at the seedling stage. Affected seedlings grow slowly, cotyledons may be more erect than usual and the margins of leaves and cotyledons may become red. Usually when pH is below 5.0 in the immediate root zone some seedlings are killed, but those plants which survive sometimes have bright yellow leaves, due to manganese toxicity. Roots are browned or blackened, and may die; new ones are often produced, leading to a distorted tap root.

Application of calcium in the form of oxide, carbonate, hydroxide, or sulphate, neutralizes soil acidity.

The magnesium concentration in leaf dry matter from healthy plants is usually in the range 0.6% in spring to 0.2 in the late summer. The first sign of magnesium deficiency is appearance of pale yellow areas 1.2 cm in diameter on the distal margines of the middle-aged leaves. Tissue in the affected areas of the leaf grows abnormally. The yellow areas extend down between the veins and within a few weeks become necrotic.

Magnesium is the main metallic element in the chlorophyll molecule, and as indicated above deficiency show up first as damage to the green leaf area. Photosynthesis is reduced as a result, and yield is subsequently depressed.

In fields where sugar beet would be subjected to magnesium deficiency symptoms, yield increases of between 6 and 20% can be expected from a well-incorporated application of magnesium fertilizer, assuming the element is in a readily available form. The wide range of responses is partly explained by water supply (the drier the soil, the larger the response) and partly by the health and extensiveness of the root system (e.g. damage by plant-parasitic nematodes can decrease uptake).

In the range (15 – 50 ppm) magnesium, fertilizer is also needed to improve (15 – 25 ppm) or maintain (25 – 50 ppm) soil magnesium status and ensure maximum production of sugar beet.

Magnesium deficiency "disease" was described first by Hale *et al.* (1940). Early attempts at correcting it used magnesium foliar sprays. Later, extensive experiments based on the knowledge that magnesium was a major plant nutrient produced large increases in yield (Dray Cott and Durrant, 1970).

In most soils, the requirements of sugar beet for micronutrients are supplied from soil reserves, weathering of minerals, rainfall, fertilizer and organic manure. One dressing of farmyard manure supplies most of the micronutrients that a sugar-beet crop removes. However, on soils where natural supplies are small and where farming practice depletes reserves, some elements need to be applied. For sugar beet to yield fully boron and manganese are the only two micronutrients of importance.

2.7 Water use and irrigation:

2.7.1 Responses to irrigation:

The amount of irrigation given to sugar-beet varies greatly world-wide. In temperate areas irrigation is supplementary to rainfall and typically only 100 – 200 mm is needed to ensure that growth is not limited by water shortage. In hot areas 500 – 1000 mm are commonly used.

2.7.2 Sugar yield:

When considering the benefits of irrigation, the main interest is usually the response of the economic components of yield, the storage root and particularly sugar. Where irrigation dominates, it is logical to relate yield to the amount of irrigation applied.

2.7.2.1 Sugar concentration in roots:

Sugar concentration in well-watered crops rises steadily through the growing season, often leveling off, before harvest, in the range 15 – 18 % sugar per 100 g of fresh roots. In stressed crops the sugar concentration rises more quickly and under severe stress, it can be 5% higher than in unstressed crops.

2.7.2.2 Nutrient uptake and root impurities:

Extra water supplied by irrigation can prevent fine roots from dying in dry soil, help nutrient ions to move towards the roots by diffusion and increase the mineralization of soil organic matter. It also enables more soil water to be transpired. On the other hand, irrigation tends to dilute the soil moisture and sometimes to leach nutrients, notably nitrogen, beyond the reach of the root system. The overall effect is usually to increase nutrient uptake, but not necessarily the concentration within the crop because extra growth resulting from irrigation tends to counteract this.

Because of these counteracting tendencies, field experiments on sugar beet have produced little evidence of significant interactions between irrigation and fertilizers except in the case of nitrogen. First, when nitrogen is limiting, irrigation sometimes increases the crop responsiveness to moderate rates of nitrogen fertilizing. Secondly, when the nitrogen supply is plentiful, irrigation can mitigate the adverse effects of excess nitrogen application by reducing the build-up of amino nitrogen impurities in the roots (Haddock *et al* 1974, Last et *al* 1983; Winter, 1990).

Potassium and sodium in the roots are also regarded as impurities because they interfere with sugar extraction. Unlike the reductions in amino nitrogen compounds, irrigation has only small, inconsistent effects on the concentrations of these impurities (Vukov, 1977; Last, etal, 1983; Winter, 1990) probably because of the various counteracting effects of irrigation on ion uptake already mentioned.

2.8. Diseases:-

2.8.1. *Cercospora* leaf spot:-

It is one of the most wide spread and destructive foliar diseases of sugar beet. Symptoms are delimited circular spots which develop on older leaves, enlarging to 2.5 mm when mature (Ruppel, 1986). Lesions are tan to light brown with dark brown or reddish –purple margines. Elongated lesions occur on petioles, and circular lesions may occur on sugar beet crowns not covered by soil (Giannopolitis, 1978). Causal agent is *cercospora beticola* sacc (Chupp, 1953; Barnett and Hunter, 1972). An integrated approach is recommended for controlling or suppressing *cercospora* leaf spot, involving cultural measures, resistant cultivars, and chemotherapy (Ruppel,1986). Deep ploughing hastens the breakdown of infected tops, leading to death of the fungus (Canova, 1959b).Sugar beet cultivars with quantitative resistance to the pathogen are available and should be grown wherever the disease is endemic and important.

2.8.2. Downy mildew:

Downy mildew is a serious sugar- beet problem in Egypt, Japan and other countries (Leach, 1931). Although seedlings may be killed by the fungus, the pathogen mostly attacks young heart leaves of older plants inducing a rosette of small, pale green, distorted, thickened, puckered leaves with down-curled margins (Leach, 1931). The pathogen is the fungus *perononspora farinose*.

To reduce disease spread, seed or steckling crops should be separated from sugar beet root crops by at least 400 – 500 m (Ford and Hull 1967). Full, uniform plant stands, an optimal amount of nitrogen fertilizer and early sowing also reduce disease incidence (Ford, 1967c).

Control of sugar beet downy mildew with fungicides has not been too successful, but some chemicals have reduced disease spread (Ford and Hull, 1963; Ford, 1975a). Prophylactic sprays of emerging steckling with maneb have been recommended if they are grown close to root crops (Ford and Hull, 1963).

2.8.3 Charcoal rot:-

The first symptom of infection is wilting of the foliage which soon turns brown and dies. Brownish-black, irregular lesions appear externally on the crown, these eventually rupture to reveal masses of charcoal-colored sclerotia in cavities and the infected root may die (Tamkins, 1938). The disease is caused by *Macrophomina phaseolina* (Tassi).

The fungus attacks sugar-beet plants that are under stress, weakened or injured. High temperature (31^{o}C) favour disease development (Tomkins, 1938). Although the disease can reduce root yield and sugar percentage, low disease incidence-precludes the need for control measure.

