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ACTION OF POTASSIUM NAPHTHENATE ON THE PHYSIOLOGY AND BIOCHEMISTRY OF SWEETPOTATO

and

THE EFFECTS OF GAMMA RADIATION ON STORAGE BEHAVIOUR OF THEIR TUBERS

by

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A thesis submitted for the Degree of Doctor of Philosophy of the University of Dacca.

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TO WHOM IT MAY CONCERN

This is to certify that Mrs. Shameun Nahar Hossain, W/o. Dr. Md. Mokbul Hossain has submitted a thesis for the degree of Doctor of Philosophy in Plant Physiology and Biochemistry on 10th May, 1982. The title of her thesis is "ACTION OF POTASSIUM NAPHTHENATE ON THE PHYSIOLOGY AND BIOCHEMISTRY OF SWEETPOTATO AND THE EFFECTS OF GAMMA RADIATION ON STORAGE BEHAVIOUR OF THEIR TUBERS". Mrs. Hossain worked on the programme in the Department of Botany, Dacca University starting from September, 1978 to May 1982. During the research programme she was an N.C.S.T. Senior Fellow from August, 1979 to May, 1982.

During the course of the investigation she has obtained serveral original results which will find ready application in the economy of our country(see abstract of the thesis).

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ABSTRACT

Many reports indicate that the application of appropriate concentration of potassium naphthenate(KNap) stimulate physiological and biochemical activities and thus lead to higher crop yield.

The present works were undertaken to study the effects of this chemical on sweetpotato plants. The following aspects were investigated:

Juvenile growth, as measured by number of branch, number and area of leaves; fresh and dry weight of aerial parts; yield parameter as determined by the weight and number of tubers per plant.

The investigation also included the biochemical parameters like chlorophyll a,b carotenoid and total pigment contents of leaves; β-carotene content of tubers of carotene-rich varieties; soluble sugar, starch and protein content of tubers and the nitrate reductase activity of leaves.

Out of four varieties of sweetpotato used in this experiment the carotene-rich Taiwan variety is considered to be the best in yield potential and other yield related parameters.

The results revealed that application of suitable concentration of KNap induced greater growth and yield of sweetpotao plants. Though the cumulative effects of this chemical ultimately led to increase in yield, the magnitude of response differed with different treatments.

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Results showed that 1000 ppm KNap stimulated maximum parameters in all the four varieties. This treatment was considered to be the best of all treatments. When considered the stimulation of different parameters in one particular variety, the responses due to 1000 ppm treatment in the Taiwan were maximum. In this regard the second best combination was the Okinawa in association with the said treatment.

Few probable explanations were provided for the physiological and biochemical basis of stimulation of growth and yield following potassium naphthenate treatments. The KNap stimulated the rate of vegetative growth which produced larger amount of photosynthate. This could be utilized in the biosynthesis of all cell constituents and serve as substrate for respiration and other chemical processes. The KNap possibly brought about changes in the levels of endogenous growth regulators present in plants which could enhance the mechanism responsible for mobilization of photoassimilates from the leaves to the storage regions. The chemical used probably stimulated the respiratory enzymes which resulted in an increased supply of available energy as ATP and reduced nucleotides for various biosynthetic activities. The increased supply of amino acids resulting from the greater activity of nitrate-reductase would be favourable for enhanced synthesis of protein evident for stimulated growth.

The second aspect studied during the investigation was the effects of gamma radiation on the storage behaviour of the tubers of sweetpotato. As regards physical changes, 9 kr treatment

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completely inhibited the sprout initiation in the Local and in the Taiwan varieties. It was observed that the cases of rot incidence were found in all varieties of sweetpotato. The tubers discarded due to rot were slightly lower in case of treated tubers.

So far as the biochemical changes are concerned, the soluble sugar content was found to increase in the control tubers of all varieties at the end of the storage period whereas in the irradiated tubers this content increased very slightly during the whole period of the experiment.

The results revealed that with the progress of the experiment the starch content registered a slight fall in the control tubers, whereas this showed a tendency to remain constant in irradiated tubers throughout the experiment. In 9 kr tubers no change in the amount of starch was observed in all the four varieties.

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I. INTRODUCTION

Sweet potato (Ipomoea batatas L) is a member of the Convolvulaceae. It is an important crop of many tropical and subtropical countries.

In Japan sweetpotato is the second biggest crop (Rashid M,1976). Its tubers are used in a variety of ways. The roots are quite palatable and do not require special process of cooking. They contain 1.6-2% protein, 25-30% carbohydrate (starch and sugar) and 0,7% fat on fresh weight basis (Adab News 1978).

The crop is well suited for cultivation in Bangladesh because of several beneficial characteristics. The production cost of this crop is low and it does well under conditions of limited input and yet a modestly high quantity of harvest assures the grower of a reasonable economic return. The vines of this crop can be grown all the year round so that cuttings are always available at planting (Adab News 1978). In the conditions of Bangladesh one acre under sweetpotato provides more than three times the calories and about twice the amount of protein compared to what one obtains in an acre of rice. In disaster-prone Bangladesh it has an additional role to play as famine reserve and disaster revovery crop (Brammer, H.1977).

Several works on different aspects of sweetpotato have been reported by different authors. Bouwkamp and his co-worker (1972) reported that root pieces application for production of the crop appeared more adaptable to mechanisation than production

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from sprouts. Comparative studies on growth and yield of five exotic varieties of sweetpotato indicate that TI B-8 variety was found to be superior in yield characteristics compared to other varieties (Progress report, BVRDC 1975-77). Similarly yield trials with different AVRDC varieties for selection of better genetic stock was made. The S-243-2 variety was found to be promising (Adab News, 1978). A study on the usefulness of sweetpotato leaf tips as vegetables was made by Villareal et al (1979). They also evaluated the yield and nutritive quality of several varieties of sweetpotato (Villareal et al 1979).

There are several methods which help increase the crop production, namely selection of varieties with characters such as high yielding capacity, resistance to pests, fungal, baterial and viral diseases and resistance to other problems like lodging, mechanical cultivation, proper use of fertilizers and the use of growth regulating substances. Out of all the different methods mentioned here use of growth stimulating chemicals is rather recent.

A number of organic chemicals either of plant origin or synthetic ones have been used for better growth and development of different types of plants and specially to increase higher grain yield.

The use of naphthenic acid, an organic acid of petroleum origin and its salts is rather recent and have been utilised primarily by Russian and Bulgarian workers (Guseinov et al 1956, Huseinov 1960, Zhukova 1965, Popoff and Boikov 1966) and very

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recently by a few others (Wort 1969, Fattah and Karmakar 1975, Fattah and Hossain 1976). It is an inexpensive growth regulating chemical. In appropriate concentrations naphthenic compounds have been found to promote vegetative growth and yield and to affect physiological and biochemical activities of a number of plants like bush bean, maize, tomato, millet etc. (Fattah and wort 1970 b, Bano 1978, Guseinov et al 1956, Huseinov 1960, Gvozdenko 1967, Hussain 1973, Rahman 1981).

The Local variety of sweetpotao is both low yielding and lacking in certain biochemical nutritional parameters i.e. β-carotene (M.C.C. Report 1979). During the present investigation four varieties of sweetpotato have been used. The local variety lacking in Vitamin A content has a comparatively low yielding ability. The American 2 and Okinawa varieties used in the experiment are exotic varieties with high yielding habit. Of the two varieties the okinawa is rich in β-carotene content (M.C.C. Report 1979). The fourth variety which is also an exotic one used in the experiment was from Taiwan. This variety is both high yielding and rich in β-carotene content (Personal communication to I.V.S. Dacca).

So far no work has been done on the effect of potassium naphthenate on growth and yield of sweetpotato. The objective of the present investigation is an attempt to increase the yield of both local and exotic varieties of sweetpotato using the growth regulating chemical, KNap. As yield parameter is dependant upon various physiological and biochemical parameters, it was

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necessary to study physiological and biochemical parameters in relation to yield. In addition to this, investigation was made to screen out the better varieties of sweetpotato with specific concentration of KNap treatment.

The objective of the other aspect of investigation was to study the effect of gamma radiation on the storage quality of sweetpotato.

Two thirds of the world population are inadequately fed and yet about 2000 millions tons of food are lost each year as a result of poor storage and distribution (Olorunda and Aboba 1977). Most of these losses occur in many of the developing countries located in the tropical zones of the world where the prevailing climatic conditions are such that ambient temperature and relative humidity remain high for most of the months in a year. Coupled with that there is an incidence of pests and ses making these food commodities very prone to spoilage by microbial and physiological factors (Olorunda and Aboba 1977)

Radiation has proved to be a potent tool for the extension of the self life of certain fruits and vegetables. Many investigators have established the possibility of controlling sprouting potatoes, onions and garlics by radiation and proved the superiority of this technique (Khan and Wahid 1978).

Extensive research has been carried out in several international laboratories to establish the wholesomeness of irradiated foods (Diehl, 1971). The third joint FAO/IAEA/WHO

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expert committee on the wholesomeness of irradiated food held in August/September 1976 in Geneva was able to recommend on the basis of all available data the unconditional acceptance as wholesome of irradiated potatoes, wheat, chicken, papaya and strawberries. It also gave provisional approval for irradiated rice, fish and onions (Elias 1976). A number of countries have given approval for the radiation; preservation of foods based on the wholesomeness and consumer acceptability of the irradiated and feasibility of this technology (IAEA report 1978).

Sweetpotato has its peculiarity in that it has practically no dormant period. It is seen that the newly harvested crop when subjected to suitable temperature and humidity starts forming sprouts. This being so, it is much too difficult to preserve the crop for a longer period. This is the reason why a promising crop like sweetpotato has not been accepted as an important crop in our country.

During the present investigation the following aspects were taken into consideration :

- Physiological Parameters:

Vegetative growth as measured by branch number, leaf number, leaf area, fresh and dry weight of aerial part. Yield parameters as determined by weight and number of tubers per plant.

- Biochemical parameters:

Chlorophyll a,b, carotenoid and total pigment contents of leaves. β-carotene content of tubers of carotene-rich varieties. Soluble sugar, starch and protein content of tubers. Besides these, the nitrate reductase activity of leaves was also studied.

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- Physical and biochemical parameters of control and irradiated tubers:

Rate of sprout initiation, weight loss and rot incidence. Soluble sugar and starch content.

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II. MATERIALS AND METHODS

1. Plant materials.

Four varieties of sweetpotato, the local, the American 2, the Okinawa and the Taiwan were used for experiments conducted at different times. The local variety was obtained from the local grower of Tansutrapur near Kaliakoir, Dacca. The American 2 and the Okinawa varieties were obtained from Bangladesh Agricultural Research Institute, Joydevpur, Dacca. The Taiwan variety was supplied by the International Voluntary Service, Dacca, Bangladesh.

The local and American 2 varieties contain whiteflesh while the two others are carotene-rich yellow fleshed varieties.

2. Cultural Practice.

During the present investigation the above-mentioned four varieties of sweetpotato were used. The experiment was conducted in an open plot situated in the vicinity of Registrar's Building of Dacca University.

2.1 Experimental field.

The plants were cultivated in a field with split-plot design. The area of the plot was measured to be 361 sq M and the distances between row to row and plant to plant were 0.4 M and 0.4 M respectively.

2.2 Fertilizer application.

During the experiment maximum effort was made to ensure equal distribution of soil nutrients in the experimental field.

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Cowdung and three types of synthetic fertilizers, Nitrogen, phosphorus, and potassium were applied in the form of Urea, Triple superphosphate and Murate of potash respectively. Sources and amount of NPK used were given below.

Urea	:	16.8 kg/acre
T.S.P.	:	37.2 kg/acre
M.P.	:	30.0 kg/acre

2.3 Preparation of the experimental field.

The experimental field was ploughed as deeply as possible. The field was ploughed three times with power tiller and with spade to ensure proper mixing of fertilizer all over the experimental field.

Sweetpotato cuttings measuring 12 inches with three nodes were planted in the experimental field on ridge and furrow system. The p H of the soil was measured and the value ranged between 5.6 to 7.0.

3. Growth regulator.

Potassium salt of naphthenic acid (KNap) was used for this experiment. KNap was used as parts per million solution (ppm).

3.1 Preparation of potassium naphthenate.

Naphthenic acid was used in the form of Naphthenic acid (practical) whose molecular weight was stated to be 230. The acid was converted to potassium naphthenate (KNap) by adding potassium hydroxide solution. The p H value of the KNap solution was adjusted to 10 by adding dilute Hcl.

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4. Treatment procedure.

During the experiment foliar spray method was applied. The procedure was as follows.

Foliar spray was applied to plants when theyaged forty days, the time when the preliminary leaves were expanded and the plants started forming branches.

5. Measurement times.

Measurement of juvenile growth and biochemical parameters were taken at an interval of 30 days (excepting in the case of branch number and leaf number where the measurement intervals were 15 days) begining from the date of treatment upto harvesting period.

6. Observation and determination.

The following observations and determinations were made during the present study.

6.1 Physiological parameters.

6.1.1. Number of branch :

Number of branch was counted at an interval of 15 days begining from the date when foliar application of KNap was used to the experimental plants (Average of 10 plants). The counting of the number of branch continued upto sixty days.

6.1.2 Number of leaf.

Number of leaf was counted at an interval of 15 days (Average of 10 plants) and these observations continued upto sixty days.

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6.1.3. Leaf area.

All the leaves of the fourth branch (counted from the base of the plant to upward direction) were taken for the determination of leaf area. Leaf area was measured by indirect method. For preparing the results an average of 10 plants were taken.

6.1.4. Fresh weight of aerial parts.

Fresh weight of aerial parts of plants were taken separately at an interval of 30 days begining from the date of treatment upto harvest of the crop. Weight was measured in gram.

6.1.5. Dry weight of aerial parts.

After recording fresh weight, the plant parts were dried in a drying oven at 70°c for 96 hours, (for obtaining a constant dry weight), at the end of which the dry weight was noted. Weight was measured in gram.

6.1.6. Yield.

For determinations of yield, effects of varieties, effects of different concentrations of KNap treatment and interactions of varieties and treatments were analysed statistically. The data were obtained from plants cultivated in a field with split-plot design (Steel and Torrie 1960). For showing the results of the yeild of sweetpotato the tuber weight per plant was converted into tons/acre.

6.2. Biochemical parameters.

6.2.1. Quantitative determination of leaf pigments (chlorophyll a,b and carotenoid content).

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Chlorophyll a, chlorophyll b and carotenoid pigment content of leaves were determined for each treatment at four stages of growth and development. The analysis of pigments were determined spectrophotometrically.

Leaf material was cut into pieces and mixed thouroughly. When plant material was chopped small amount of sodium carbonate ($Na_2 Co_3$) was added to prevent degradation of pigment. One gram of leaf material was blended with 60 ml of 80% acetone in a waring blender for three minutes. The homogenate was filtered through Whatman number 1 filter paper and was made upto 100 ml with acetone. The optical density (O.D) for each solution was measured at 663, 645 and 440.5 m μ against 80% acetone as blank.

The amount of chlorophyll a and b were determined by using specific absorption co-efficient of Mckinney (1940) and the formulae of Maclachalan and Zalik (1963). The formulae used were as follows:

$$Ca = \frac{(12.3\ D\ 663 - 0.86\ D\ 645)V}{d \times 1000 \times W}$$

$$Cb = \frac{(19,3\ D\ 645 - 3.6\ D\ 663)\ V}{d \times 100 \times W}$$

Where

C = Concentration in mg/g weight (fresh)

a = Chlorophyll a

b = Chlorophyll b

D = OD at wave-length indicated

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V = Final volume of extract

W = Fresh weight of leaf material used

d = Length of light path in cm.

The amount of carotenoids were determined by the equation of Von Wettstien (1957).

$$Cc = 4.695\ D_{440.5} - 0.268\ C\ (a+b)$$

Where :

C = Concentration of chlorophylls in mg/l.

The carotenoid content was then converted to mg/g fresh leaf.

6.2.2. B -carotene content of tuber .

β-carotene content of tuber was determined by the following method (Fattah and Khan 1977).

2 g of the sample was mashed in small glass mortar, washed with 2 ml ethanol and 3 ml petroleum ether in 15 ml glass stoppered centrifuge tube. Mixed in high speed vortex mixture for 5 minutes after addition of 0.1 g Magnesium carbonate. This was then centrifuged at 3000 rpm for 5 minutes. The supernatant aliquot was transferred in another tube, residue was again resuspended with 2 ml ethanol and 2 ml petroleum ether, mixed and centrifuged. The two extracts were combined and ethyl alcohol was washed out five times each with 20 ml of distilled water. Then the petroleum ether extract was treated with 0.1 g tri-calcium phosphate and 0.1 g of Aluminium oxide and centrifuged.

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I ml supernatant was transferred in a microcell of light path 10 mm. Optical density was measured at 450 mμ in Unicam-Sp Spectrophotometer for β-carotene against petroleum ether blank. A standard curve was prepared by dissolving 0.2, 0.4, 0.6, 0.8, 1.0 and 2.0 μg β-carotene/ml. Result was directly obtained from the standard curve and final concentration was calculated by multiplying the result with

$$\frac{5 \times 100}{2} = \mu g/100 \text{ g}$$

6.2.3. Soluble sugar content of tuber.

Total sugars were determined by phenol-sulphuric acid method of Dubois et al (1956). 3 gms of fresh material of sweetpotato tubers were mashed in a morter and then transferred in a beaker with 50 ml cold distilled water and was stirred for an hour. Transferred to a filter paper and washed with 250 ml of cold distilled water. 1 ml of the solution was pipetted into a test tube followed by the addition of 4% solution of phenol in water (1 ml). Concentrated H_2SO_4 (5 ml) was then added rapidly, the stream of acid being directed against the liquid surface in order to obtain good mixing. After standing 30 minutes, the optical density of the solution was read in a Unicam sp 500 spectrophotometer at 490 mμ against a blank. The sugar concentrations were then calculated by reference to a standard curve for known solutions of glucose.

6.2.4. Starch content of the tuber.

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Estimation of starch by acid hydrolysis of the plant material was carried out (AOAC 1960). 3 gms of fresh material of sweetpotato tuber was mashed in a morter and stirred in a beaker with 50 ml of cold distilled water for an hour. This was transferred to a filter and washed with 250 ml of cold distilled water. Refluxed the insoluble residue for two and half hours with 250 ml of water and 20 ml of concentrated Hcl in a heating mantle; cooled and neutralized with 12N NaOH and filtered. The filtrate was then diluted to a standard volume (1 litre). 1 ml of the solution was pipetted into a test tube followed by the addition of 4% solution of phenol in water (1 ml). Concentrated H_2SO_4 (5 ml) was then added rapidly, the stream of acid being directed against the liquid surface in order to obtain good mixing. After standing for 30 minutes, the optical density of the solution was read in a Unicam sp 500 spectrophotometer at 490 m μ against a blank. The sugar concentration were then calculated by reference to a standard curve for known solution of glucose.