2.9 Storage:

Stored sugar-beet roots metabolize their own sucrose for life support through respiration. This process usually accounts for 50 – 60 % of the total sucrose loss (Wyse and Dexter, 1971). Excessive loss of sucrose which results from normal respiration can be attributed to three causes:

- The physiological state of roots as influenced by pre- and post- harvest factors.
- Deterioration of juice quality by microbial activity.
- Injury to roots from mechanical harvesting and cleaning operation.

2.9.1. Physiological causes:

The Physiological state of the sugar-beet plant at harvest affects its storability. Proper soil fertility and adequate soil moisture are therefore important factors in producing roots which store well. Adequate phosphate fertilization reduces the amount of sucrose lost from stored roots, apparently because of decreased respiration rate (Larmer, 1937).

Nitrogen fertility is important because this element influences juice purity, which in turn affects the crystallization of sucrose. The ideal situation is to have enough soil nitrogen-available during most of the growing season to produce a healthy crop, low nitrogen supply at the end of the season isw important so that energy is spent on storing sucrose and not producing new growth. Roots grown in these conditions have low impurity content and consequently store better (Dexter et al., 1966). In beet-growing regions of the world available nitrogen can be measured accurately and successful nitrogen management to produce roots with the desired qualities is possible.

Dehydration is a major cause of sucrose loss from roots on the outer 60 cm of a storage pile; "Rim-loss" can amount to 40% of the total pile loss although the rim might comprise only 17% of the pile volume. Thus, pile protection efforts are largely directed at reducing the rim-loss.

2.9.2 Microbiological causes:

The intact, undamaged sugar-beet root is remarkably resistant to pathogens. However, roots are seldom placed in the storage pile completely free of damage, and fungal storage pathogens find their way through root injury that occurs during harvest and piling. Bacteria seldom cause storage diseases unless oxygen is depleted within the pile. If oxygen depletion does occur, however bacteria and yeast initiate fermentation and generate heat, which accelerates further deterioration.

2.9.3 Mechanical causes:

Rapid mechanized harvesting causes physical damage to the sugar-beet root. The first major mechanical injury to the sugar-beet is the removal of the crown before the root is harvested. This has been a traditional practice because the crown tissue is low in sucrose and high in impurities compared with the tap root. Crown removal is an acceptable practice if the roots are to be processed within a few days but it can cause problems if the roots are to go into storage because sucrose loss during storage is greater from crowned than from uncrowned roots (Stout and Smith, 1950, Dexter et al., 1970a; Wyse, 1978b).

Effective cleaning methods are necessary to reduce the amount of soil taken into storage piles. Harvesters and pilers are designed to achieve this by handling a large volume of roots in a rough manner in order to remove clinging soil. As a result the respiration rate of damaged roots is increased during the entire storage period.

2.9.4 Reducing storage losses:

Considerable research effort has been made over the years to find ways of decreasing the large amount of sucrose that can be lost while sugar- beet roots are stored awaiting processing.

2.9.4.1 Controlling the storage pile environment:

The optimal environmental requirements for successful sugar beet storage are a temperature of 4.6 ^{o}C and a relative humidity of 95 – 98 %. Conversion of sucrose, raffinose accumulation, bacterial and fungal growth and root sprouting are also all reduced in an atmosphere of 6% carbon dioxide and 5% oxygen at 2 ^{o}C (Karnick *et al.*, 1970). But with industrial storage it is possible to manipulate the temperature and to a limited extent, the humidity of the storage pile. Quickly lowering the temperature of the harvested roots decreases its respiration rate and retards microbial activity. Adequate humidity retards root dehydration and promotes wound healing.

Enhanced control of the pile environment can by achieved if some sort of covering is used. Roots have been covered with straw, plastic sheets, plastic enclosures with canopied roofs, plastic supported by air pressure and rigid structures.

The ultimate storage environment is a freezing temperature if roots are to be stored in frozen condition. It is important that root temperatures should be less than - 5 ^{o}C because it was shown that damage and loss of sugar occur at - 30 ^{o}C and that respiration dose not stop until root temperature reaches - 18 ^{o}C when the root becomes frozen solid (Wyse, 1978).

2.9.5 Applying chemicals to storage pile:

Various chemical compounds have been used to alter the temperature of the roots, to decrease the root respiration rate, and to inhibit sprouting and storage rot. Usually the compounds are applied to roots from spray nozzles mounted at the end of the piler's boom.

In the case of sprout inhibiters, applications are made to the growing plant prior to harvest. After 35 days of storage, sucrose loss in untreated roots was 13 % whereas loss in the treated roots was only 1 % (Dray Cott 1972).

2.9.6 Decreasing mechanical damage:

Designing commercial harvesting and piling equipment that will remove soil whilst causing minimal root damage is difficult however, progress has been made and root damage was reduced by 62 – 88% in two years of trials with a modified harvester (Peterson *et al*., 1982).

2.9.7 Plant breeding approach:

Two characteristics that a sugar beet cultivar should possess for satisfactory performance under long term storage are resistance to storage rot pathogens and low respiration rate. Various levels of storage rot resistance, none of which are adequate, exist among current cultivars. Heritable resistance to storage rot pathogens, as well as to other diseases, is present in the sugar-beet gene pool.

2.10 Guide to harvesting:

When there is a choice of fields to be harvested, the results of a systematic plant analysis program can serve as a guide to scheduling of beet harvest. Those fields depleted of N are the first would be scheduled for an early harvest. Those high in N would be harvested until the N is depleted or would be held as long as possible before harvesting. Root- pulp as well as petioles may be analyzed to determine depletion of N before harvest. Pulp from pre harvest root samples may be analyzed for nitrate by a semi quantitative spot test using the diphenylamine reagent, or, more accurately, by other quantitative methods. To maximize the sucrose concentration of beet roots, petioles and/or roots should be below critical NO_3 – N levels about 4 to 8 weeks before harvest (Dray Cott 1972).

2.11 Nutrition:

The nutrition of sugar-beet was comprehensively described by (Dray Cott, 1972). Correct nutrition is vital for foot processing quality and concern over issues such as straw burning and nitrates in groundwater has stimulated research into nutritional strategies which minimize adverse effects on the environment.

In common with other crops, sugar beet usually satisfies only part of its needs for a particular nutrient from the soil, the reminder must be obtained from fertilizers. The climate plays an important role in the nutrition of the crop because it sets limits on the potential yield and therefore the uptake of nutrients. Indirectly, the climate also affects the amounts of nutrients needed because it determines to a large degree, the soil characteristics through leaching and other soil formation processes.

2.11.1 Nitrogen:

Nitrogen is the most important element supplied to sugar beet in form of fertilizers, because few soils contain sufficient nitrogen in an available form, i.e. nitrate or ammonium to provide for maximum growth. Where the element is in short supply yield is drastically reduced.

The fertilizer N has a remarkable effect on the appearance of the crop, most noticeable by improving the color and vigor of the leaf canopy. This has led to wide spread overuse of nitrogen, which decreases both sugar percentage and juice quality. Progress has been made towards optimizing the use of nitrogen through a better understanding of the crop requirements under varying conditions of soil and climate. Since 1945 there has been a rapid annual increase in the average application rate in many countries, reaching amounts which were clearly excessive in the 1960s and 1970s (Van Bung *et al.*, 1983).

During the last decade of the 20^{th} century, largely as a result of detailed research and development works, there has been a change towards more realistic quantities, which is to the advantage of producers and processers alike.

2.11.1.1 Nitrogen uptake and concentration:

Sugar beet crop generally takes up to 200 – 250 kg/N/ha, in order to give maximum sugar yields. Few mineral soils in continuous arable canopy cropping can provide more than 60 kg/ha of nitrogen each year without regular additions of fertilizes. Thus the crop obtains part of its nitrogen requirement from applied fertilizer and part from soil reserves.

Recent research in several countries has helped in the understanding of nitrogen uptake by sugar beet. Haunold (1983) showed that with a normal application of fertilizer, 50% of the nitrogen was taken up by the crop, 20%

as left in the soil and 30% disappeared presumably by de-nitrification or leaching. Similar studies by Lindeman *et al.* (1983) over a five years period on various soils showed that 50 – 80% of N was taken up by the crop and that the soil contributed 100 – 215 kg/N/ha.

Broeshart (1983) placed N^{15} at depths down to 120 cm and found that sugar beet took up N effectively from greater depths particularly during later stages of development. (Dray Cott 1972).

2.11.1.2 Effect of nitrogen on growth and foliar efficiency:

In addition to improving the color of the leaves, nitrogen noticeably increases their size and number, early in the season Therefore nitrogen increases dry matter production per unit area, mostly from leaves and petioles. Later in the season, nitrogen maintains this increase in leaf and petiole dry matter and also increases root dry matter production, which is reflected in greater sugar production per unit area.

Armstrong *et al.* (1983) showed that nitrogen fertilizer did not affect the conversion of intercepted radiation to dry matter but greatly increased the amount intercepted. Much work has been undertaken recently to measure these effects. Milford *et al.* (1985) showed that the rate of leaf expansion per unit thermal time was positively related and very sensitive to nitrogen concentration of the leaves. The period of rapid uptake of nitrogen extends from the time when the plants have four or five leaves until the canopy is complete. Thus in any specific soil the fertilizer policy should be such that nitrogen is available to meet this demand.

In many crop species particularly those whose yield is mainly foliage, there are direct relationships between the yield and the amount of nitrogen that the crop contains. In beet over the period when the canopy is expanding it is directly related to the amount of nitrogen in the crop. This is however, not directly related to the amount of nitrogen in yield and there are several reasons why the link is weak. First, there is a lack of direct proportionality between leaf area and light interception. Secondly, a relatively small canopy is able to intercept much of the radiation late in the season. Thirdly N has an adverse effect on harvest index. While a certain amount of N uptake is required to produce and maintain a full canopy, the light which the canopy intercepts and the amount of sugar which it produces is then determined by the incident sunlight, the level of disease incidence and the degree of drought. Over periods when the crop is growing at full potential the nitrogen concentration of the storage roots can be as little as 5 kg N/ha dry matter. A properly fertilized crop can reduce the available nitrogen concentration of the top meter of soil to only 20 – 30 kg N/ha toward the end of the season. (Dray Cott 1972).

2.11.1.3 Effect of nitrogen during germination emergence and establishment:

When seeds are sown to stand, quite moderate amounts of nitrogen fertilizer can kill some seedlings, slow emergence of others and decrease the number of plants which are established. Many experiments have investigated possible solutions to this problem. Initially, various forms of placement were tested. Later work showed that a small, initial broadcast dose permits full establishment and gives optimum early growth. Once the crop is established, the required balance of nitrogen fertilizer can be applied at the 2 - 4 true leaf stage.

2.11.1.4 Effect of nitrogen on yield:

More experiments have been done on this subject than on any other related to sugar beet production. The primary effect of nitrogen fertilizer is on root and top dry matter production, much of which is eventually stored in the form of sugar.

On soils containing little residual nitrogen the peak of the N response curve is usually in the range 100 – 150 kg/ha of fertilizer nitrogen. Where there are large amounts of nitrogen already present in the soil, e.g. on organic soils or where N residues are present from previous crops the response peak occurs at lower N levels. In some soils where huge amounts of residual nitrogen are present, sugar yield is maximal with no additional fertilizer and experiments have even been done to discover whether yield is increased by growing a preceding crop to remove some of the residual nitrogen (Winter, 1984).

Nitrogen is a key factor in sucrose utilization and sugar concentration in the storage root. When the plant is abundantly supplied with nitrogen top growth is favored over root growth, perhaps because the raw materials for sugar utilization, nitrogen and sugar meet in the young leaves. Conversely, when nitrogen supply is limited sugar using processes decrease and sugar tends to accumulate throughout the plant. Under these conditions, sugar utilization appears to be located primarily in the root, where sugar from the tops first meets the nitrate from the soil. This favors storage root growth and thus sugar accumulation.

A sugar beet plant in a favorable environment grows indefinitely. Apparently, no internal mechanism for ripening induces the plant to develop, high sucrose content. In growth, the sugar beet plant produces new leaves at a uniform rate. The leaves enlarge, mature and gradually die. At the same time, the storage root enlarges at a uniform rate and once the sucrose concentration in the storage root remains relatively constant, "ripening" under these conditions occurs.

Only a change in environment, such as a lowered night temperature, depletion of nitrogen or a combination of these factors and others will increase the sucrose content of the beet root. Ripening is also favored by small root size during nitrogen depletion, since small roots "fill up" with sugar faster than large roots under similar climatic conditions.

2.11.2 Phosphorus:

The phosphorus requirement of sugar beet has been well researched over many years. Cultivated soils usually rely on additions of phosphorus in fertilizers, organic manure's and crop residues to replace that removed at harvest. Few soil forming minerals contain phosphorus so little is released during weathering in contrast to other nutrients such as potassium, calcium and magnesium. Recently, phosphorus concentration in the soil tended to increase each year because more is applied as fertilizer than is removed at harvest even with the greatly increased yields of cereals, sugar beet, potatoes and other crops (Dray cott, 1972)

2.11.2.1 Uptake and concentration of phosphorus:

In sugar beet crops, about half the phosphorus is in the roots and half is in the tops. In crops grown without any additions of the element for many years, the crops take up very little phosphorus, e.g.5 Kg /ha $P_2 O_5$ at

Rothamsted and yield is very poor. In contrast, currently well-fertilized crops, grown to produce a large yield, can take up over 100 kg P_2O_5/ha and typical figures are 50 – 90 kg P_2O_5/ha.