Starch content was determined by the following method.

Starch = dextrose x 0.9.

6.2.5. Quantitative determination of tuber protein.

The method of Lowry et al (1951) was employed to determine the protein content of fresh tuber.

The water soluble tuber protein was extracted by blending one gm of codrsely chopped tissue of tuber with distilled water

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in a morter and pestle. The homogenate was rapidly strained through four layers of cheese cloth and was used for protein assay.

To 0.2 ml of protein preparation, 2 ml of alkaline copper solution (prepared by mixing 50 ml of 2% Na_2Co_3 in 0.1N NaOH and 1 ml of 0.5% $CuSo_4$, $5H_2O$ in 1% sodium potassium tartarate) was added and the contents were mixed. After 10 minutes 0.2 ml of folin reagent was added. The optical density (530 mμ) of each experimental solution and its blank (all reagents except protein solution which was taken under determination) was measured. Protein content was determined by comparison with a standard curve prepared from O.D measurements of solutions with known amounts of bovine albumin. The values were expressed as mg protein per gram of the tuber.

6.2.6. Enzyme extraction and assay.

Preparation of extract : Crude enzyme extract was prepared by grinding 5 g of finely chopped fresh leaf material with 25 ml of cold 0.1M phosphate buffer, pH 8, containing 10-3M reduced glutathione, in a waring blender, for 2 to 3 minutes, at $4^{o}c$. The homogenate was rapidly strained through four layers of cheesecloth and was centrifuged for 20 minutes at $4^{o}c$ and the resulting supernatant solution was used for the assay of the activity.

Procedure : The activity of nitrate reductase was measured by the procedure of Evans and Nason (1953) as modified by Yang

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by Yang (1964). At Zero time 0.2 ml of the enzyme preparation was added to a reaction mixture containing 0.1 ml of 0,IM KNo_3, 0,05 ml of $2x10^{-5}$M FAD,0,05 ml of $2x10^{-3}$M $NADH_2$ and 0,IM phosphate buffer, PH 7,0 to give a total volume of 0.5 ml. The resulting mixture was incubated for 30 minutes in a constant temperature water bath at 30°c. The reaction was stopped by the addition of 1 ml of distilled water and 1 ml of 1% (W/V) sulfanilamide reagent. One ml of 0.22% (W/V) N.(napthyl) ethylene diamine hydrochloride reagent was added and the contents were mixed by inverting the test tube. The colour was allowed to develop for 15 minutes. By using an Unicam spectrophotometer the O.D. of each experimental solution and its blank (complete except for $NADH_2$) was measured at 540 mM . The amount of nitrite formed was determined from a standard curve prepared from O.D. measurements of known quantities of nitrite.

The specific activity was defined as mM moles of nitrite formed per mg protein in the enzyme extract per hour. Estimation of protein in enzyme extracts was carried out by the procedure of Lowry et al (1951).

6.3. Effect of radiation on the storage quality of sweetpotato:

In the second experimental set up gamma radiation effects on storage behaviour of sweetpotato were studied.

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The tubers of different varieties of sweetpotato were collected twenty days after harvest. The tubers were analysed for rot and only healthy ones were selected for the investigation.

For each variety of sweetpotato the tubers were divided into three lots of 75 tubers in each. The tubers were serially numbered and weighed. Out of 3 lots of 75 tubers, two lots were subjected to doses of radiation of 7 and 9 kr with a ^{60}Co gamma nominal 50,000 Curie Source (Model GB 650,A.E.Canada Ltd.) at a dose rate of 19 kr/hour and the remaining lot was kept as control. Soon after radiation treatment these tubers were kept in a wooden rack in a semiventilated room at an average temperature of 84°F (70-92°F) and an average humidity of 86% (58-98 R.H.). Then their physical and biochemical changes were recorded over a period of 75 days. The tubers of each treatment were divided into three groups. One group was kept for the observation of initiation of sprouting, the other was kept for the observation of rot incidence and the rest group was kept for the observation of weight loss and biochamical studies.

6.3.1. Physical observations :

6.3.1.1.Sprouting.

The sprouting of tubers were counted at an interval of 15 days begining from the date of radiation treatment and the experiment was conducted for 75 days.

6.3.1.2. Weight loss.

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During the investigation loss of weight of control and irradiated tubers were initially recorded at an interval of 15 days and afterwards at an interval of 30 days following radiation treatment. The experiment was conducted for 75 days.

6.3.1.3. Rot incidence.

Rot incidence of the tubers were observed at an interval of 15 days following radiation treatment.

6.3.2. Biochemical measurements:

Soluble sugar and starch content were measured following radiation treatment. The procedures for their measurements have been mentioned earlier.

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III RESULTS

During the present experimental work different concentrations of Potassium naphthenate were used as foliar spray. To avoid repeatation of writing 0 ppm (control), 1000 ppm, 2500 ppm and 4000 ppm, the symbols T_0, T_1, T_2 and T_3 respectively have been used in the following texts, tables and figures.

The values obtained as a result of KNap treatment are expressed as percentages of corresponding control plant values in the following texts and figures. In the text plant age will be considered from the date when the foliar application of KNap has been made.

1. Physiological parameters.

1.1. Effect of different concentrations of KNap on number of branch.

1.1.1. Local (Table 1, Fig 1)

Results obtained at 30 days showed that the branch number remained unaffected following the three different treatments. At the age of 60 days the T_2 decreased the branch number significantly. The decrease was 18%.

1.1.2. American 2 (Table 1, fig 1)

At the age of 30 days the number of branch increased significantly. The increases were 9,12 and 8% following T_1, T_2, and T_3 respectively. Observations made on 60 days showed that the number of branch increased non significantly. The increases

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were 20, 12 and 12% following T_1, T_2, and T_3 application of KNap treatments respectively.

1.1.3. Okinawa (Table 1, fig 1)

Observations made on 30 days indicated that the number of branch increased non significantly following three different treatments. During the final observations made on 60 days, significant increases in number of branches were recorded for T_1, T_2 and T_3 treatments of KNap. The increases were 14. 5, 14.5 and 12.5% following T_1, T_2 and T_3 respectively.

1.1.4. Taiwan (Table 1, fig 1)

In this variety the KNap treatment showed a very little effect on the number of branch. Results recorded at the age of 60 days showed that there were non significant increases in the number of branches following T_1 and T_2 treatments and the increases were 5 and 2%.

1.2. Effect of different concentrations of KNap on number of leaf.

1.2.1. Local (Table 1, fig 2)

Observations made on 30 days indicated that the number of leaf increased significantly following T_1. The increase was 5.5%. Observations made on 60 days showed that there were non significant increases in the number of leaf. The increases recorded were 13 and 12% following T_1 and T_2 treatments respectively.

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Table I. Effect of different concentrations of KNap on the number of branch and leaf of four varieties of sweetpotato.[1]

Variety	Treatment	Time in days							
		15		30		45		60	
		Branch	Leaf	Branch	Leaf	Branch	Leaf	Branch	Leaf
Local	T_0	11,9	63,6	15,1	87,3	19,4	106,2	24,6	119,9
	T_1	11,7	64,9	14,7	91,9**	18,1	109,3	25,7	135,9
	T_2	11,8	57,3	14,6	84,6*	16,8	110,6	20,1**	134,2
	T_3	12,8	54,5	15,4	71,6**	16,4	93,3	23,7	115,2
American 2	T_0	14,9	72,9	18,1	98,3	21,9	128,0	25,2	153,1
	T_1	14,9	79,1	19,8*	107,9**	24,1	149,4	30,4	176,1**
	T_2	16,7	77,4	20,3**	104,2**	23,7	123,8	28,3	154,1
	T_3	15,6	67,2	19,7*	97,6	23,0	106,5	28,2	144,8**
Okinawa	T_0	4,9	65,5	6,9	85,5	8,2	96,6	10,3	112,7
	T_1	5,6	61,7	7,9	88,6	9,5	111,8	11,8*	137,1**
	T_2	5,3	53,7	7,5	80,8	9,5	107,9	11,8*	128,4*
	T_3	5,5	47,0	7,5	73,6*	9,6	97,4	11,6*	113,5
Taiwan	T_0	6,6	39,3	8,4	51,2	10,0	64,3	11,7	98,5
	T_1	6,8	44,7	8,9	65,9**	10,5	85,1	12,3	121,4**
	T_2	6,4	48,9	8,5	75,2**	10,2	89,8	11,9	108,8**
	T_3	5,7	47,6	7,8	71,5**	9,5	88,8	11,6	111,1*

1. Average of 10 replicates.

** Significant at 1% level.

* Significant at 5% level.

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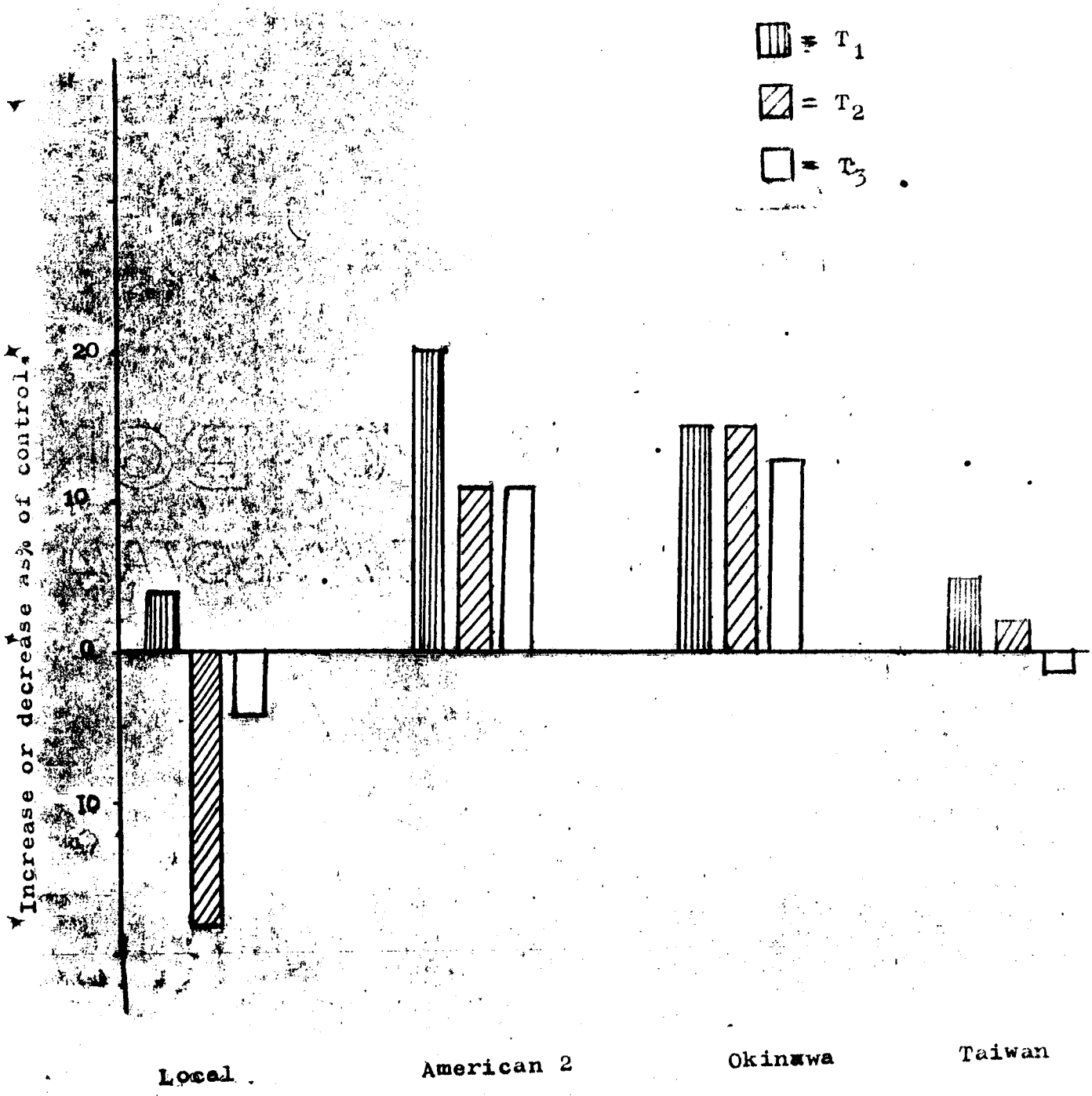
Fig 1 : Effect of different concentrations of KNap on the number of branch of four varieties of sweetpotato. Results were obtained harvest time.



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1.2.2. American 2 (Table 1, fig 2)

Data presented in the table 1 indicated that at 30 days the leaf number increased significantly following T_1 and T_2 treatments. The increases were 9,5 and 6% following T_1 and T_2 treatments respectively. During the final observations made on 60 days the increases were 15 and 1% following T_1 and T_2 treatments. At this stage the T_1 increased the leaf number significantly, where as T_2 increased the same nonsignificantly.

1.2.3. Okinawa (Table 1, fig 2)

Results obtained at 30 days indicated that T_1 increased the number of leaf nonsignificantly whereas at 60 days, both T_1 and T_2 increased the same significantly. The increases at the final observations were 21 and 13% following T_1 and T_2.

1.2.4. Taiwan (Table 1, fig 2)

Following all the three different concentrations of KNap application the number of leaf increased at 30 and 60 days of the experiment significantly. The increases at the age of 60 days were 23,10 and 13% following T_1, T_2 and T_3 treatments respectively.

1.3. Effect of different concentrations of KNap on leaf area.

Leaf area were measured at harvest time, the time when plants attained 120 days after the foliar application of KNap.

1.3.1. Local (Table II, fig 3)

The leaf area increased significantly following T_1 treatment

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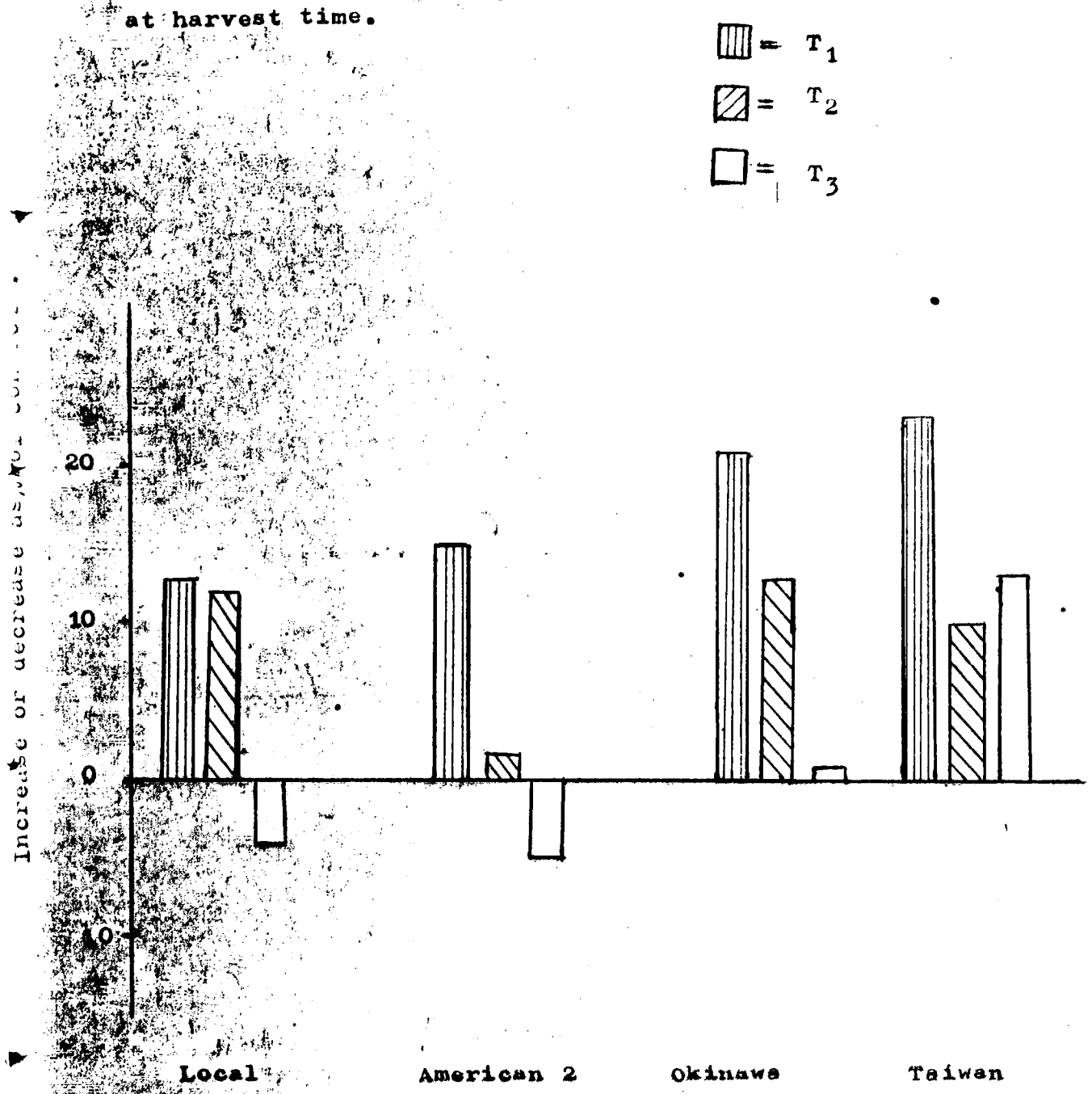
Fig 2 : Effect of different concentrations of KNap on the number of leaf of four varieties of sweetpotato . Results were obtained at harvest time.



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The increase was 19.5 following the treatment. A nonsignificant increase of 3.5% was obtained following T_3 treatment of KNap.

1.3.2. American 2 (Table II, fig 3)

In this variety of sweetpotato all the three treatments increased the leaf area significantly. The increases were 19.5, 18.5 and 7% following T_1, T_2 and T_3 respectively.

1.3.3. Okinawa (Table II, fig 3).

Results recorded for leaf area in this variety showed that all the three different concentrations of KNap increased the leaf area significantly. The increases were 8.5, 12.5 and 10.5% following T_1 , T_2 and T_3 treatments respectively.

1.3.4. Taiwan (Table II, fig 3)

In this variety too, the leaf area was found to be increased significantly following three treatments. In this case the leaf area increases were 13, 12 and 10,5% following T_1, T_2 and T_3 treatments respectively.