The concentration of phosphorus in all plant parts decreases from soon after emergence to harvest. Typical concentrations for seedlings are 0.7% P in top dry matter and 0.4% in root dry matter, decreasing to 0.4 and 0.3% respectively. In the mature plants these concentrations are 0.35 and 0.2% respectively.

2.11.2.2 Phosphorus deficiency symptoms:

Phosphorus deficiency symptoms are rarely seen on nature sugar-beet plants. They symptoms appear only where the concentration of available soil phosphorus is extremely low. Symptoms are more common on seedlings especially where other factors such as soil acidity, pest, disease or herbicides have damaged the root system and inhibited nutrient uptake. Irrespective of the age of the plant, phosphorus deficiency is typified by dark green leaves and stunting of the whole plant. Leaves have a characteristic purple red coloration when severely deficient and this may develop into browning and death. Tap-root growth is also retarded by shortage of phosphorus and a mass of fiberous secondary roots is often produced (Dray Cott, 1972).

2.11.2.3 Effect of phosphorus fertilizer on yield:

Phosphorus fertilizer only gives worth while yield increases on soils containing little available phosphorus. In most countries where sugar beet is grown, the element has now been applied for many years. Even in the humid climate, phosphorus does not leach and the amount of available phosphorus in soils has tended to increase because more has been applied than has been removed in crops. Many recent experiments lead to the conclusion that the response to phosphorus by sugar beet is usually small.

2.11.2.4 Soil Analysis for available phosphorus:

Soil analysis has become a useful tool to decide whether the crop will respond economically to the application of phosphorus fertilizers, and in making recommendations on fertilizer rates based on soil concentrations of available phosphorus. Available phosphorus is determined using soil extractants such as sodium bicarbonate, calcium ammonium lactate, water and ion-exchange resins. All these give values which are move closely related to field responses than the acid extractants used previously (Olsen's bicarbonate extraction method (Olsen *et al.*, 1954).

2.11.2.5 Phosphorus balance:

In fields adequately supplied with reserves of phosphorus, future fertilizer use needs to be planned ahead on the basis of nutrient uptake. Uptake can be balanced against fertilizer input, aiming to maintain soil concentrations which are sufficient to ensure maximum yield of all crops in the rotation. Long-term experimental work in the UK suggests that soil phosphorus extracted by sodium bicarbonate should be stabilized at 20 – 30 mg P_2O_5/100g soil for sugar beet/cereal rotations (Last, *et al.*, 1985).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental:

A field experiment was conducted for one season (2005) in the Experimental Farm of the faculty of Agriculture, University of Khartoum, Shambat, latitude 15^o – 40' N, longitude 32^o – 32' E and latitude 380 m above sea level. The soil at the site is heavy clay (46% clay) and alkaline with pH of 8.5.

3.2 Treafments and design:

The three sugar beet cultivars studied were Tomba, Posada and Monza designated as $CV_{1,}$ CV_2 and CV_3 respectively whereas the fertilizer treatments were three nitrogen levels (0 – 100 – 200 kg N / ha) designated as N_o, N_1 and N_2 and two phosphorus levels (0 – 100 kg P_2O_5 /ha) designated as P_o and P_1 respectively.

The objectives were to study the response of three sugar beet (*Beta vulgaris*.L) cultivars to nitrogen and phosphorus fertilization.

The experiment was laid out in a randomized complete block design with three replications. The experimental unit was a plot 4 x 5 m in area, consisting of 5 ridges at 70 m spacing.

The seeds of sugar beet cultivars were obtained from the Arab Authority for Agricultural Iinvestment and Development (AAAID).

The crop was sown on the 9th of January, 2005 at the rate of 4seeds/hole and spacing of 20 cm between holes, thinning to two plants per hole was carried out after the fourth irrigation when the plants were 6 weeks old.

Urea (46% N) as N source and triple super phosphate (48% (P_2O_5) as P source were applied on one side of the ridge at sowing, the crop was irrigated immediately after sowing; the subsequent irrigations were given every 7 days. Four manual weedings were carried out during the growing season.

3.3 Measurements:

3.3.1 Growth attributes:

Measurements of vegetative attributes were based on five random plants taken from the outer two ridges in each plot every two weeks starting one month after sowing until harvest, and included:

3.3.1.1 Number of leaves/plant:

Determined by counting all the leaves of the sampled plants and then obtaining the mean number of leaves per plant

3.3.1.2 Leaf area index:

It was determined using Watson Method (1953) (Appendix 1).

3.3.1.3 Dry weight of shoot:

Shoots of the sampled plants were separated, and left to air dry for one month and weighed to determine shoot dry weight by using sensitive balance (Metler P3).

3.3.1.4 Dry weight of roots:

Roots separated from the above mentioned plants were washed and roots were sun-dried for one month and weighed to obtain root dry weight/plants.

3.2.2 Yield attributes:

3.3.2.1 Root yield/plot:

Roots of plants in an area of 3 m^2 in the middle of three central ridges in each plot were dug out by a hand implement and cleaned from adhering mud. When the plants were 20 weeks old the roots of each plant were weighed to obtain root yield per plot.

3.3.2.2 Mean root weight:

It was calculated from the root yield of each plot.

3.4 Chemical analysis:

Roots harvested from each plot were crushed and blended to be used for chemical analysis.

3.4.1 Sugar content (Pol %):

The blended sample of each plot was strained by filter paper. A sample of 25 ml of juice was taken from each sample and used for determination of sugar content using Cold Aqueous Digestion Method (Appendix 2).

3.4.2 Insoluble Solids (Brix %):

Brix percentage was determined by Meade and Chen Method (1975) (Appendix 3). A sample of 1000 g of root material from each treatment was used for this purpose.

3.4.3 Fiber %:

The fiber percentage was determined by the (AOAC, 1984) method (Appendix 4). A sample of 20 g from each treatment was used.

3.4.4 Purity:

It was obtained by dividing Pol % by Brix %:

$$\text{Purity} = \frac{\text{Pol \%}}{\text{Brix \%}}$$

3.4.5 Moisture %:

It was measured by Hesse Method (1971) (Appendix 5).

3.5 Mineral content:

3.5.1 Nitrogen content:

Nitrogen content of sugar beet was determined by using micro Kjeldhal method (Appendix 6). A sample of 1g was taken from each treatment to estimate N content.

3.5.2 Phosphorus content:

Phosphorus content was determined by Pearson Method (1970), (Appendix 7).

3.5.3 Potassium content:

Measured by Wilox Method (1937) (Appendix 8).

3.5.4 Sodium content:

Determined by Banber and Kolthoff Method (1928).

3.6 Statistical analysis:

Analysis of variance (ANOVA) s appropriate for R.C.B.D was conducted on the data and mean separation was carried out using the Duncan's Multiple Range Test (DMRT), Gomez and Gomez (1984).

CHAPTER FOUR
RESULTS

4.1. Vegetative Growth Parameters:-

4.1.1 Leaf Number:-

The results showed that there was no significant effect of the treatments on leaf number of sugar beet at all stages (Table 1). However, N_0 gave the highest number of leave at 10^{th} week, while N_2 gave the lowest number of leaves. The cultivar (CV_2) gave the greatest number of leaves in comparison with (CV_1) and (CV_3). There was no significant interaction between treatments on this character.

4.1.2. Leaf Area index:-

Statistical analysis showed that, nitrogen, phosphorus and cultivars had no significant effete on leaf area index (Table 2). There was no significant interaction between treatments on this character.

4.1.3 Shoot Dry Weight.

There was no significant effect on shoot dry weight due to nitrogen although N_2 produced a marked but insignificant increase in this parameter. Phosphorus application had no significant effect on shoot dry weight (Table 3) but P_0 gave higher shoot dry weight than P_1. Cultivars were not significantly different in shoot dry weight, but CV_2 produced slightly greater weight than the others.

The interaction between treatments had no significant effect on this parameter.

Table 1: - Effect of Nitrogen and Phosphorus on Leaf number of Three Sugar Beet Cultivars.

Treatments	Leaf Number		
	6^{th} week	8^{th} week	10^{th} week
Nitrogen N_0	14.6a	16.2 a	20.6a
N_1	13.4a	16.0 a	19.2 a
N_2	13.9a	14.8 a	18.a
SE ±	0.4	0.5	1.0
Phosphorus P_0	13.8a	15.1 a	20.2 a
P_1	14.1a	16.2 a	18.9 a
SE ±	0.3	0.4	0.8
Cultivars CV_1	13.6a	15.2 a	18.2 a
CV_2	14.1a	15.4 a	21.2 a
CV_3	14.2a	16.3 a	19.3 a
SE ±	0.4	0.5	1.0
C.V	0.11 %	0.14 %	0.22 %

Means followed by the same letter are not significantly different at (0.05) level of probability according to (DMRT).

Table 2:- Effect of nitrogen and phosphorus application on leaf area index of three sugar beet cultivars.

Treatments	Leaf area index		
	6th week	8th week	10th week
Nitrogen N_0	0.8a	0.9a	1.8a
N_1	0.6a	1.1a	1.1a
N_2	0.7a	1.1a	1.5 a
SE ±	0.1	0.2	0.3
Phosphorus P_0	0.7a	1.2a	1.6a
P_1	0.6a	0.9a	1.3a
SE ±	0.1	0.1	0.3
Cultivars CV_1	0.7a	1.1a	1.3a
CV_2	0.5a	1.0a	1.4a
CV_3	0.7a	1.1a	1.6a
SE ±	0.1	0.2	0.3
C.V	0.87 %	0.36 %	0.9 %

Means followed by the same letter are not significantly different at (0.05) level of probability according to (DMRT).

Table 3:- Effect of nitrogen and phosphorus application on shoot dry weight (g) of three sugar beet cultivars.

Treatments	6^{th} week	8^{th} week	10^{th} week	Shoot dry/weight at harvest
Nitrogen N_0	21.8a	12.5a	20.3a	117.0a
N_1	22.0a	12.8a	19.1a	186.3a
N_2	21.5a	13.6a	25.5a	256.7a
SE ±	2.2	1.2	2.7	18.6
Phosphorus P_0	22.2a	14.8b	23.6a	174.9a
P_1	21.3a	11.1a	19.7a	198.5a
SE ±	1.8	1.0	2.3	15
Cultivars CV_1	21.9a	13.8a	21.5a	183.7a
CV_2	21.8a	13.4a	23.1a	181.4a
CV_3	21.6a	11.6a	20.3a	195.0a
SE ±	2.2	1.2	2.7	18.6
C.V	0.4%	0.5%	0.4%	0.45%

Means followed by the same letter are not significantly different at (0.05) level of probability according to (DMRT).

4.1.4 Root Dry Weight:-

The results showed that N had no significant effect on root dry weight but N_2 produced greater root dry weight than other N levels. Phosphorus and cultivars had no significant effect on root dry weight, but P_0 gave higher root dry weight than P_1 while CV_1 and CV_2 tended to have greater root dry weight than CV_3 (Table 4). There was no significant interaction of the treatments on this parameter.

4.2 Yield and Yield Components:-

4.2.1 Root Weight/Plant (kg)

Root weight/plant increased with increase in N and P application but the increase was not significant. Moreover, CV_1 gave higher root weight/plant than CV_2 and CV_3 but the difference was not significant (Table 5). The interaction between treatments on this parameter was also not significant.

4.2.2 Root Yield (kg/ha):

There was no significant difference in root yield due to the treatments. However, root yield increased with increase in nitrogen and phosphorus application. Moreover, CV_1 had higher root yield than CV_2 and CV_3 but differences were not significant (Table 5). The interaction between treatments was also not significant.

Table 4:- Effect of nitrogen and phosphorus application on root dry weight of three sugar beet cultivar.

Treatment	Root dry weight (g)		
	6^{th} week	8^{th} week	10^{th} week
Nitrogen N_0	1.0a	6.9a	19.0a
N_1	0.9a	6.9a	15.6a
N_2	1.2a	6.5a	28.4b
SE ±	0.1	0.9	2.5
Phosphorus P_0	1.0a	7.7a	23.7a
P_1	1.0a	5.9a	18.3a
SE ±	0.1	0.7	2.0
Cultivars CV_1	1.1a	8.1a	19.2a
CV_2	1.1a	6.5a	25.5a
CV_3	0.9a	5.9a	18.4a
SE ±	0.3	2.0	6.0
C.V	0.53%	0.51%	0.49%

Means followed by the same letters are not significantly different at (0.05) level of probability according to (DMRT).

Table 5:- Effect of nitrogen and phosphorus application on yield and juice quality of three sugar beet cultivars.