1.4. Effect of different concentrations of KNap on fresh weight of aerial part.

1.4.1. Local (Table III, fig 4).

The fresh weight of aerial part increased significantly at 30 days following T_1 treatments. Observations made at 120 days

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Table II : Effect of different concentrations of KNap on Leaf area [1] of four varieties of sweetpotato.[2]

Treatment	Variety			
	Local	American 2	Okinawa	Taiwan
T_0	58,3	55,2	120,5	77,9
T_1	69,7**	66,1*	130,8*	88,6**
T_2	57,5	65,6*	135,8**	87,3**
T_3	60,3	62,1*	133,5**	86,5*

1. Leaf area in cm^2
2. Average of 10 replicates.

** Significant at 1% level.

* Significant at 5% level.

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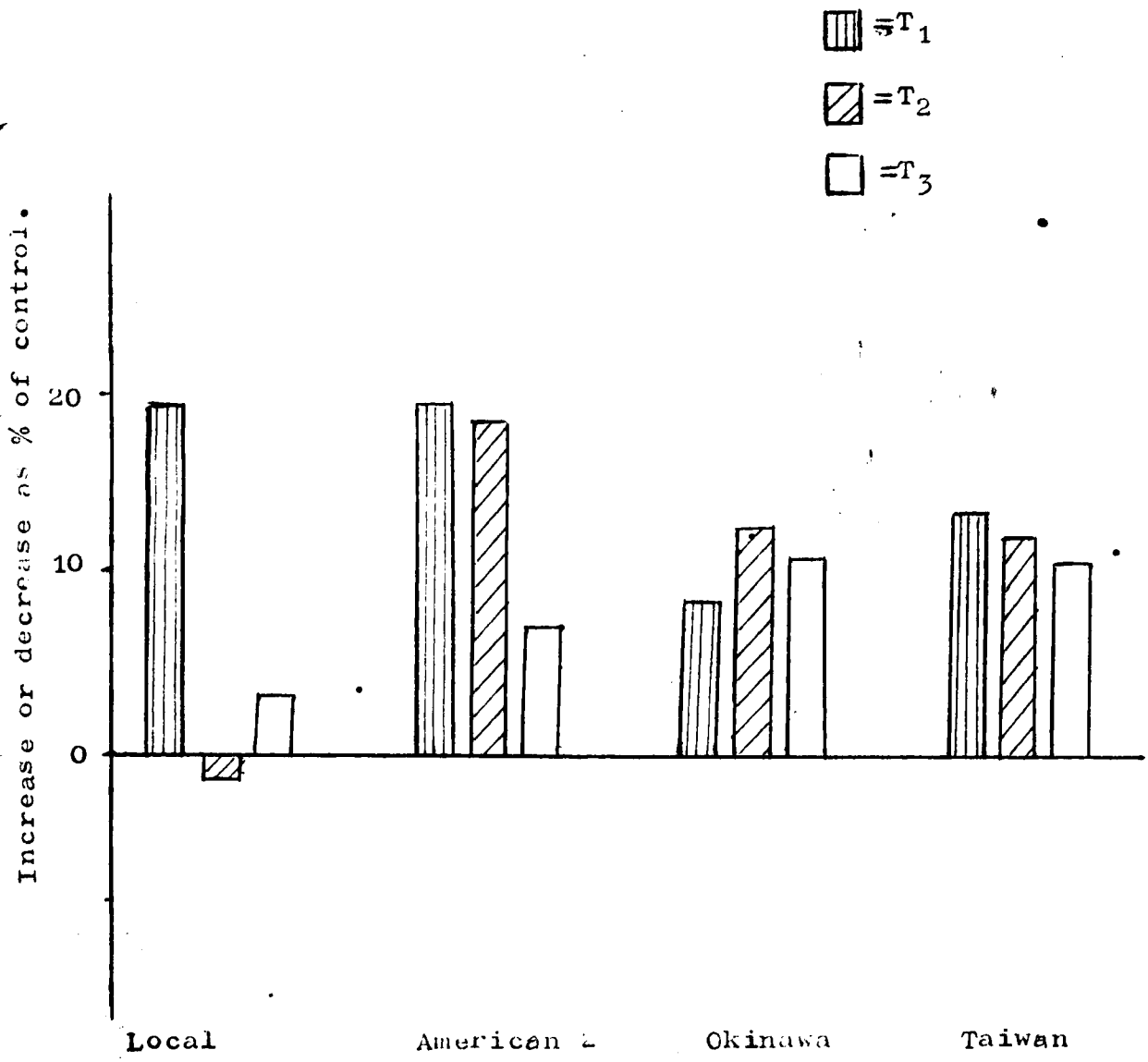
Fig 3 : Effect of different concentrations of KNap on the leaf area of four varieties of sweetpotato. Results were obtained at harvest time .



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indicated that the fresh weight increases were significant following T_1 and nonsignificant following T_2 and T_3 KNap treatments. At this stage the increases were 10, 3 and 3% following T_1, T_2 and T_3 treatments respectively.

1.4.2. American 2 (Table III, fig 4).

Results obtained at 30 days indicated that the fresh weight was increased significantly following T_1 and T_2 treatments. The increases were 25 and 12% following T_1 and T_2 treatments respectively. At this stage there was a significant decrease of of 9% following T_3 treatments. Observations made at 120 days showed that the T_1 and T_2 increased significantly the fresh weight of aerial part. The increases were 16 and 11% following T_1 and T_2 treatments.

1.4.3. Okinawa (Table III, fig 4).

Fresh weight of this variety decreased significantly at the age of 30 and 60 days. However, at the age of 60 days the T_1 treatment increased nonsignificantly this parameter. Estimations made at 120 days showed that T_1 and T_2 treatments increased fresh weight of this variety significantly. The increases were 6 and 16% respectively.

1.4.4. Taiwan (Table III, fig 4).

All the different treatments used in this experiment increased the fresh weight of aerial parts of Taiwan variety of

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Table III : Effect of different concentrations of KNap on the fresh weight[1] of aerial part of four varieties of sweetpotato[2]

Variety	Treatment	Time in days			
		30	60	90	120
Local	T_0	134	220	290	293
	T_1	156**	221	274	325**
	T_2	106**	223	277	302
	T_3	116**	196	224**	302
American 2	T_0	106	241	301	319
	T_1	132**	259*	310**	371**
	T_2	119**	221**	287**	356*
	T_3	96**	256*	273**	302
Okinawa	T_0	150	297	372	408
	T_1	135**	305	371	433**
	T_2	135**	254**	344	476**
	T_3	126**	222**	317	404
Taiwan	T_0	71	244	275	300
	T_1	92**	179**	280	342**
	T_2	102**	224**	331**	380**
	T_3	102**	253*	323**	365**

1. Weight in gm.
2. Average of 10 replicates.
** Significant at 1% level.
* Significant at 5% level.

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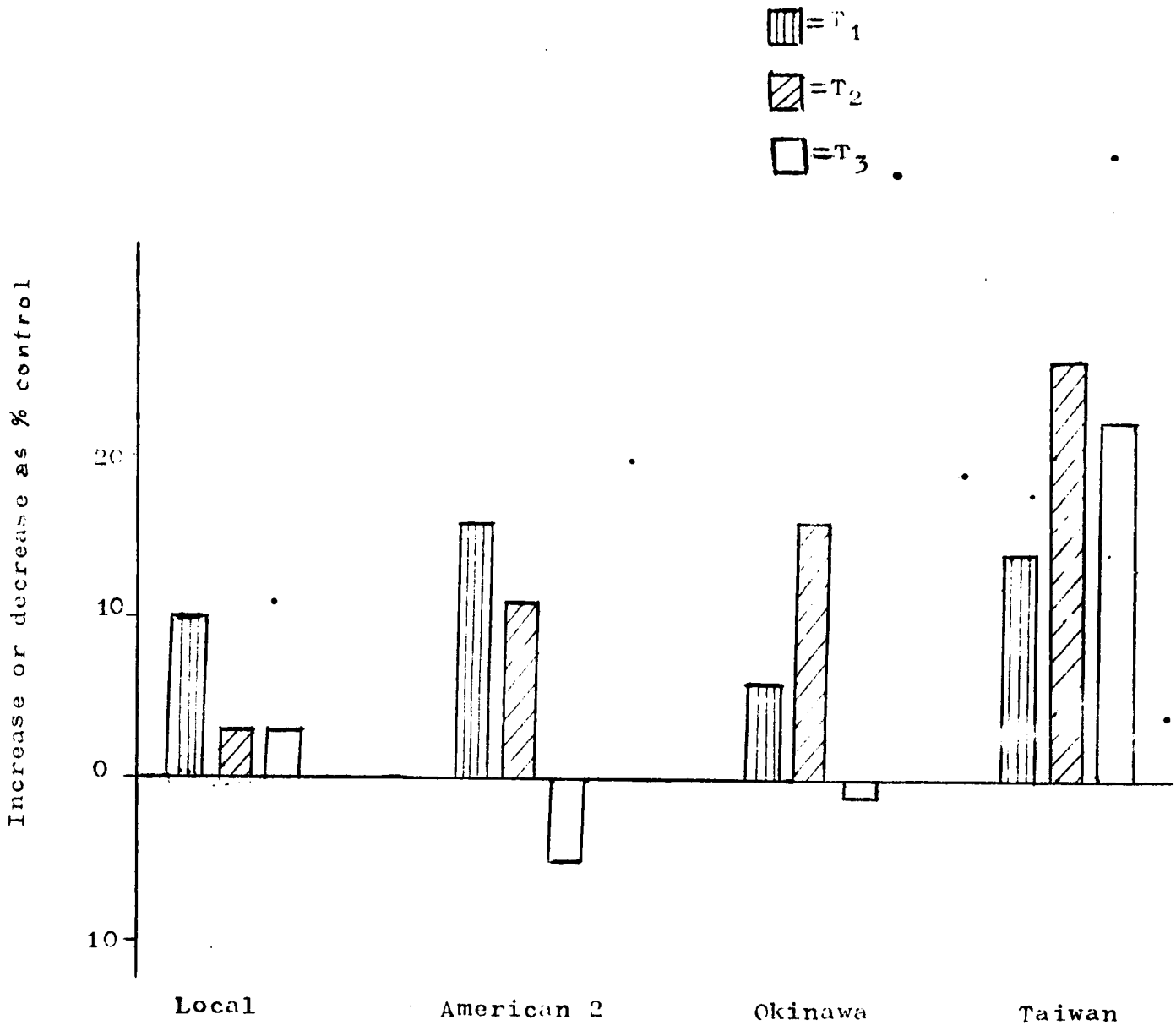
Fig 4 : Effect of different concentrations of KNap on the frosh weight of aerial part of four varieties of sweetpotato. Results were obtained at harvest time .



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sweetpotato. Observations made at 120 days of experiment indicated that the different treatments increased significantly the fresh weight of this variety. The increases were 14,26 and 22% followed by T_1, T_2 and T_3 treatments respectively.

1.5. Effect of different concentrations of KNap on dry weight of aerial part.

1.5.1. Local (Table IV, fig 5).

Data presented in table IV and fig 5 showed that at 120 days the dry weight of aerial part ofthis variety was increased significantly following T_1 and T_2 and nonsignificantly following T_3 treatments. The increases were 36, 12 and 6% following T_1, T_2 and T_3 treatments respectively.

1.5.2. American 2 (Table IV, fig 5).

Dry weight of American 2 varieties of sweetpotato was increased following T_1 and T_2 treatments when observations made at 30 days. The increases were 48 and 45% following T_1 and T_2 treatments. Observations made at 60 days showed that the T_2 treatments decreased the dry weight of aerial part of this variety significantly. Dry weight increases recorded at the age of 120 days was significant following T_1 treatment while the T_2 increased the same nonsignificantly. The increases were 20 and 5% following T_1 and T_2 KNap treatments respectively.

1.5.3. Okinawa (Table IV, fig 5).

Observations made on 30 days after the foliar application of KNap showed that at this stage T_2 and T_3 slightly decreased

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Table IV : Effect of different concentrations of KNap on dry weight[1] of aerial part of four varieties of sweetpotato.[2]

Variety	Treatment	Time in days			
		30	60	90	120
Local	T_0	26,3	37,3	66,9	56,2
	T_1	35,3	52,3**	59,0	77,0**
	T_2	21,7	39,4	53,2	63,1*
	T_3	21,5	29,5**	43,4	59,8
American 2	T_0	19,8	37,4	57,3	61,4
	T_1	29,5	46,6**	60,9	74,2**
	T_2	28,8	30,7**	51,0	64,3
	T_3	19,6	42,4**	53,9	58,5
Okinawa	T_0	27,4	56,5	66,9	73,5
	T_1	27,4	57,3	62,6	75,7
	T_2	23,5	51,4**	60,8	96,2**
	T_3	22,4	37,4**	55,0	68,6**
Taiwan	T_0	12,8	41,6	46,0	50,5
	T_1	16,0	29,6**	47,5	56,9**
	T_2	17,8	37,4**	57,2	63,7**
	T_3	18,8	43,3	59,6	64,9**

1. Weight in gm.
2. Average of 10 replicates.

** Significant at 1% level.
* Significant at 5% level.

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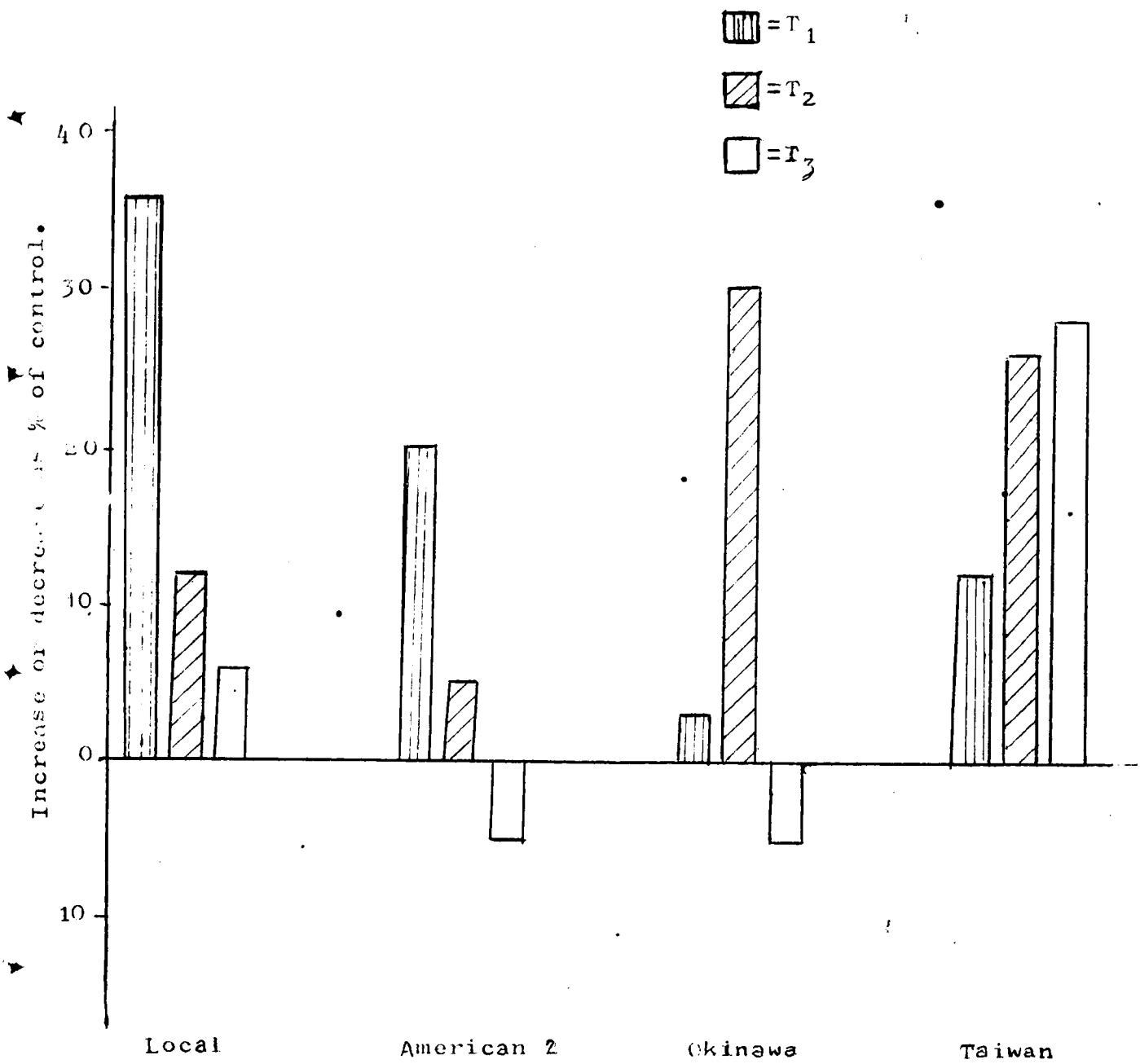
Fig 5 : Effect of different concentrations of KNap on the dry weight of aerial parts of four varieties of sweetpotato. Results were obtained at harvest time.



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the dry weight of the aerial part. At the age of 60 days T_2 and T_3 decreased significantly the dry weight. The decreases were 9 and 33% respectively. Final observations made at the age of 120 days showed that the T_2 increased significantly this parameter. The increase was 30% following this treatment.

1.5.4. Taiwan (Table IV, fig 5).

Results obtained at 60 days indicated that the T_1 and T_2 decreased significantly the dry weight of aerial part. Estimations made on 120 days indicated that the dry weight increased significantly following three different treatments. The increases were 12, 26 and 28% following T_1, T_2 and T_3 respectively.

1.6. Effect of different concentrations of KNap on yield and yield component (Tables V, VI, VII, VIII & IX, fig 6 and 7).

1.6.1. Weight of tuber/plant (Tables V,VI,VII,VIII,fig 6).

Results obtained after harvest of four varieties of sweetpotato indicated that T_1 treatment significantly increased the yield of tuber of local variety. The increase was 18% due to this treatment. In American 2, the T_1 and T_2 significantly increased the yield of tuber and the increases were 21 and 19% respectively. In Okinawa variety all the three treatments increased significantly the yield of tuber. The increases were

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Table V : Effect of different concentrations of KNap on weight[1] of tuber per plant of four varieties of sweetpotato[2].

Variety	Treatment	Block I	Block II	Block III	Block IV	Block mean
Local	T0	375,0	412,0	390,0	316,0	373,0
	T_1	492,0	436,0	489,0	351,0	442,0*
	T_2	397,0	345,0	346,0	393,0	370,0
	T_3	302,0	323,0	298,0	322,0	311,0
American 2	T_0	350,0	334,0	361,0	322,0	342,0
	T_1	331,0	372,0	455,0	491,0	412,0*
	T_2	391,0	367,0	382,0	495,0	409,0*
	T_3	371,0	339,0	325,0	358,0	343,0
Okinawa	T_0	381,0	354,0	347,0	346,0	357,0
	T_1	478,0	415,0	394,0	393,0	420,0*
	T_2	452,0	455,0	450,0	451,0	452,0**
	T_3	470,0	441,0	405,0	485,0	450,0**
Taiwan	T_0	432,0	450,0	418,0	428,0	432,0
	T_1	501,0	527,0	507,0	538,0	518,0**
	T_2	483,0	468,0	470,0	445,0	466,0
	T_3	453,0	447,0	492,0	436,0	457,0

1. Weight in gm.
2. Average of 20 plants (Taking tubers of five plants from each block).

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Table VI : Results of analysis of variance for the data obtained.

Source of variation	df	SS	MS	Observed F	Required F 5%	1%
Blocks	3	0,10	0,03			
Variety(A)	3	64,00	21,33	19,39**		
Error(a)	9	9,96	1,10			
Treatments(B)	3	33,35	11,16	13,60**		
Interactions AB	9	23,90	2,65	3,23**		
Error(b)	36	29,65	0,82			

Table VII : Standard Errors.

Difference between	Standard error as tons / acre
Two variety means factor A	$\sqrt{\frac{2 \times (1,10)}{4 \times 4}} = 0,36$
Two treatment means factor B	$\sqrt{\frac{2 (0,82)}{4 \times 4}} = 0,32$
Two treatment means in same variety	$\sqrt{\frac{2 \times 0,82)}{4}} = 0,64$
Two variety means for same treatment	$\sqrt{\frac{2 [(3) 0,82 + 1,10]}{4 \times 4}} = 0,66$

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Table VIII. Effect of different concentrations of KNap on yield[1] of four varieties of sweetpotato[2].

Variety	TREATMENTS				Variety means
	T_0	T_1	T_2	T_3	
Local	9,3	11,0	9,2	7,6	9,7
American 2	8,4	10,1	10,1	8,4	9,3
Okinawa	8,9	10,4	11,2	11,2	10,4
Taiwan	10,7	12,9	11,7	11,4	11,7
Treatment means	9,3	11,1	10,5	10,1	

1. Yield in ton/acre.
2. Average of 20 plants.

Table IX. Effect of different concentrations of KNap on the number of tuber/plant of four varieties of sweetpotato[1].

Treatment	Variety			
	Local	American 2	Okinawa	Taiwan
T_0	4,0	4,8	2,9	1,8
T_1	4,3	4,8	2,8	2,2
T_2	4,3	4,3	3,1	1,9
T_3	4,0	4,4	3,2	2,0

1. Average of 20 replicates.

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Fig 6 : Effect of different concentrations of KNap on the yield (per acre) of four varieties of sweetpotato . Results were obtained at harvest time.

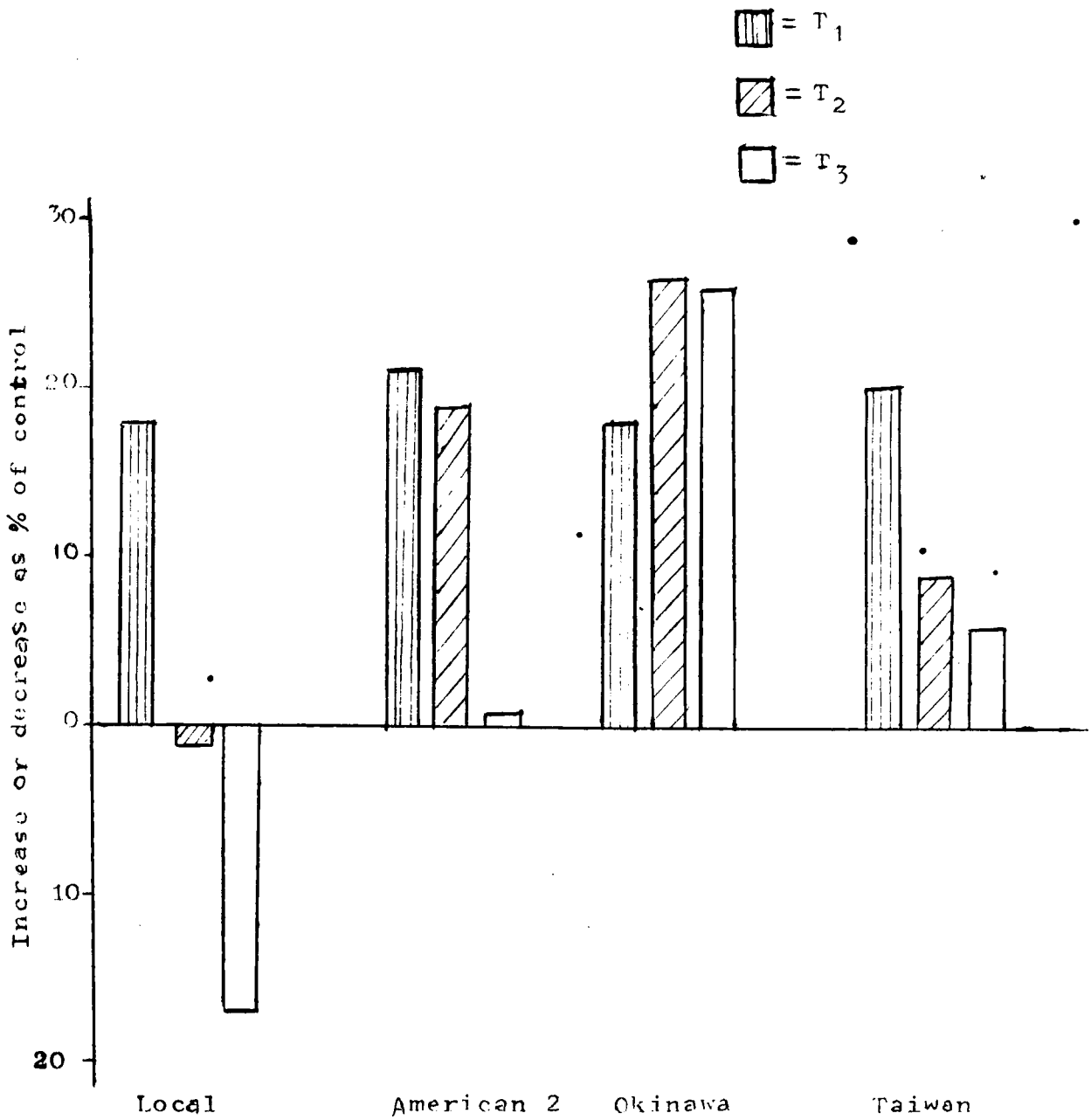

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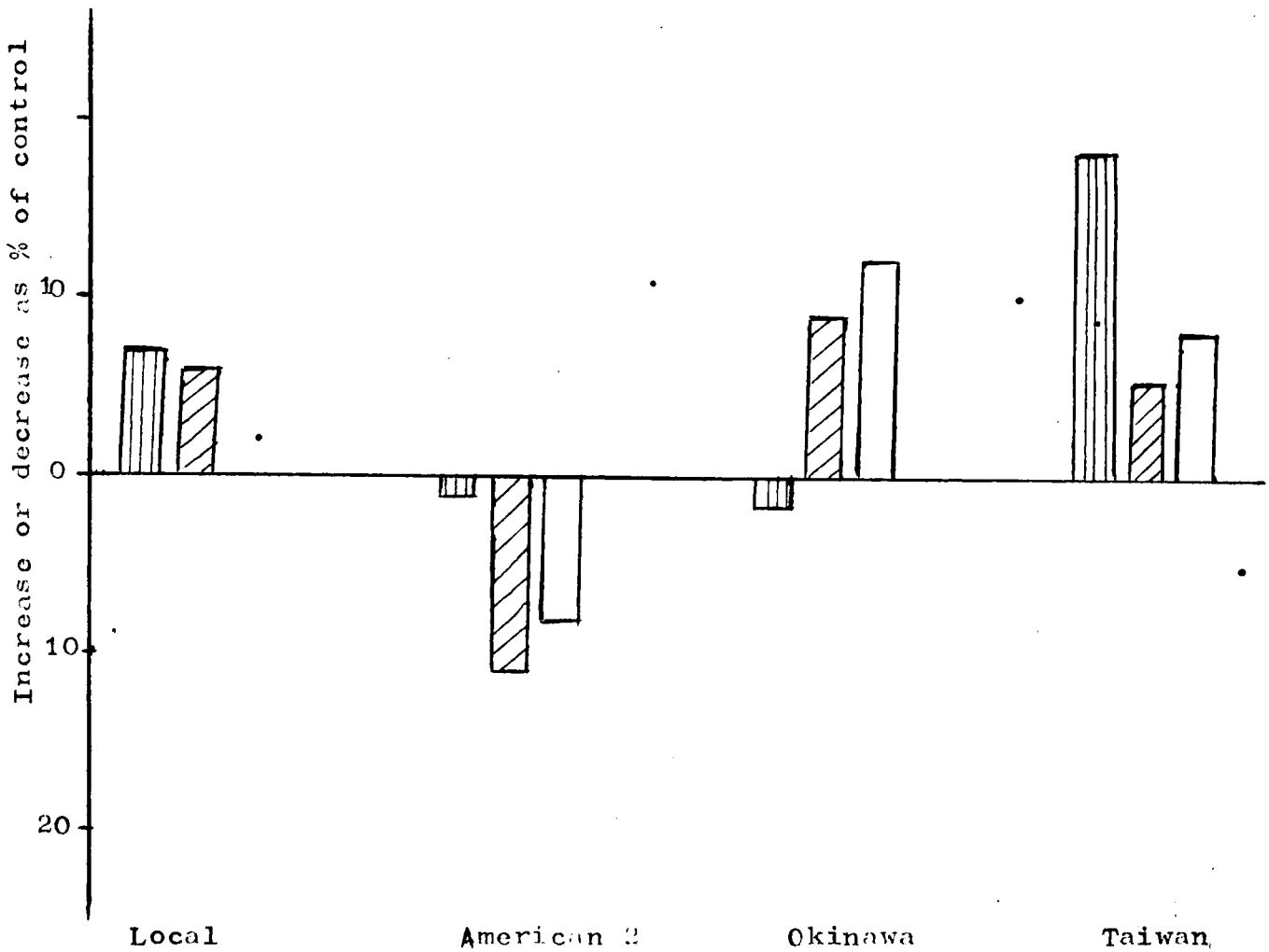
Fig 7 : Effect of different concentrations of KNap on the number of tuber (per plant) of four varieties of sweetpotato. Resuls were obtained at harvest time.



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18, 26. 5 and 26% following the T_1, T_2 and T_3 treatments respectively. In Taiwan variety the significant increase of 20% was found following T_1 treatment of KNap application.

1.6.2. Number of tuber per plant (Table IX, fig 7).

Estimations made after harvest of the sweetpotato indicated that the number of tuber per plant was found to be increased in Local variety by 7 and 6% following T_1 and T_2 treatments respectively. In Okinawa variety the T_2 and T_3 treatments increased the number of tuber by 9 and 12% respectively. Results obtained indicated that all the three treatments increased the number of tuber in Taiwan variety. The increases were 18, 5 and 8% following T_1, T_2 and T_3 respectively.

2. Biochemical Parameters :

2.1. Effect of different concentrations of KNap on leaf pigments.

The pigment contents were estimated at four stages of plant growth and development.

2.1.1. Local (Table X, Fig 8,9,10,11).

Results obtained on 30,60,90 and 120 days indicated that T_1 increased signicantly the chlorophyll a content of leaves. This treatment increased the chlorophyll a contant by 20,22,26,5 and 29% at four stages respectively. At harvest time the increases were 29 and 4.8% following T_1 and T_2 treatments respectively (Fig 8). At this stage, a decrease of 3% was observed following T_3 treatment.

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Table X. Effect of different concentrations of KNap on chlorophyll a, b, carotenoid and total chlorophyll content[1] of Local variety[2].

Treatment		TIME IN DAYS			
		30	60	90	120
Chlorophyll a	T_0	0,45	0,54	0,60	0,62
	T_1	0,54**	0,66*	0,76**	0,80**
	T_2	0,48	0,58*	0,62	0,65
	T_3	0,44	0,50*	0,57	0,60
Chlorophyll b	T_0	0,30	0,35	0,45	0,50
	T_1	0,32	0,41**	0,60**	0,60**
	T_2	0,26*	0,30**	0,40**	0,44**
	T_3	0,26*	0,38	0,38**	0,40**
Carotenoid	T_0	2,0	2,2	2,4	3,0
	T_1	2,2	2,5**	2,7*	2,8
	T_2	1,7	1,8**	2,2	2,8
	T_3	1,8	2,0*	2,4	2,7
Total Chlorophyll	T_0	2,75	3,09	3,45	4,12
	T_1	3,06	3,57	4,06	4,20
	T_2	2,44	2,68	3,22	3,89
	T_3	2,50	2,88	3,35	3,70

1. mg/g fresh leaf weight.
2. Average value of 3 determinations each.
** Significant at 1% level.
* Significant at 5% level.

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Due to KNap treatment chlorophyll b content was increased significantly at 60,90, and 120 days old plant following T_1 treatment and the increases were 19,33, and 20% respectively. The T_2 treatment decreased the same at all the four stages of growth of the plant.

Estimation made on 60 days showed that T_1 treatment increased significantly the carotenoid pigment content. The increase was 17.5% following the treatment. At the final estimation made on 120 days the carotenoid contents were found to be decreased following all the three treatments (fig-10).

Results obtained at the age of 120 days of the plant after treatment indicated that T_1 treatment increased the total chlorophyll content by 3% (fig-11).

2.1.2. American 2 (Table XI, fig 8,9,10,11)

The chlorophyll a content was increased significantly following T_1 treatment of KNap at the three stages of growth and development of the plant. The increases were 20,40.5 and 36% at 60,90 and 120 days respectively. The T_2 treatment of KNap increased significantly the chlorophyll a content at three stages (60,90 and 120 days). At the three stages the increases were 8, 11 and 10% respectively. The T_3 decreased significantly the chlorophyll a at two stages, 30 and 60 days (fig-8).

Measurement made at three different stages of growth and development indicated that the T_1 treatment of KNap increased significantly the chlorophyll b content of leaves of this variety of sweetpotato.

Observations made on 120 days indicated that T_1 and T_2 increased the chlorophyll b content significantly and the increases were 28 and 12% respectively (fig-9).

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Table XI. Effect of different concentrations of KNap on chlorophyll a, b, carotenoid and total chlorophyll content[1] of American 2 variety[2].

Treatment		Time in days			
		30	60	90	120
Chlorophyll a	T_0	0,48	0,50	0,54	0,58
	T_1	0,52	0,60**	0,76**	0,80**
	T_2	0,46	0,54*	0,60**	0,64**
	T_3	0,42*	0,46*	0,54	0,56
Chlorophyll b	T_0	0,24	0,32	0,48	0,50
	T_1	0,30**	0,38**	0,60**	0,64**
	T_2	0,28**	0,30	0,54**	0,56**
	T_3	0,25	0,34	0,38**	0,40**
Corotenoid	T_0	1,40	2,40	2,60	2,80
	T_1	1,60	2,20	2,80	3,40**
	T_2	1,70	1,90**	2,30	2,10*
	T_3	1,50	1,70**	2,00**	2,10**
Total Chlorophyll	T_0	1,72	3,22	3,62	3,88
	T_1	2,42	3,18	4,16	4,84
	T_2	2,44	2,24	3,44	4,30
	T_3	2,17	2,50	2,92	3,06

1. mg/g of fresh leaf weight.
2. Average value of 3 determinations each.
** Significant at 1% level.
* Significant at 5% level.

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Fig 8 : Effect of different concentrations of KNap on the chlorophyll a content of the leaf of four varieties of sweetpotato. Results were obtained at harvest time.

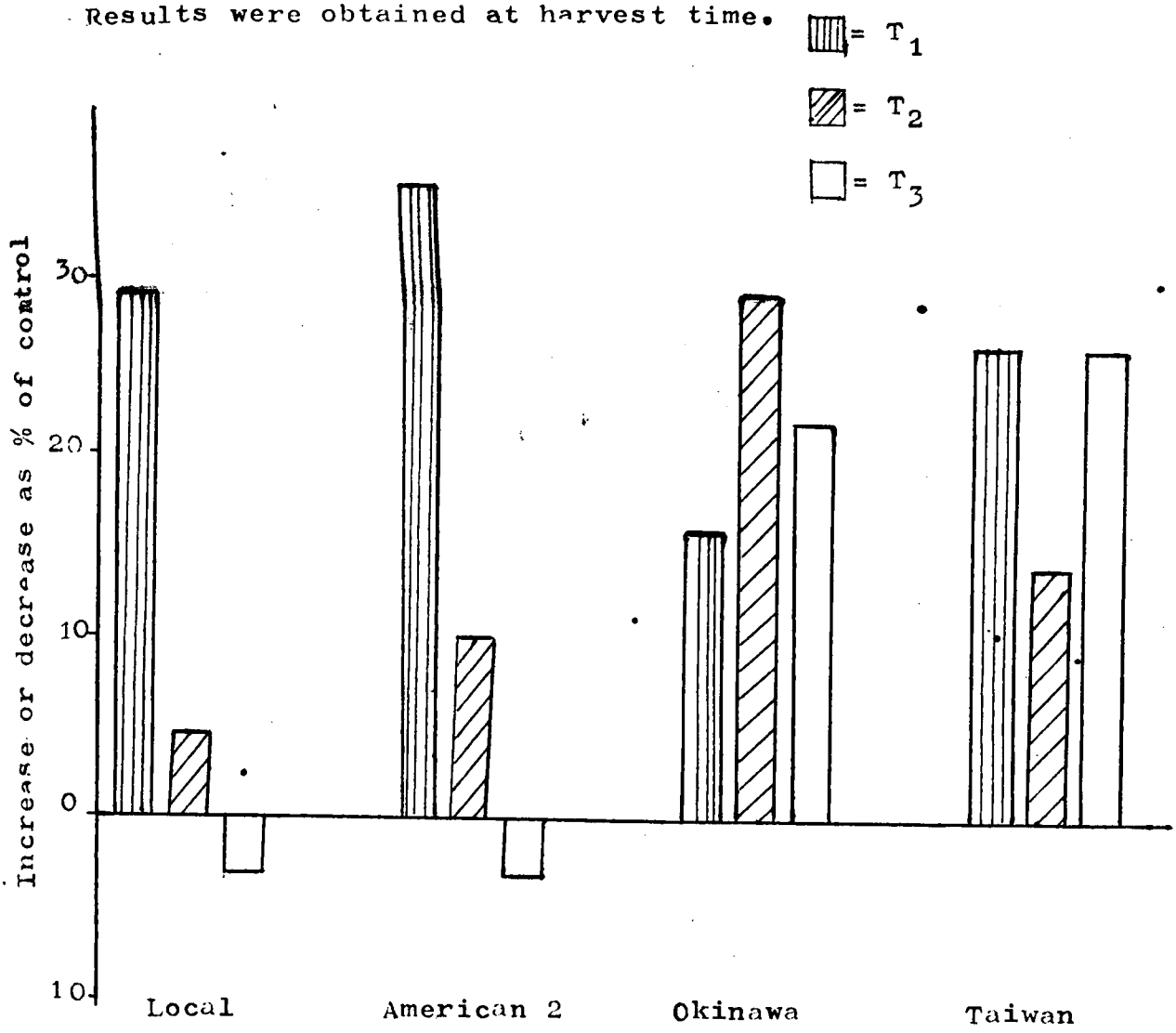

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Fig 9 : Effect of different concentrations of KNap on the chlorophyll b content of the leaf of four varieties of sweetpotato. Results were obtained at harvest time .