Treatment	Root Weigh/Plant/kg	Root yield(kg/ha)	Sugar% (Pol %)	Brix%	Purity%	Fiber%	Moisture%
Nitrogen N_0	**0.9a**	**2977.5a**	**14.6a**	**17.8a**	**81.8a**	**2.9a**	**81.7a**
N_1	**1.2a**	**3277.2a**	**13.9a**	**16.7a**	**82.1a**	**4.0a**	**81.8a**
N_2	**1.3a**	**3780.6a**	**12.0a**	**15.1a**	**78.7a**	**2.6a**	**82.9a**
SE ±	**0.5**	**254.4**	**0.5**	**0.5**	**1.08**	**1.0**	**0.9**
Phosphorus P_0	**1.1a**	**3225.9a**	**13.7a**	**16.8a**	**81.3a**	**3.1a**	**81.0a**
P_1	**1.3a**	**3464.8a**	**13.3a**	**16.4a**	**80.4a**	**3.3a**	**83.2a**
SE ±	**2.4**	**205.5**	**0.4**	**0.4**	**0.8**	**0.2**	**0.7**
Cultivars CV_1	**1.3a**	**3505.6a**	**14.3a**	**17.4a**	**82.1a**	**3.2a**	**81.3a**
CV_2	**1.1a**	**3091.2a**	**13.4a**	**16.7a**	**80.6a**	**3.1a**	**81.9a**
CV_3	**1.1a**	**3438.9a**	**12.7a**	**15.7a**	**79.9a**	**3.2a**	**83.1a**
SE ±	**0.5**	**254.5**	**0.5**	**0.5**	**0.08**	**1.0**	**0.9**
C.V	**0.4%**	**31.9%**	**0.12%**	**0.12%**	**0.05%**	**0.3%**	**0.04%**

Means followed by the same letter are not significantly different at (o.o5) level of probability according to (DMRT).

4. 3 Juice quality:-

4 .3.1 Sugar Content (pol %):-

Nitrogen caused consistent but insignificant reduction in sugar content (Table 5) Also phosphorus caused a slight and insignificant reduction in sugar content in comparison to the control. In addition, there were differences in sugar content between the cultivars, with $CV_{1,}$ giving the highest value, but such difference was not significant. The interaction between treatments was not significant.

4. 3. 2 Unsolible Solide (Brix %):-

Nitrogen caused consistent reduction in this character but the reduction wan not significant (Table 5). Phosphorus also caused slight and insignificant reduction in this character, while cultivars showed slight but inignificant differences, with CV_1 giving the highest brix percentage. The interaction between treatments was not significant.

4.3.3 Purity %:-

Nitrogen caused non significant reduction in juice purity (Table 5). Also phosphorus and cultivars had no significant effect on this character, but CV_1 exhibited higher purity than the others (Table 5). The interaction between treatments was not significant.

4.3.4 Fiber %:-

Nitrogen application produced inconsistent effect on fiber percentage, N_1 causing substantial but inignificant increase in this character, whereas N_2 had no effect. Phosphorus and cultivars showed no effect on fiber percentage (Table 5). The interaction between treatments was not significant.

4.3.5 Moisture Content:-

Nitrogen tended to increase root moisture content but the effect was not significant. Phosphorus caused a slight but insignificant decrease in moisture content. As for cultivars, CV_3 roots contained higher moisture than the others but the difference was not significant (Table 5). The interaction between treatments was not significant.

4.4 Minerals Composition of Root:-

4.4.1 Nitrogen Content:-

Nitrogen, Phosphorus and cultivars had no significant effect on mineral content of root of sugar beet (Table 6), however CV_3 showed higher nitrogen content than the others. There was no significant interaction between treatments on this character.

4.4.2 Phosphorus Content:-

Phosphorus content of beet roots was not affected by any of the treatments (Table 6).

4.4.3 Potassium Content:-

Nitrogen caused consistent but insignificant increase in potassium content of beet roots, while phosphorus and cultivars had no significant effect on this character (Table 6). Also there was no significant interaction between treatments.

4.4.4 Sodium Content:-

Nitrogen, phosphorus and cultivars had marked but insignificant effect on sodium content of beet roots (Table 6). CV_3 had higher Na content than the others, but the differences were not significant. No significant interaction between treatments was observed.

Table 6:- Effect of nitrogen and phosphorus application on mineral content of roots of three sugar beet cultivars.

Treatments	N%	P%	K%	Na%
Nitrogen N_0	**2.5a**	**0.3 a**	**2.7 a**	**2.9 a**
N_1	**2.3a**	**0.4 a**	**2.8 a**	**3.1 a**
N_2	**2.5a**	**0.4 a**	**3.1 a**	**5.9 a**
SE ±	**0.1**	**0.05**	**0.2**	**1.2**
Phosphorus P_0	**2.4a**	**0.4 a**	**2.9 a**	**4.8 a**
P_1	**2.4a**	**0.4 a**	**2.8 a**	**3.1 a**
SE ±	**0.09**	**0.03**	**0.1**	**0.9**
Cultivars CV_1	**2.4a**	**0.4 a**	**2.8 a**	**3.4 a**
CV_2	**2.2a**	**0.4 a**	**2.8 a**	**5.5 a**
CV_3	**2.6a**	**0.4a**	**0.9a**	**5.5a**
SE ±	**0.5**	**0.09**	**0.8**	**2.8**
C.V	**0.2%**	**0.41%**	**0.2%**	**1.2%**

Means followed by the same letters are not significantly different at, (0.05) level of arability according to (DMRT).

CHAPTER FIVE

DISCUSSION

5.1 Vegetative Growth:-

Nitrogen and phosphorus application had no significant effect on leaf number of sugar beet. This is probably due to the fact that the crop was not sown at the optimum date. Dray Cott (1972) found that nitrogen noticeably increased size and number of leaves early in the season. Nitrogen increases dry matter production mostly from leaves and later in season nitrogen maintainers this increase in leaf and petiole dry matter, and also increases dry matter production per unit area.

Armstrong *et al*., (1983) showed that nitrogen fertilizer did not affect the conversion of intercepted radiation to dry matter but greatly increased the amount intercepted.

Milford *et al*., (1985) showed that the rate of leaf expansion per unit thermal time was positively related and very sensitive to nitrogen concentration of the leaves. El shaier, et. At (1993) showed that the increase of nitrogen level in general led to increase of shoot growth and thus late maturity and increase of amino a cid and this led to decrease of sugar content and purity percentage. Also the increase of shoot growth was linked with disease sucesspitability. Dubetz and Hills (1958) determined that the optimum nitrogen rate to obtain high root yield was 11-16.5 Kg N/ha. Ulrich (1954) showed that the high nitrogen application led to delayed maturity.

A number of studies showed that the nitrogen fertilizer had important effects on improvement of root quality and sugar yield and purity. Hartt (1936) mentioned that when the plant suffers from nitrogen, phosphorus and potassium deficiency the sucrose is translocated below the leaf blade. Elkarkagi (1963) mentioned that the phosphorus fertilizer is the limiting factor in increasing sugar beet yield and added that the nitrogen and potassium available have greater affects in increase of yield of sugar beet.

Phosphorus application tended to stimulate root growth and hasten maturity although the effect was not significant. This result agrees with Osman (personal communication).

The little response to phosphorus in this study could be attributed to low phosphorus availability in the alkaline clay soil at the experimental site. In such soils, phosphorus is fixed physically by strong adsorption on the clay soil particles, and chemically by conversion to less soluble di and tri- calcium phosphate in the alkaline calcareous soils (Simpson 1986).

The cultivar (CV_2) gave best performance which was exhibited in fast seedling growth, early maturity, larger roots and higher sugar content as compared to (CV_3) but (CV_1) gave higher root yield which agrees with Al-Khalifa (2003). Also studies at Kenana Sugar Company (1999) on four sugar beet cultivars showed that the cultivar Posada gave the highest yield when grown on 30th November.