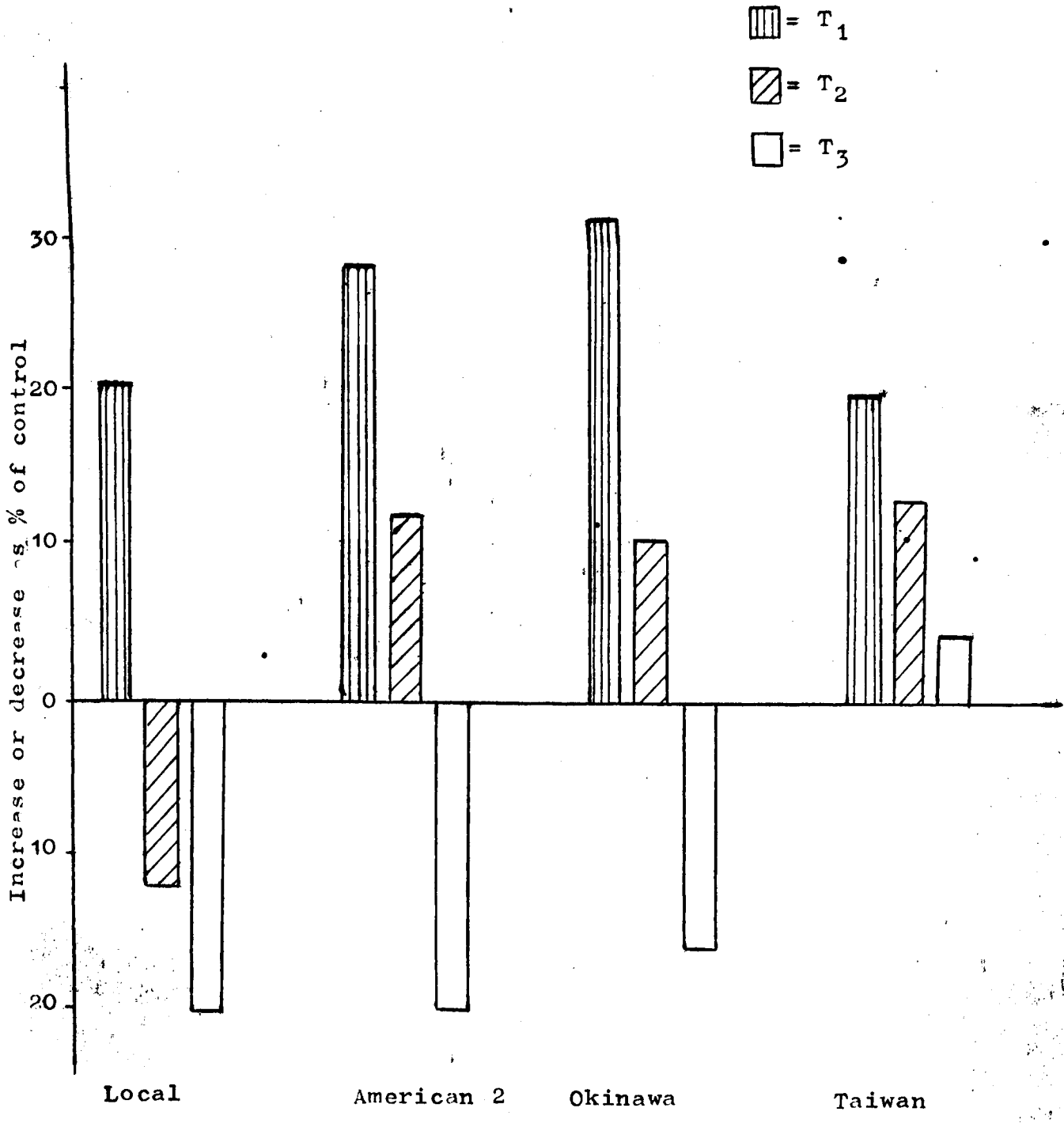

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Fig 10 : Effect of different concentrations of KNap on the carotenoid pigments of the leaf of four varieties of sweetpotato. Results were obtained at hervest time .

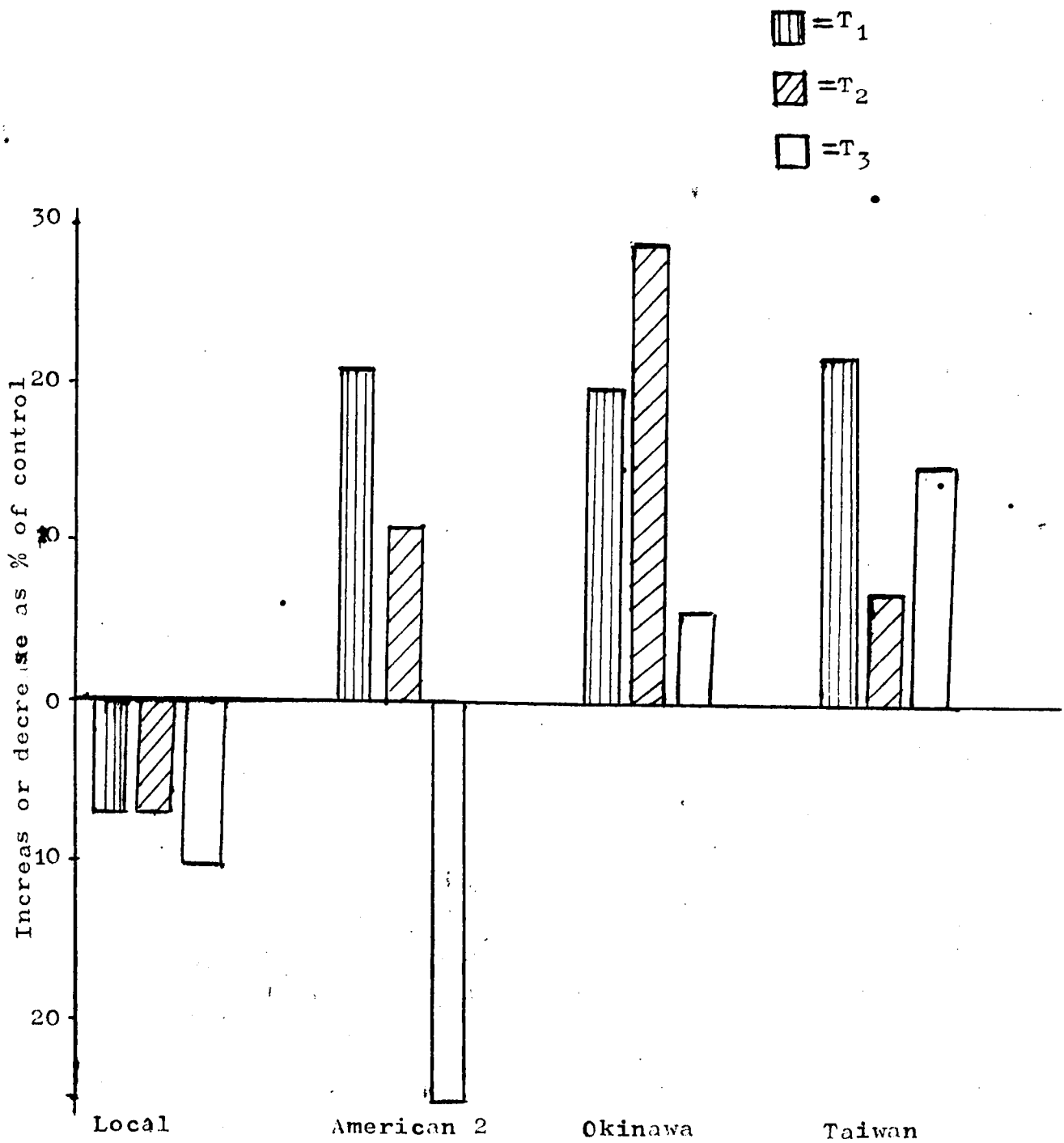

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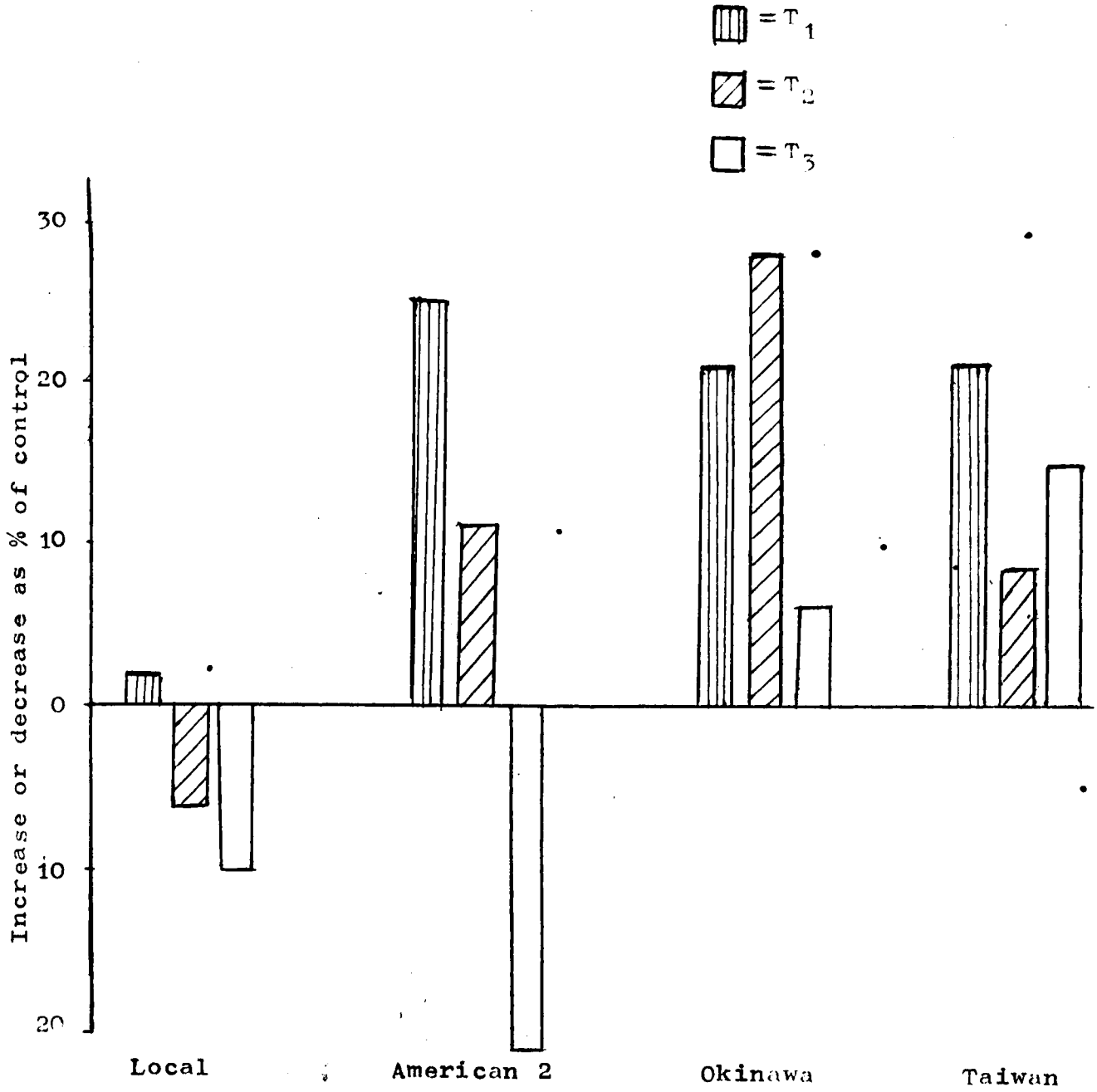
Fig 11 : Effect of different concentrations of KNap on the total chlorophyll content of the leaf of four varieties of sweetpotato. Results were obtained at harvest time.



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The T_3 decreased the parameter significantly by 20% .

At harvest time the carotenoid contents were found to be augmented significantly by T_1 and T_2 treatments. The increases were 21 and 11% following T_1 and T_2 treatments respectively (fig-10).

Estimations made at the time of harvest indicated that the T_1 and T_2 treatments increased the total chlorophyll content in this variety. The increases were 25 and 11% respectively (fig-11).

2.1.3. Okinawa (Table XII fig 8,9,10,11).

Results of the observations indicated that the T_1,T_2 and T_3 treatments increased the chlorophyll a content at all stages of growth and development of the plant. At the age of 30 and 60 the T_3 increased the chlorophyll a content nonsignificantly. Final observations made on 120 days showed that due to different concentrations of KNap the chlorophyll a content was increased significantly. The increases were 16,29 and 22% following T_1,T_2 and T_3 respectively (fig-8).

T_1 and T_2 treatments of KNap increased significantly the chlorophyll b content of the leaves of Okinawa variety of sweetpotato at four different stages of growth and development of the plant. At final observations the increases in chlorophyll b content due to T_1 and T_2 were 31.5 and 10.5% respectively (fig-9).

The carotenoid contents in this variety was increased at all stages of observations following different treatments. At final observations the T_3 increased nonsignificantly. The T_1 and T_2 increased significantly the carotenoid content at this stage where the increases were 20 and 29% respectively (fig-10).

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Table XII. Effect of different concentrations of KNap on chlorophyll a, b, carotenoid and total chlorophyll content[1] of Okinawa variety[2].

	Treatment	Time in days			
		30	60	90	120
Chlorophyll a	T_0	0,38	0,46	0,54	0,62
	T_1	0,42**	0,52**	0,70**	0,72**
	T_2	0,44**	0,54**	0,66**	0,80**
	T_3	0,40	0,48	0,66**	0,76**
Chlorophyll b	T_0	0,24	0,28	0,34	0,38
	T_1	0,30**	0,31*	0,42**	0,50*
	T_2	0,28**	0,33**	0,38*	0,42
	T_3	0,25	0,25	0,28**	0,52*
Carotenoid	T_0	2,20	2,60	3,10	3,[illegible]0
	T_1	2,40	3,30**	3,70**	4,10**
	T_2	2,70**	3,00**	3,50**	4,40**
	T_3	2,80**	3,00**	3,60**	3,60
Total Chlorophyll	T_0	2,82	3,34	3,98	4,40
	T_1	3,12	4,13	4,82	5,32
	T_2	3,42	3,87	4,54	5,62
	T_3	3,45	3,73	4,54	4,68

1. mg/g of fresh leaf weight.
2. Average value of 3 determinations each.
** Significant at 1% level.
* Significant at 5% level.

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The result of the observations made at the age of 120 days indicated that all the three different treatments increased the total chlorophyll content in this variety. The increases were 21, 28 and 6% following T_1, T_2 and T_3 treatments (fig-11).

2.1.4. Taiwan (Table: XIII fig 8,9,10,11).

Results obtained at different times indicated that the chlorophyll a content was increased following T_1, T_2 and T_3 application of KNap. The observations made on 60,90 and 120 days showed that the chlorophyll a content increased significantly at all these stages. Final observations made on 120 days indicated that the chlorophyll a content was increased significantly by the three different treatments and the increases were 26,14 and 26% following T_1, T_2 and T_3 applications of KNap respectively (fig-8).

T_1, T_2 and T_3 increased the chlorophyll b content of leaves of this variety of sweetpotato at all stages of observations. At 30, 60 and 90 days of observations the three different treatments increased significantly the chlorophyll b content. At 90 days the increases were 31,21 and 15% following T_1, T_2 and T_3 concentrations of KNap treatment. During the final observations the T_1 and T_2 increased the chlorophyll b content significantly and the increases were 20 and 13% respectively (fig-9).

Due to the application of different concentrations of KNap the carotenoid pigments were increased at all the four stages of growth and development of the plant. Observations made at 30 days indicated that the increases due to these treatments were

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Table XIII. Effect of different concentrations of KNap on chlorophyll a,b, carotenoid and total chlorophyll contents[1] of Taiwan variety[2].

	Treatment	Time in days			
		30	60	90	120
Chlorophyll a	T_0	0,34	0,38	0,40	0,49
	T_1	0,42**	0,54**	0,50**	0,62**
	T_2	0,36	0,44*	0,50**	0,56**
	T_3	0,38	0,48**	0,54**	0,62**
Chlorophyll b	T_0	0,30	0,32	0,38	0,44
	T_1	0,40**	0,41**	0,50**	0,53**
	T_2	0,36**	0,40**	0,46**	0,50*
	T_3	0,34**	0,38**	0,44**	0,46
Carotenoid	T_0	2,50	3,00	3,70	4,10
	T_1	3,00**	3,50**	4,60**	5,00**
	T_2	3,20**	3,40*	4,00**	4,40
	T_3	2,80**	3,70**	4,20**	4,70**
Total Chlorophyll	T_0	3,14	3,70	4,48	5,03
	T_1	3,82	4,45	5,60	6,15
	T_2	3,92	4,25	4,96	5,46
	T_3	3,52	4,56	5,18	5,78

1. mg/gm of fresh leaf weight.
2. Average value of 3 determinations each.
** Significant at 1% level.
* Significant at 5% level.

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significant at this stage and the increases were 20,28 and 12% following T_1,T_2 and T_3 applications of KNap respectively. Final observations made at 120 days showed that T_1 and T_3 increased the carotenoid content significantly and the increases were 22, 7 and 15% following T_1 , T_2 and T_3 treatments respectively (fig-10).

Fig 11 showed that the increases in the total chlorophyll content were 21,8 and 15% at harvest period.

2.2. Effect of different concentrations of KNap on β-carotene content of tuber:

β-carotene content of tubers was measured in Okinawa and Taiwan varieties . In the two other varieties namely Local and American 2 it has not been possible to measure the same because of very slight presence or absence of this biochemical parameter in their tubers.

2.2.1. Okinawa (Table XIV fig-12).

Due to KNap treatment β-carotene content was found to be increased in all the stages of growth and development of the plant. The maximum increase was observed on 90 days and the increase was 41% following T_1 treatment. In the final observations the T_1 increased significantly this parameter while increases due to T_2 and T_3 were nonsignificant. The increases were 28,3 and 6% following T_1 ,T_2 and T_3 applications of KNap.

2.2.2. Taiwan (Table XV,fig-12).

In this variety, the T_1 and T_3 application of KNap increased the β-carotene content at all stages of observations. The T_2 slightly decreased the β-carotene content at 30,90 and 120 days. Results of

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Table XIV. Effect of different concentrations of KNap on β-carotene content[1] of tubers of Okinawa variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	2,6	3,0	3,4	3,9
T_1	3,1	4,2**	4,8**	5,0**
T_2	2,9	3,8**	3,9**	4,0
T_3	3,0	3,2	4,0**	4,1

Table XV. Effect of different concentrations of KNap on β-carotene content[1] of tubers of Taiwan variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	4,4	5,4	6,4	7,1
T_1	4,8	6,8	7,6**	9,0**
T_2	4,2	5,6	6,0*	7,0*
T_3	4,6	6,0**	7,0**	8,6**

1. mg/100 gm of fresh tuber weight.
2. Average value of 3 determinations each.

** Significant at 1% level.
* Significant at 5% level.

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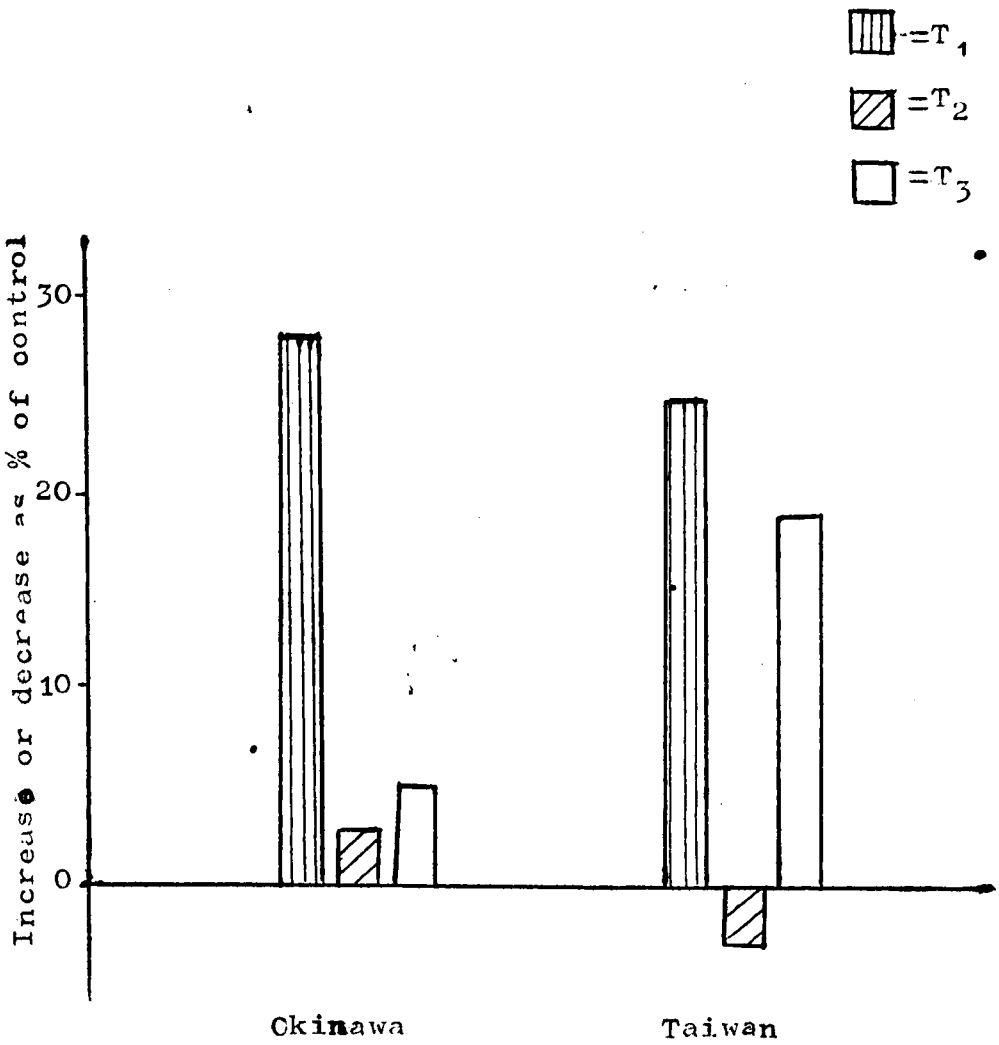
Fig 12 : Effect of different concentrations of KNap on the β-carotene content of the tubers of two varieties of sweetpotato. Results were obtained at harvest time.



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the observations made on 120 days of the experiment showed that the T_1 and T_3 increased this parameter significantly and the increases were 25 and 19% respectively.

2.3. Effect of different concentrations of KNap on soluble sugar content of tuber :

The soluble sugar content of tubers of different varieties were estimated at different ages of plants i.e. 30,60,90 and 120 days after treatment.

2.3.1. Local (Table XVI, fig-13).

Results of the observations indicated that T_2 increased the soluble sugar content at all stages of growth and development of plants. T_1 and T_3 applications of KNap decreased the sugar content at 60,90 and 120 days of the experiment. In final observations made on 120 days of the experiment indicated that T_2 increased the sugar content by 12,5% where as the T_1 and T_3 applications of KNap decreased the same by 17 and 21% respectively.

2.3.2. American 2 (Table XVII, fig-13).

During the present investigation it was observed that at 30 days the soluble sugar content was increased nonsignificantly following T_1, T_2 and T_3 application of KNap. The T_2 increased the sugar content at all four stages of observations. T_1 application of KNap decreased the sugar content at 60,90 and 120 days. The decreases were found to be nonsignificant at these stages. The final observations made on 120 days indicated that T_2 and T_3 increased the sugar content by 16 and 12, 5% respectively.

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Table XVI : Effect of different concentrations of KNap on soluble sugar content[1] of tubers of Local variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	11.0	10.0	8.0	8.0
T_1	14.0	8.0	6.6	6.6
T_2	13.0	12.0	10.0*	9.0
T_3	10.0	9.0	7.0	6.3

Table XVII : Effect of different concentrations of KNap on soluble sugar content[1] of tubers of American 2 variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	15.0	11.0	10.0	8.0
T_1	16.0	10.6	8.0	6.6
T_2	17.0	12.0	12.0*	9.3
T_3	17.0	13.0	10.0	9.0

1. gm/100 gm fresh tuber weight.
2. Average value of 3 determinations each.

** Significant at 1% level.

* Significant at 5% level.

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2.3.3. Okinawa (Table XVIII , fig-13).

Observations made at 30 days indicated that the T_1 application of KNap decreased the soluble sugar content. The decreases were 9,11,12 and 14% at four successive stages respectively. The T_2 treatment increased nonsignificantly the sugar content of tuber of this variety at three earlier stages of growth and development. The increases were 18,22 and 25% for the three stages respectively. Observations made on 120 days showed that the T_1,T_2 and T_3 decreased nonsignificantly the sugar content and the decreases were 14, 14 and 20% respectively.

2.3.4. Taiwan (Table XIX, fig-13).

The results of the observations made at 30 days indicated that the soluble sugar content was decreased nonsignificantly following T_1,T_2 and T_3 applications of KNap. The decreases were 20,30 and 10% following three treatments respectively. The T_1 and T_2 decreased the sugar content of tubers at 60 and 120 days. Results of the observations made on 120 days indicated that T_1 and T_2 decreased nonsignificantly the sugar content of tuber by 14% . The T_3 applications of KNap increased nonsignificantly the sugar content at 60,90 and 120 days. The increases were 12,14 and 14% following three successive observations respectively.

2.4. Effect of different concentrations of KNap on starch content of tuber:

2.4.1. Local (Table XX , fig-14).

The results obtained at different stages of growth and development of the plant showed that T_1 application of KNap increased nonsignificantly the starch content of tubers . At 90 days the increase was

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Table XVIII : Effect of different concentrations of KNap on soluble sugar content[1] of tubers of Okinawa variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	11.0	9.0	8.0	7.0
T_1	10.0	8.0	7.0	6.0
T_2	13.0	11.0	10.0	6.0
T_3	12.0	10.0	7.0	5.6

Table XIX. Effect of different concentrations of KNap on soluble sugar content[1] of tubers of Taiwan variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	10.0	8.0	7.0	7.0
T_1	8.0	7.0	6.0	6.0
T_2	7.0	7.0	8.0	6.0
T_3	9.0	9.0	8.0	8.0

1. gm/100 gm of fresh tuber weight.

2. Average value of 3 determinations each.

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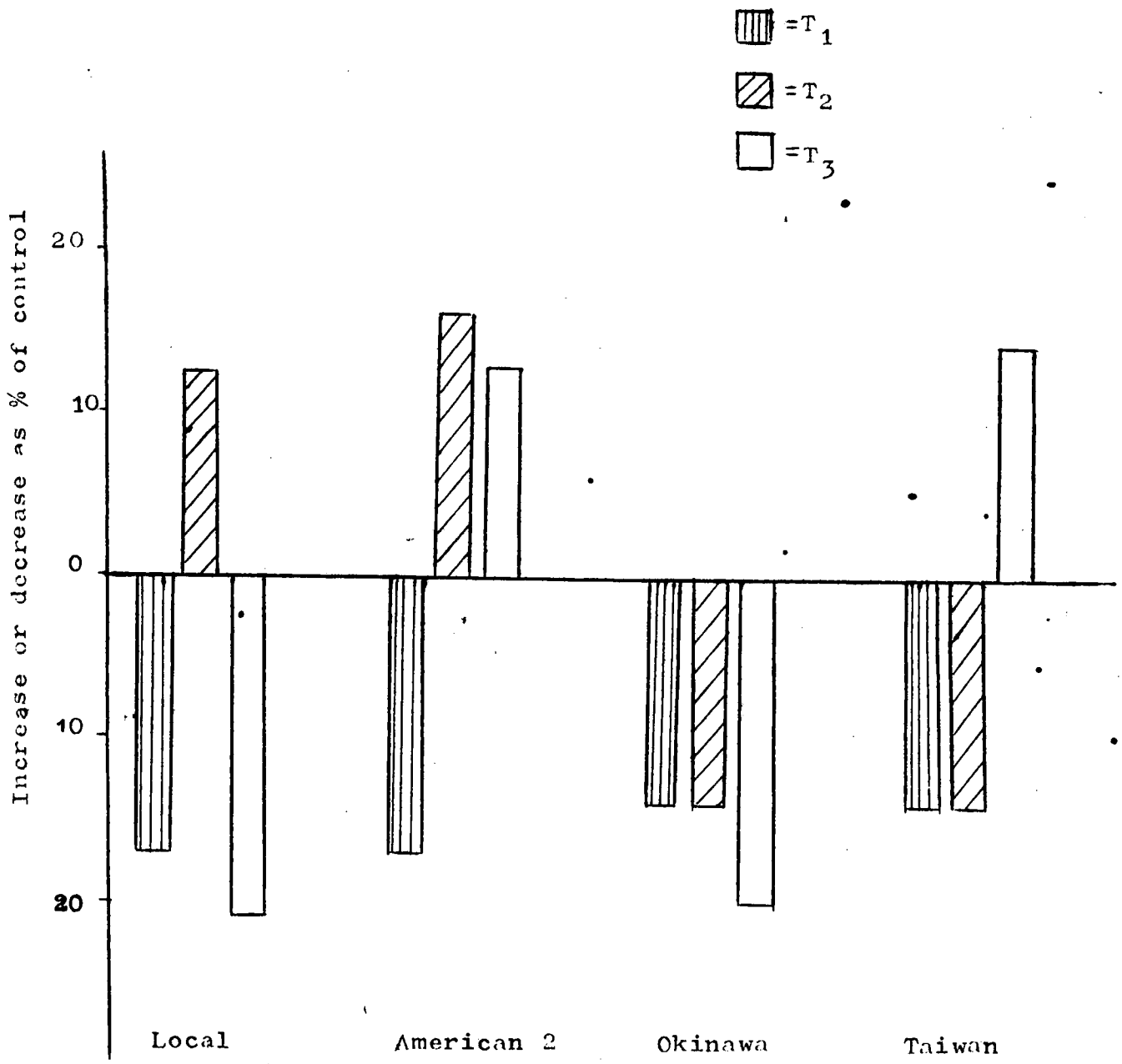
Fig 13 : Effect of different concentrations of KNap on the soluble sugar content of the tubers of four varieties of sweetpotato Results were obtained at harvest time.



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significant. The increases were 20,33,22 and 29% at four successive stages respectively. The final observations made on 120 days indicated that T_1,T_2 and T_3 increased nonsignificantly the starch content of tubers. The increases were 29,16 and 8% following T_1,T_2 and T_3 treatments respectively.

2.4.2. American 2 (Table XXI, fig-14).

T_1 increased the starch content at four different stages of growth and development of the plants. This treatment increased the content significantly on 60 and 120 days. The increases were 25 and 42% at the above two stages respectively. The T_2 decreased nonsignificantly the starch content on 60 and 90 days. The decreases were 10 and 8% at two different stages respectively following this treatment. At harvest period a nonsignificant increase of 5% was observed following T_3 treatment.

2.4.3. Okinawa (Table XXII, fig-14).

Observations made on 30 and 60 days showed that all the three different concentrations of KNap increased the starch content nonsignificantly. At 60 days old plant the increases were 14,28 and 23% following T_1,T_2 and T_3 treatments of KNap. The T_3 treatments showed a significant increase of 28% at 90 days. At 120 days the results of the observations showed that T_1 and T_3 increased the starch content by 13 and 4% respectively. The T_2 however decreased significantly this content by 17% .

2.4.4. Taiwan (Table XXIII, fig-14).

Results of the observations made at four stages indicated that the starch content was increased in tubers of Taiwan variety following

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Table XX. Effect of different concentrations of KNap on starch content[1] of tubers of Local Variety[2].

Treatment	Time in days			
	30	60	90	120
T0	5,0	12,0	18,0	24,0
T1	6,0	16,0	22,0*	31,0
T2	5,6	11,0	19,0	28,0
T3	6,0	9,0	15,0	26,0

Table XXI. Effect of different concentrations of KNap on starch content[1] of tubers of American variety[2].

Treatment	Time in days			
	30	60	90	120
T0	5,0	10,0	13,0	21,0
T1	7,0	15,0**	16,0	30,0**
T2	6,0	9,0	12,0	21,0
T3	5,5	11,0	14,0	22,0

1. gm/100 gm of fresh tuber weight.
2. Average value of 5 determinations each.

** Significant at 1% level.
* Significant at 5% level.

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Table XXII. Effect of different concentrations of KNap on starch content[1] of tubers of Okinawa variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	3,3	7,0	14,0	23,0
T_1	3,7	8,0	16,0	26,0
T_2	4,0	9,0	13,0	19,0*
T_3	4,0	8,6	18,0*	24,0

Table XXIII. Effect of different concentrations of KNap on starch content[1] of tuber of Taiwan variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	5,0	8,0	14,0	18,0
T_1	6,0	10,0	19,0**	24,0**
T_2	5,5	9,0	17,0	21,0
T_3	6,0	8,5	18,0*	23,0*

1. gm/100 gm of fresh tuber weight.
2. Average value of 3 determinations each.

** Significant at 1% level.

* Significant at 5% level.

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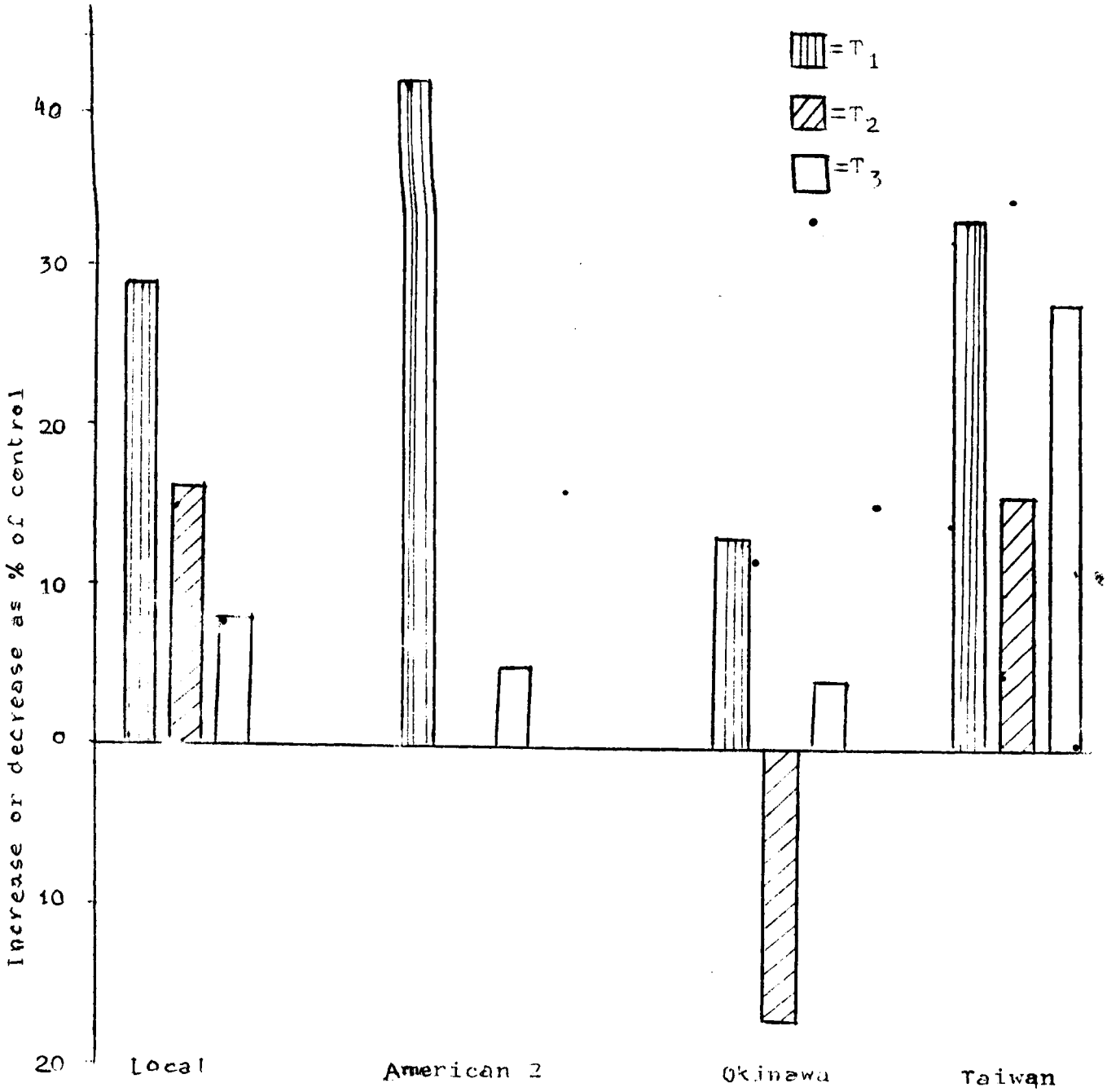
Fig 14 : Effect of different concentrations of KNap on the starch content of the tubers of four varieties of sweetpotato. Results were obtained at harvest time .