5.2 Yield and chemical composition:-

Nitrogen application to sugar beet increased the root weight/plant and root yield/ha. This agrees with Dray Cott (1973) who showed that the primary effect of nitrogen was on root and top dry matter production much of which is eventually stored in the form of sugar in the roots. Dry Cott 1972) showed that nitrogen is a key factor in sucrose utilization and sugar concentration in the storage root.

Nitrogen tended to decrease sugar content of sugar beet. This result is in agreement with Dray Cott (1972) who showed that when nitrogen supply is limited sugar using processes decrease and sugar tends to accumulate throughout the plant.

Dray Cott and Durrant (1971) showed that in soils which contain a large concentration of available nitrogen the addition of only a small amount of fertilizer causes a rapid decline in sugar percentage and juice purity. This results from increased water retention by roots. The drop in juice purity largely reflects increasing concentration of amino compounds caused by excessive uptake of nitrate late in the season.

Dutton and Bowler (1984) found that an increase in amino nitrogen concentration of 100mg N/100g sugar decreased sugar percentage in roots by about 0.8%.

On the other hand phosphorus application had no significant effect on chemical composition of sugar beet. This result agrees with Dray Cott (1972) who showed that the response to phosphorus by sugar beet is usually small.

The Cultivar CV_2 gave the lowest amount of insoluble solids compared with others. This agrees with Silin (1958) who also reported variation between sugar beet cultivars in amount of soluble solids.

The fiber percentage was affected positively by nitrogen and phosphorus, increasing with increase of nitrogen and phosphorus levels as was brix percentage and purity.

Nitrogen and phosphorus application led to increase of nitrogen, phosphorus, potassium and sodium content of juice. Dray Cott (1971) showed that young plants contain 5% N in leaf dry matter and 3% in the roots. In crops producing maximum sugar beet yields, the tops contain about 3.0% N and roots about 0.8% in dry matter at harvest.

Phosphorus content also increased with increasing phosphorus level. Dray Cott (1972) showed that the concentration of phosphorus in all plant parts decreases from soon after emergence to harvest. Wand and Wad Leigh (1949) indicated that phosphorus availability is the major limiting factor for crops in alkaline calcareous soils. Also in alkaline soils nitrogen is most limiting nutrient for growth of most crops except legumes. Typical phosphorus concentrations in root dry matter are reported to be about 0.3% Dray cott (1972) which conforms with values observed in this study which ranged from (0.3 - 0.4 %).

The results showed that nitrogen and phosphorus application to sugar beet increased moistur content of roots. This agrees with Milford, *et al.*, (1977) who found that besides increasing the area, thickness and succulence of the leaves nitrogen and phosphorus also increased the water capacity of treated plants and buffered them against conditions of moderate water stress. All of these beneficial effects are reflected in increase in sugar yield.

SUMMARY AND CONCLUSIONS

A field experiment was conducted for one season (2004 – 2005) in the Experimental Farm of the Faculty of Agriculture at Shambat to study the effect of nitrogen and phosphorus application on the growth and yield of three sugar beet (*Beta vulgaris.L*) cultivars.the treatments consisted of three N doses (0 – 100 – 200 kg N/ ha) designated as N_0 , N_1 and N_2 and two P doses (0 – 100 kg P_2O_5 /ha) decignated as P_0 , P_1 and three cultivars Tomba , Possada and Monza decignated as CV_1, CV_2 and CV_3 respectively.

The experiment was laid out in randomized complete block design with three replications.

The results of this study can be summarized in the following:

1- Vegetative growth: nitrogen and phosphorus had no significant effect on leaf number, leaf area index, shoots and root dry weight.
2- Yield parameters: nitrogen had no significant effect on all yield parameters.
3- Chemical composition of roots: nitrogen, phosphorus, potassium and sodium content were not significantly affected by nitrogen and phosphorus application.
4- Juice qualaty: sugar content, brix %, fiber %, purity %, moisture % were not significantly affected by nitrogen and phosphorus application.
5- Cultivars: there were no significant differences between cultivars in all parameters studied but possada CV_2 preferment slightly better than the other.

6- The results of this study are not conclusive since neither the soil conditions nor the sowing date were optimum for the crop thefore further studies under more favourable conditions are needed for better understanding of the response of sugar beet to feritlizers.

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Appendix (1)

Determination of leaf area index

By Watson method (1953)

Calculated:

Leaf area per plant: total area of leaves discs x total dry weight of leaves/dry weight of leaves disc.

Then the L.A.I was calculated as follows:

L.A.I = Leaf area per plant/plant ground area.

Appendix (2)

The determination of the polarization of sugar beet

By the Macerator or cold aqueous digestion method

Using lead acetate as clarifying agent-official

Reagents:

1. Basic lead acetate
2. Basic lead acetate solution
3. Dilute basic lead acetate solution
4. Glazed paper
5. Filer paper, kieselguhr

Procedure:

Preparation and defecation of sample solution:

Form a well-mixed sample weigh 26.00 ± 0.05 g of freshly produced sugar beet brei on a glazed paper as rapidly as possible. Transfer the brei "including the paper" to the blending vessel (macerator). Add a volume of 177.0 ± 0.35 ml of dilute basic lead acetate solution from the (automatic) pipette.

Close the lid of the blending Bessel, connect to the motor drive and run for 3 minutes at 12000 – 15000 rev/min. remove the vessel from the drive motor and place a rubber stopper in the base to cover the drive assembly. Slacken the lid and place the vessel in the water- bath.

Determination of the polarization:

Use flow through on side- filling Polarimeter tubes- rinse and fill the flow through tubes with the main portion of the filtrate. Rinse side- filling tubes thoroughly at least twice with the filtrate and fill them in such away that no air bubbles are entrapped. Handle the tube as little as possible to avoid warming. Polonise the clear filtrate.

The temperature of the Polarimeter and the Polarimeter tube and the filtrate should be 20.0 ± 0.1 ^{o}C with a visual Polarimeter take four readings and average + 0.01 ^{o}Z.

Calculation:

If a Polarimeter tube of the length specific to the Polarimeter use (generally 200 mm) is employed multiply the Polarimeter reading with the specific factor to obtain sugar in beet (% or ^{o}Z).

Appendix (3)

Brix %

Meade and Chen Method

Reagents and Materials:

1. Lead acetate base
2. Re fractometer

Procedure:

Mix a weighed sample of crushed material (1000 g). Add 200 g distilled water, wait for about 15 minutes and use Brixmeter to read Brix percentage.