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all the three different concentrations of KNap application. Final observation made on 120 days showed that T_1 and T_3 applications of KNap increased significantly the starch contents whereas the increase due to T_2 was nonsignificant. The increases in starch content at this stage were 33, 16 and 28% following T_1, T_2 and T_3 treatments.

2.5. Effect of different concentrations of KNap on protein content of tuber:

2.5.1. Local (Table XXIV, fig-15).

The T_1 application of KNap increased the protein content of tubers of this variety at all stages of estimations. At 30 and 90 days the increases were significant and were found to be 31 and 29% respectively. At final observations the increase due to T_1 was 9% (nonsignificant). The two other treatments at this stage decreased slightly the protein content of tubers of this variety.

2.5.2. American 2 (Table XXV , fig-15)

Observations made at 30 days showed that T_1 significantly increased the protein content of tuber whereas nonsignificantly increased the same at the other three stages of growth and development of plants. Results of the observations made on 120 days showed that protein content of tubers increased nonsignificantly following the three different concentrations of KNap. The increases were 27,

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Table XXIV. Effect of different concentrations of KNap on protein content[1] of tubers of Local variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	8,0	12,0	17,0	22,0
T_1	10,5**	12,5	22,0*	24,0
T_2	7,0	15,0	18,5	21,5
T_3	7,5*	12,0	16,0	20,5

Table XXV. Effect of different concentrations of KNap on protein content[1] of tubers of America 2 variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	6,0	10,5	12,0	16,5
T_1	8,0**	12,0	16,0	21,0
T_2	6,0	9,5	13,0	18,0
T_3	5,0	10,0	12,5	17,0

1. mg/gm fresh tuber weight.
2. Average value of 3 determinations each.

** Significant at 1% level.

* Significant at 5% level.

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9 and 3% following T_1 ,T_2 and T_3 treatments respectively.

2.5.3. Okinawa (Table XXVI, fig-15).

The protein content was increased following all the treatments at different stages of growth and development of plants. Observations made on 60 days indicated that T_2 and T_3 applications of KNap significantly increased the protein content of tuber. The increases were 26 and 36% following T_2 and T_3 treatments. At final observation all the three treatments increased the protein content.The T_1 and T_2 increased significantly and the increases were 25 and 43% respectively where as the T_3 treatment showed an increase of 6% (nonsignificant).

2.5.4. Taiwan (Table XXVII, fig-15)

Results of the observations made on 30,60 and 90 days.indicated that during these stages the protein content of tubers was increased following T_1, T_2 and T_3 treatments . At 60 days the T_1 significantly increased the protein contnet by 41%. At 120 days the T_1 treatment showed an increase of 27% (significant) and T_3 showed a nonsignificant increase of 11% and T_2 treatment showed a nonsignificant decrease of 5% .

2.6. Effect of different concentrations of KNap on Nitrate reductase activity of leaves:

The nitrate reductase activity of leaves of four varieties of sweetpotato was estimated at three stages of growth and development begining from 60 days after the KNap application.

2.6.1. Local (Table XXVIII, fig-16).

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Table XXVI. Effect of different concentrations of KNap on protein content[1] of tubers of Okinawa variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	7,0	9,5	14,0	16,0
T_1	8,0	10,0	16,0	20,0*
T_2	9,0	12,0*	18,0	23,0**
T_3	8,5	13,0*	15,0	17,0

Table XXVII. Effect of different concentrations of KNap on protein content[1] of tubers of Taiwan variety[2].

Treatment	Time in days			
	30	60	90	120
T_0	10,0	12,0	16,0	18,0
T_1	14,0	17,0**	20,0	23,0**
T_2	10,5	13,0	17,0	17,0
T_3	12,0	14,5	18,0	20,0

1. mg/gm of fresh tuber weight.

2. Average value of 3 determinations each.

** Significant at 1% level.

* Significant at 5% level.

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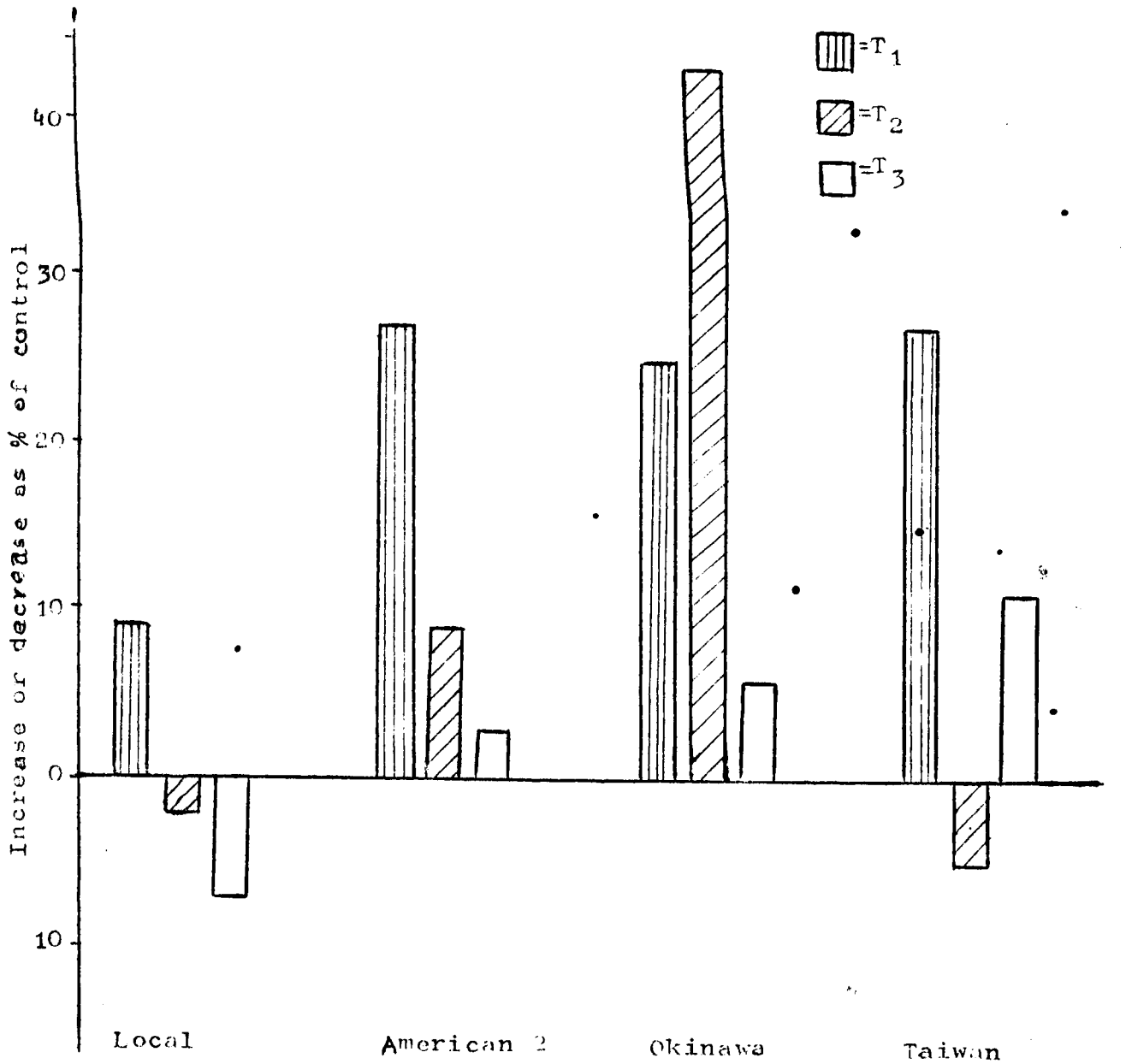
Fig 15 : Effect of different concentrations of KNap on the protein content of the tubers of four varieties of sweetpotato. Results were obtained at harvest time .



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Observations made at 60 days indicated that all the three different treatments increased nonsignificantly the nitrate reductase activity at this stage. The increases were 7.5, 3.5 and 4.5% following T_1, T_2 and T_3 treatments respectively. It is evident from the results that the T_1 increased the nitrate reductase activity at three stages of observations. The increases due to this treatment were 7.5, 6 and 2% at 60,90 and 120 days respectively.

2.6.2. American 2 (Table XXIX, fig-16).

The results of the observations made on 60 days indicated that T_1 nonsignificantly decreased the nitrate reductase activity, whereas T_3 decreased the activity significantly. Results of the estimations of all the three different treatments increased nonsignificantly the activity at 90 and 120 days. Final observations made at 120 days indicated that the three treatments increased the nitrate reductase enzyme activity at this stage. The increases were 9,2 and 3% following T_1, T_2 and T_3 treatments respectively.

2.6.3. Okinawa (Table XXX, fig-16).

Estimations made at 60 days indicated that T_1 increased nonsignificantly the nitrate reductase activity in the leaves of this variety. The increase was 2.5% following this treatment. The T_2 and T_3 treatments increasesd significantly the enzyme activity and the increases were 6 and 12% respectively. Observations made at 90 days showed that the T_3 nonsignificantly decreased the nitrate reductase activity. The

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Table XXVIII: Effect of different concentrations of KNap on specific activity[1] of nitrate reductase[1] of fresh leaf of Local variety[2].

Treatment	Time in days		
	60	90	120
T_0	1,05	1,35	1,42
T_1	1,13	1,43	1,45
T_2	1,09	1,25	1,41
T_3	1,11	1,21	1,34**

Table XXIX: Effect of different concentrations of KNap on specific activity[1] of nitrate reductase[1] of fresh leaf of American-2 variety[2].

Treatment	Time in days		
	60	90	120
T_0	0,96	1,05	1,23
T_1	0,95	1,15	1,34
T_2	0,98*	1,11	1,25
T_3	0,89**	1,08	1,27

1. mMmole nitrite formed / mg protein/hour.

2. Average of 3 determinations each.

** Significant at 1% level.

* Significant at 5% level.

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decrease was 4% following the treatment. The results of the final observations made on 120 days indicated that the T_1 and T_2 treatments of KNap increased significantly the enzyme activity and the increases were 7.3 and 13% respectively. The T_3 increased nonsignificantly the enzyme activity. The increase was 3,5% due to this treatment.

2.6.4. Taiwan (Table XXXI, fig-16).

Results obtained at 60 days of experiment indicated that T_2 treatment of KNap increased significantly the nitrate reductase activity and the increase was 16,5% due to this treatment. The T_1 and T_3 increased the enzyme activity nonsignificantly and the increases were 9,5 and 1% respectively following these treatments. At 90 days the results showed that the three different treatments increased nonsignificantly the enzyme activity. The increases were 14,5 and 7% following T_1, T_2 and T_3 treatments respectively. Results of the final observations made on 120 days indicated that T_2 treatment decreased nonsignificantly the enzyme activity at this stage. The decrease was 2% following the treatment. T_1 treatment of KNap increased significantly the enzyme activity by 12% . Due to T_3 treatment the enzyme activity was increased nonsignificantly. The increase in enzyme activity was 6,5% at this stage.

3. Effect of ionising radiation on the storage quality of sweetpotato:

3.1. Physical observations:

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Table XXX: Effect of different concentrations of KNap on specific activity of nitrate reductase[1] of fresh leaf of Okinawa variety[2].

Treatment	Time in days		
	60	90	120
T_0	0,95	1,10	1,14
T_1	0,97	1,18	1,23*
T_2	1,01**	1,21	1,29*
T_3	1,07**	1,07	1,18

Table XXXI: Effect of different concentrations of KNap on specific activity of nitrate reductase[1] of fresh leaf of Taiwan variety[2].

Treatment	Time in days		
	60	90	120
T_0	1,02	1,15	1,22
T_1	1,12	1,31	1,37*
T_2	1,19**	1,21	1,19
T_3	1,03	1,23	1,30

1. mMole nitrite formed /mg protein/hour.

2. Average value of 3 determinations each.

** Significant at 1% level.

* Significant at 5% level.

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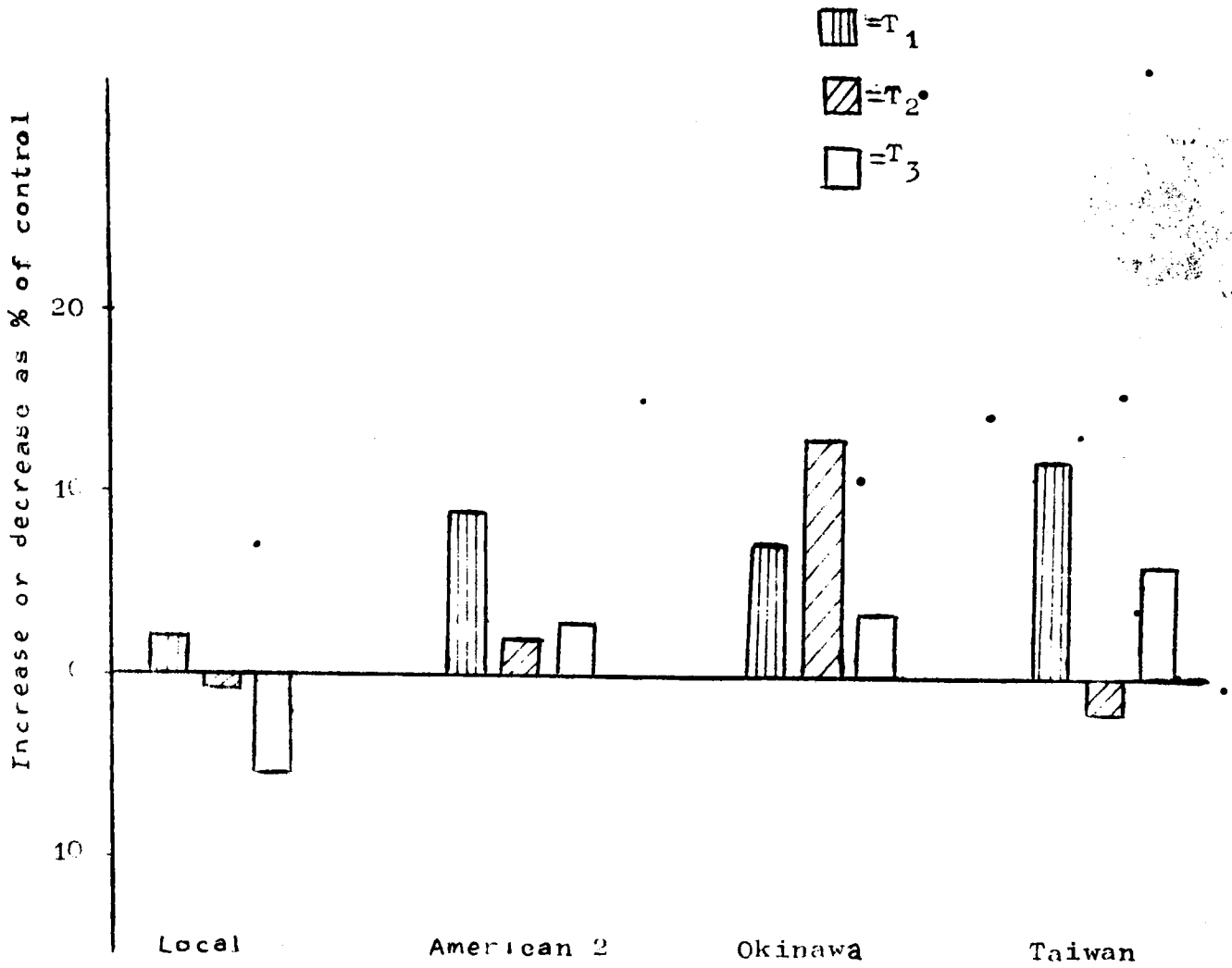
Fig 16 : Effect of different concentrations of KNap on the specific activity of nitrate reductase of fresh leaf of four varieties of sweetpotato. Results were obtained at harvest time.



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The control and irradiated tubers showed no marked change in colour throughout the experiment. The control tubers gradually became soft following sprout initiation. The irradiated tubers remained compact throughout the experiment. During the experiment the sprout initiation, weight loss and rot incidence of both contro and irradiated tubers were observed.

3.1.1. Sprout growth:

3.1.1.1. Local (Table XXXII).

Table XXXII showed the results of the initiation of sprouting of tubers of sweetpotato stored for a period of 75 days. Sprouting initiated at 15 days after the irradiation. At the age of 45 days of the experiment the initiation of sprouting in the control tubers were complete. Sprouting occured in the 7 krad tuber in a very lesser number. At the end of the experiment 8% sprouting was observed in these tubers. Results of the observation showed that 9 krad irradiation of ionising radiation almost completely inhibited sprout formation. In 9 krad tubers only there was an initiation of 2% sprouting at 45 days of experiment. These sprouts were dried up at the later part of the experiment.

3.1.1.2. American 2 (Table XXXIII).

Results of the observations indicated that at 45 days of the experiment the sprouting of the tubers were complete in control. At the end of the experiment 10% sprout initiation was found in the case of 7 krad tuber. In 9 krad tuber a sprout

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Table XXXII : Effect of gamma radiation on percentage of initiation of sprouting of the tubers of Local variety.

Treatment	Time in days					Total
	15	30	45	60	75	
0 Krad	20	32	46	-	-	98
7 Krad	2	2	4	0	0	8
9 Krad	0	0	2	0	0	2

Table XXXIII : Effect of gamma radiation on percentage of initiation of sprouting of the tubers of American 2 variety.

Treatment	Time in days					Total
	15	30	45	60	75	
0 Krad	22	40	34	-	-	96
7 Krad	0	4	2	2	2	10
9 Krad	0	2	2	2	0	6

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Table XXXIV : Effect of gamma radiation on the percentage of initiation of sprouting of the tubers of Okinawa variety.