Calculation:

$$\text{Brix \% beet} = \frac{\text{Brix extract (2 + 0.01 + moisture \%}}{1 - 0.01 \text{ Brix \% extract}}$$

Appendix (4)

Fiber Content

Determined by AOAC (1984)

Associate of official agricultural chemist

Procedure:

1. Oven
2. Thermometer
3. Filter 325 pore/inch^2

Methodology:

- 20 g of fine beet past was weighted.
- 400 ml of cold water were added for 30 minutes.
- Replicate 3 times for 15 minutes till clean solution obtained.
- 400 ml of hot water (80 ^oC) were added for 15 minutes.
- Dried by using over (110 ^oC) till constant weight obtained

Calculation by :

$$\frac{W2}{W1} \times 100$$

Appendix (5)

Moisture Content

By Hesse (1971)

For this analysis, 5 roots were randomly selected from each plot at harvest. The roots were cut into small pieces and fed into the Jeffco cutter grinder. 50 grams from the ground roots were oven-dried at 105 C^{o} for 5 hours to determine the

Moisture content using the following formula:

$$\text{Moisture content} = \frac{\text{Loss in weight (gm)}}{\text{50 gm}} \times 1000$$

Appendix (6)

Nitrogen content

Determine by kjedahal method

Reagents:

1. Sulpharic Salicylic acid.
2. Sodium triosulphate
3. Sulphate mixture (Potassium Sulphate and ferrous).
4. Sodium hydroxide.
5. Boric acid.
6. Bromocresol + methyl red dissolved in 100ml
7. 95% ethanol.

Procedure:

Transfer a weighed sample of dry material to 800ml Kjeldahl flask. Add 50 ml of the sulphuric salicylic acid mixture and swirl so as to bring the dry sample auickly into in timat contact with reagent. Allow to stand overnight.

Add 5g of Sodium thiosulphate and heat the sulphate mixture gently and digest in Kjeldahl apparatus at full heat. The digestion is continued for one hour after the solution has cleared. When the digestion is complete, cool and adds 300ml of concentrated sodium hydroxide.

Add a large piece of mossyzine. Connect the distillation head, agitate and distil of 150 ml into 50ml of 2% boric acid solution. Add 10 drops of the bronocresol green Methyl red indicator and titrat to the first faint pink point with standard sulphuric acid. Blanks should be run and the titration is carried to same end point.

Calculation:

$$N\% = \frac{S - B \times N \times 14 \times 100}{100 \times \text{weight of plant sample}}$$

Where as:

S= ml H_2SO_4 equivalent to sample titration

B= H_2SO_4 equivalent to the blank titration

N= Normality of the acid.

Appendix (7)

Phosphorus Content

Pearson Method (1970)

Reagents:

1. Ammonium heptamolytdate. Ammonium vanadate in vitric acid.
2. Standard stock solution.

Methodology:

1. Pipette 10 ml of the digest filtrate into a 100 ml volumetric flask, add 10 ml ammonium. Vanadamoly date reagent, and dilute the solution to volume with DI water.
2. Prepare a standard curve as follows:

- Pipette 1, 2, 3, 4 and 5 ml standard stock solution and proceed as for the samples.
- Also make a blank with 10 ml ammonium- vanadomoly date reagent and proceed as for the sample.
- Read the absorbance of the blank, standards and samples after 30 minutes at 410 nm wave length a spectrophoto-meter.

3. Prepare a calibration curve for standards, plotting absorbance against the respective P concentration.
4. Read P concentration in the unknown samples from the calibration curve.

Calculation:

$$\% \text{ P} = \text{ppm P (from calibration curve)} \times \frac{R}{Wt} \times \frac{100}{1000}$$

Where:

R = Ratio between total volume of the digest aliquot and the digs/aliquot volume used for measurement.

Wt = Weight of dry plant (g).

Appendix (8)

Potassium content by

Wilcox Method

Reagent:

Hydrochloric acid (HCI),2 N.

Procedure:

1. Weigh 0.5 – 1.0 g portions of ground plant material in a 30 – 50 porcelain crucibles or Pyrex glass beakers.
2. Place Porcelain crucibles into a cool muffle furnace and increase temperature gradually to 550 ^{o}C.
3. Continue aching for 5 hours after attaining n550 ^{o}C.
4. Shut off the muffle furnace and open the door calitiously for rapid cooling.
5. When cool, take out the Porcelain crucibles carefully.
6. Dissolve the cooled ash in 5 ml portions 2N hydrochloric acid and mix with a plastic rod.
7. After 15 – 20 minutes, make up the volume (50 ml) using distilled water.
8. Mix thoroughly allows to standing for about 30 minutes. Analyze the aliquots by flame photometer.

Appendix (9): Mean squares from analysis of variance showed the effect of nitrogen and phosphorus application on growth, yield, yield components and chemical composition of *Beta vulgarise*

Parameters		Leaf Number			Leaf area index		
Source of variation	DF	6th week	8th week	10th week	6th week	8th week	10th week
Treatments	17	5.9 ns	9.0ns	30.6ns	0.2ns	0.2ns	1.2ns
Block	2	12.2 ns	2.5ns	111.6ns	0.6ns	0.2ns	2.2ns
Error	34	2.8	5.0	19.3	0.3	0.4	1.6
SE ±		0.9	1.3	2.5	0.3	0.4	0.7
CV		0.11	0.1	0.2	0.9	0.4	0.9

Appendix (10):

Parameters		Shoot dry weight			Root dry weight		
Source of variation	DF	6th week	8th week	10th week	6th week	8th week	10th week
Treatments	17	40.8ns	32.3 ns	75.1 ns	0.5 ns	18.0 ns	379.9 ns
Block	2	13.2 ns	45.9 ns	39.0 ns	0.4 ns	23.7 ns	36.0 ns
Error	34	88.5	27.6	128.5	0.3	12.0	110.0
SE ±		3.0	5.4	6.6	0.3	2.0	6.0
CV		0.4	0.4	0.5	0.5	0.5	0.5

Appendix (11):

Source of variation	DF	Root.w/plot/Kg	Root yield/Kg/ha	Pol%	Brix%	Fiber%	Purity%	Moisture%
Treatments	17	0.2 ns	1473964.4 ns	9.9 ns	8.7 ns	4.4 ns	36.8 ns	14.5 ns
Block	2	0.4 ns	2221157.4 ns	35.7 ns	18.9 ns	7.9 ns	202.6 ns	51.4 ns
Error	34	0.2	1142382.8	3.8	3.8	1.0	18.3	11.4
SE ±		0.3	617.0	1.1	1.1	0.6	2.5	1.9
CV		0.4	31.9	0.1	0.1	0.3	0.05	0.04

Appendix (12):

Source of variation	DF	N%	P%	K%	Na%
Treatments	17	0.6 ns	0.03 ns	0.6 ns	28.6 ns
Block	2	1.09 ns	0.12 ns	2.03 ns	32.6 ns
Error	34	0.3	0.02	0.3	24.0
SE ±		0.5	0.09	0.8	2.8
CV		0.2	0.4	0.2	1.2