Treatment	Time in days					Total
	15	30	45	60	75	
0 Krad	10	18	34	36	-	98
7 Krad	0	2	6	2	2	12
9 Krad	0	0	0	2	2	4

Table XXXV : Effect of gamma radiation on the percentage of initiation of sprouting of the tubers of Taiwan variety.

Treatment	Time in days					Total
	15	30	45	60	75	
0 Krad	10	20	26	40	-	96
7 Krad	4	2	2	0	0	8
9 Krad	2	0	0	0	0	2

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initiation of 6% was observed.

3.1.1.3. Okinawa (Table XXXIV).

Results of the table showed that the sprout initiation in this variety was completed at 60 days in case of control tubers. In 9 krad tubers the sprout initiated at 60 days of experiment. The results recorded at the end of the experiment showed that there were 12% and 4% sprout initiation following 7 and 9 krad treatments.

3.1.1.4. Taiwan (Table XXXV).

Data presented in the table showed that the initiation of sprouts was observed in all treatments including control at 15 days of the experiment. The control tubers showed the complete initiation of sprouting in 60 days of experiment. There were 8% and 2% sprout initiation in this variety following 7 and 9 krad treatments.

3.1.2. Weight loss:

Weight loss due to irradiation was estimated at three stages of the experiment.

3.1.2.1. Local (Table XXXVI).

During the present investigation it was observed that the maximum loss of weight was recorted in the case of control tubers. The weight loss in control tubers at the end of the experiment was 32,38% . The two other weight losses were 12.15 and 11,51% following 7 and 9 krad treatments.

3.1.2.2. American 2 (Table XXXVII).

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Table XXXVI : Effect of gamma radiation on the percentage of weight[1] loss of tubers[2] of Local variety .

Treatment	Time in days		
	15	45	75
0 Krad	6.28	18.23	32.58
7 Krad	5.36	9.06	12.15
9 Krad	4.49	8.70	11.51

Table XXXVII : Effect of gamma radiation on the percentage of weight[1] loss of tubers[2] of American 2 variety.

Treatment	Time in days		
	15	45	75
0 Krad	7.96	16.66	30.84
7 Krad	3.76	7.28	10.05
9 Krad	4.46	7.19	9.42

1. Weight in gm.
2. Average of 10 tubers.

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Results obtained indicated that there was 30,84% loss of weight in control tuber at the end of the experiment and there were 10.05 and 9.42% loss of weight following 7 and 9 krad treatments.

3.1.2.3. Okinawa (Table XXXVIII).

The results of the observations showed that loss of weight was higher in the case of control tuber. The loss of weight in control tuber at 75 days of experiment was 25.55% . The loss of weight due to 7 and 9 krad treatments were 11.32 and 9.72% respectively .

3.1.2.4 Taiwan (Table XXXIX).

The table XXXIX showed that the loss of weight was found to be 25.54% in control tuber at the end of the experiment. At this stage the weight loss due to 7 and 9 krad were 7.34 and 7.96% respectively.

3.1.3. Rot Incidence:

3.1.3.1. Local (Table XL).

Results presented in the table XL showed that there was a higher rate of rot incidence in the case of control tubers. At the end of the experiment the rot incidence was 22% in case of control tubers and 18% in both the 7 and 9 krad treatments.

3.1.3.2 American 2 (Table XLI).

Results of the observations showed that at 75 days of the

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Table XXXVIII : Effect of gamma radiation on the percentage of weight[1] loss of tubers[2] of Okinawa variety .

Treatment	Time in days		
	15	45	75
0 Krad	7.77	12.44	25.55
7 Krad	4.95	9.19	11.32
9 Krad	2.54	7.63	9.72

Table XXXIX : Effect of gamma radiation on the percentage of weight[1] loss of tubers[2] of Taiwan variety .

Treatment	Time in days		
	15	45	75
0 Krad	4.80	10.26	25.54
7 Krad	3.02	5.39	7.34
9 Krad	2.87	5.53	7.96

1. Weight in gm.
2. Average of 10 tubers.

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experiment there was a rot incidence of 22% in case of control tubers and 20 and 18% of rot incidence were observed at this age following 7 and 9 krad treatments.

3.1.3.3. Okinawa (Table XLII).

The results showed that rot incidence was found in all the three cases. At the 75 days of experiment there was 24% rot incidence in case of control and 20% in the case of 7 and 9 krad treatments.

3.1.3.4 Taiwan (Table XLIII).

The results of the experiment showed that the rot incidences were observed from the beginning of the observation in all the cases. Final observations at 7 days of storage showed a 22% rot incidence in the case of control tubers and 20 and 18% rot incidences in the case of 7 and 9 krad treatments respectively.

3.2. Biochemical changes:

The soluble sugar and starch content were estimated at three stages of storage time following radiation treatment.

3.2.1. Soluble sugar content:

3.2.1.1. Local (Table XLIV).

The results recorded in XLIV showed that there was an increase in the soluble sugar content in the control tuber with the progress of the experiment. In the irradiated tubers the soluble sugar content increased slightly. Observation made at 75 days indicated

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Tabel XL : Effect of gamma radiation on the percentage of rot incidence of the tubers of Local variety.

Treatment	Time in days					Total
	15	30	45	60	75	
0 Krad	0	2	6	6	8	22
7 Krad	2	2	4	4	6	18
9 Krad	0	2	2	6	8	18

Table XLI : Effect of gamma radiation on the percentage of rot incidence of tubers of American 2 variety .

Treatment	Time in days					
	15	30	45	60	75	Total
0 Krad	2	2	6	6	6	22
7 Krad	0	2	2	8	8	20
9 Krad	0	2	4	4	8	18

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Table XLII : Effect of gamma radiation on the percentages of rot incidence of tubers of Okinawa variety.

Treatment	Time in days					Total
	15	30	45	60	75	
0 Krad	0	2	6	8	8	24
7 Krad	2	2	4	6	6	20
9 Krad	2	4	4	4	6	20

Table XLIII :Effect of gamma radiation on percentage of rot incidence of tubers of Taiwan variety.

Treatment	Time in days					Total
	15	30	45	60	75	
0 Krad	2	2	4	6	8	22
7 Krad	2	2	4	4	8	20
9 Krad	2	2	2	4	8	18

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that a greater amount of soluble sugar content was found to be present in the control tubers. In the treated tubers on the other hand there was a lesser amount of the content. As regards sugar content the difference between the control and treated tubers was found to be significant.

3.2.1.2. American 2 (Table XLV).

The results of the above table showed that the amount of soluble sugar content was always less in treated tubers throughout the experiment. At 75 days of the experiment a significant defference was observed between the control and treated tubers. At this stage there were less amount of sugar contents in both 7 and 9 krad treated tubers.

3.2.1.3. Okinawa (Table XLVI).

Results recorded in the table XLVI showed that in all stages of storage period the soluble sugar content was found to be lesser in amount in cases of radiated tubers. The control tubers always maintained a higher quantity of soluble sugar content throughout the experiment.

3.2.1.4. Taiwan (Table XLVII).

Results of the observations indicated that in Taiwan variety of sweetpotato the soluble sugar content was found to be lesser in case of both 7 and 9 krad treated tubers. The control tubers always maintained a greater amount of this content.

3.2.2. Starch content .

3.2.2.1. Local (XLVIII).

Results of the table XLVIII showed that in control tubers the

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Table XLIV :Effect of gamma radiation on the soluble Sugar content [1,2] of the tubers of Local variety .

Treatment	Time in days		
	15	45	75
0 Krad	8	12	17
7 Krad	6	7 **	9 **
9 Krad	5	6 **	6 **

Table XLV : Effect of gamma radiation on the soluble Sugar content [1,2] of the tubers of American 2 Variety.

Treatment	Time in days		
	15	45	75
0 Krad	9	14	15
7 Krad	5	5 **	7 **
9 Krad	5	6 **	6 **

1. Average value of 3 determinations each .
2. Sugar in gm/100 gm of fresh tuber weight.

** Significant at 1% level.

** Significant at 5% level.

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Table XLVI: Effect of gamma radiation on the soluble sugar content [1,2] of the tubers of Okinawa variety.

Treatment	Time in days		
	15	45	75
0 Krad	7	8	13
7 Krad	4*	5 *	8 **
9 Krad	4 *	6	7 **

Table XLVII : Effect of gamma radiation on the soluble sugar content [1,2] of the tubers of Taiwan variety .

Treatment	Time in days		
	15	45	75
0 Krad	6	9	11
7 Krad	3 **	5 **	6 **
9 Krad	4 *	4 **	4 **

1. Average value of 3 determinations each.

2. Sugar in gm/100 gm. of fresh tuber weight.

** Significant at 1% level .

* Significant at 5% level .

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starch content decreased slighly with the progress of the experiment. In treated tubers on the other hand, there was a very little change in their content. Results of the observations made at 75 days showed a significant difference in starch content in 9 krad and control tubers.

3.2.2.2. American 2 (Table XLIX).

Results of the observations indicated that the starch content decreased very slowly in 9 krad tuber. At 75 days of experiment a significant difference was observed as to the quantity of starch between 9 krad and control tubers.

3.2.2.3. Okinawa (Table L).

Data presented in table L showed that differences in starch content among the irradiated and control tubers were nonsignificant at three stages of observations.

3.2.2.4. Taiwan (Table LI).

Results showed that in all stages of observations the differences in starch content among the irradiated and control tubers were nonsignificant.

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Table XLVIII : Effect of gamma radiation on the starch content[1,2] of the tubers of Local variety.

Treatment	Time in days		
	15	45	75
0 Krad	22	18	17
7 Krad	24	22	21
9 Krad	24	23	22 *

Table XLIX : Effect of gamma radiation on the starch content[1,2] of the tubers of American 2 variety.

Treatment	Time in days		
	15	45	75
0 Krad	21	19	16
7 Krad	22	19	18
9 Krad	23	22	22 *

1. Average value of 3 determinations each.
2. Starch in gm/100 gm of fresh tuber weight.

* Significant at 5% level .

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Table L : Effect of gamma radiation on the starch content[1,2] of the tubers of Okinawa Variety .

Treatment	Time in days		
	15	45	75
0 Krad	16	14	14
7 Krad	18	17	15
9 Krad	18	17	17

Table LI : Effect of gamma radiation on the starch content[1,2] of the tubers of Taiwan variety .

Treatment	Time in days		
	15	45	75
0 Krad	17	16	15
7 Krad	19	17	16
9 Krad	20	20	19

1. Average value of 3 determinations each.
2. Starch in gm/100 gm of fresh tuber [illegible].

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IV. DISCUSSION

The effect of potassium naphthenate (KNap) on the growth, physiology and development of a number of crop plants has been studied by various workers, following application of different concentrations of the chemical at different growth stages of plants. Results of different workers have established the positive nature of stimulation of plant growth and biochemical processes following appropriate concentrations of KNap application(Yur'eva 1965; Naghibin 1966; Chu 1969; Wort 1969; Fattah 1969; Roy 1972; Khatun 1973; Fattah et al 1977; Bano 1978; Islam 1980 and Rahman 1981).

The diversity of opinion regarding the usefulness of growth regulators has arisen.from the accumulation of reports citing beneficial as well as adverse effects. However, it is now generally accepted that the effects induced by growth regulators is dependant on a variety of factors viz. specific concentration of. the growth regulator used, mode of application,the age of plants, vigor and growth, environmental conditions and level of endogenous growth regulator. It has been found that the sensitivity of growth regulator application shows considerable variation from species to species. A particular growth regulator which shows stimulation effect in one species might have no or opposite effect on another species. Likewise the concentrations of growth regulators and stage of growth of the plant are also of pivotal importance. The role of environmental factors can not be underestimated; temperature, humidity and light conditions greatly affect the responses

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of plant to growth regulators. Also various endogenous substances interact with an externally applied chemical and produce results which may be entirely different from what was expected.

Results presented herein are consistent with the view that when applied in appropriate doses to certain plants at the correct ontogenic stage and under appropriate climatic conditions, naphthenate can bring about significant stimulation of juvenile growth and this may lead to improved yield and composition as well as bring about stimulation of some physiological and biochemical activities (Fattah,1969). The present discussion is mainly based on the results obtained at harvest. The following aspects were taken into consideration during the discussion of data obtained. First a comparison has been made between four varieties with respect to all parameters considered. Secondly a comparison of all the treatments has been made separately for all the varieties in order to show which treatments brought about significant effects in different varieties. Furthermore, the objective of the investigation was to find out the concentration of KNap which stimulated the maximum parameters in one particular variety.

1. Physiological parameters:

1.1. Leaf number and leaf area (Table I and II, Figs 2 and 3)

During the present investigation the highest number of leaves were observed in the American 2 variety. The T_1 treatment

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increased the number of leaves in American 2, Okinawa and Taiwan. The T_2 treatment was found to increase the leaf number in Okinawa and Taiwan varieties.

The highest leaf area was recorded in Okinawa variety. The T_1 treatment has been found to increase significantly the leaf area in all the four varieties of sweetpotato and T_2 and T_3 treatments increased the leaf area in the American 2, Okinawa and Taiwan varieties but failed to do so in the Local one.

Using 50 ppm naphthenate, both as seed soaking as well as foliar spray Egiyani (1965) found no change in the leaf number of maize plants. Alizade and Guseinov (1965) obtained 143% increase in assimilative area of the leaves of egg plants treated with 500 ppm KNap solution. Fattah and Wort (1970 b) reported that 5000 ppm KNap spray increased the number of leaves in bush bean plants. Spraying 50 ppm and 5 ppm naphthenate on mulberry and olive trees Guseinov and Masiev (1965) obtained accelerated growth and development of aerial part of plants. Khatun (1977) found 20% increase in leaf area index of rice by soaking the seeds with 10 ppm followed by spraying the plant with 1000 ppm KNap. Bano (1978) obtained 66% increase in leaf area in maize following treatments with 2500 ppm KNap. Rahman (1981) obtained an increase in leaf area in Italian millet by successive spraying of the crop with 500 ppm and 1000 ppm KNap on 35 and 40 days old plants.

An increase in leaf number is of vital importance for plants because of the physiological role of leaf for photosynthesis. The importance of leaf growth in agricultural crop yield

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was stressed by Watson (1966). Relation between leaf area and yield in maize was reported by Eik and Hanway (1966). Wardlaw and Porter (1967) were of opinion that the carbohydrate in grains of cereals was largely derived from photosynthesis during the period of grain development and the major source of carbohydrate was the leaf.

Hanway (1966) obtained results which suggest that the yield of maize grain is associated with the leaf area produced early in the season and maintained during the grain formation period.

The results of the present investigation are in accord with those of some workers (Khatun 1977, Bano 1978 and Rahman 1981). If may be stated that KNap increases assimilative area of the treated plants, thereby contributing potential to better growth, development and eventually to more yield.

1.2. : Fresh and dry weight of aerial part of plants (Tables III and IV; Figs 4 and 5):

The results of the above tables show that both fresh and dry weight were found to be maximum in the Okinawa variety of sweetpotato without treatment. The T_1 treatment significantly increased the fresh weight of all varieties of sweetpotato. The T_2 treatment was found to increase significantly the fresh and dry weight of Okinawa and Taiwan varieties. A significant decrease in dry weight, was observed in Okinawa following T_3 treatment.

Both increase and decrease of plant parts following

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naphthenate treatments have been reported by different authors (Ladygina 1965, Wort and Patel 1970, Wort 1969, Begum 1977, Bano 1978). Ladygina (1965) obtained an increase in shoot number and assimilative surface per plant when he soaked potato tubers in 50 ppm growth promoting petroleum derivative for an hour before planting. Wort and Patel (1970) reported that 5000 ppm foliar spray of potassium naphthenate to the raddish plant resulted in an increase in the fresh and dry weight of leaves. Wort (1969) found that the foliar application of 5000 ppm solution of potassium naphthenate stimulated the growth of bush bean plants significantly. The application of 2500 ppm naphthenate to tobacco plants resulted in an increase in fresh weight of leaves by 25% (Begum 1977). Bano (1978) obtained an increase of 116,64% and 63,76% fresh weight of the stem and the leaf respectively following 2500 ppm foliar spray of KNap in maize.

According to Watson(1966) several factors influence the rate of production of dry matter and the total amount of the same. Since dry matter of any crop is mainly the accumulated products of photosynthesis it is affected by the crop's total photosynthetic area.

1.3: Yield (Tables V.VI,VII,VIII and IX; Figs 6 and 7).

The results of the comparison of control of different varieties of sweetpotato indicate that the Taiwan variety gave the highest yield in comparison to other cultivars of sweetpotato. It has been observed that T_1 treatment increase the yield in all

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the varieties of sweetpotato significantly. All the three treatments increased the yield of the Okinawa variety significantly. Although this variety is considered to be high-yielding (Adab News, 1978), in our experiment it gave a lower yield, lower yield than that of the Local variety, the variety which is considered to be low yielding. But the Okinawa responded very well with KNap application. In all the three concentrations of KNap the yield of this variety increased significantly.

Naphthenate have been found to increase the yield of various crop plants. For instance Baivarovskaya et al (1963) found that the plants sprayed during the vegetative period with 500 ppm sodium naphthenate solution showed a 17% increase in potato tubers yield and the same effect can be obtained by soaking tubers with 5 ppm growth promoting petroleum derivative before planting. The application of 200 ppm and 500 ppm naphthenate to two species of potato plants resulted in an increase in tuber yield of 9 to 9.6% respectively (Ladygina 1965). Guseinov et al (1956) reported that 2500 ppm KNap increased cabbage yield by 206% when the hormone was used along with normal fertilizer. By soaking seeds in 4000 ppm KNap before sowing Shakizade (1963) obtained 30% increase in yield in winter wheat. Huseinov (1960) reported that a 50 ppm solution of naphthenate applied to egg plants resulted in 32% increase in yield. Gianatdinov and Karpilov (1965) obtained a positive effect in yield when he planted the seeds of sugarbeet soaked in 50 ppm petroleum growth

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promoting substances for six hours. Yur'eva (1965) noted 13% increase in grain yield of maize by the application of 50 ppm KNap solution. Spraying of tangarine plants with 500 ppm growth promoting petroleum derivative before and during flowering increased the yield by 18.6 - 21.2% (Marshaniya et al 1967). Wort (1969) found that the foliar application of 5000 ppm solution of potassium naphthenate stimulated the juvenile growth of bushbean plants significantly and resulted in a 21% greater weight of green pods per plant. A 42% increase in yield of Early warba potato plants has been obtained by applying a 5000 ppm solution of potassium naphthenate 33 days before the tubers were dug out (Wort and Huges 1970). Applying 5000 ppm solution of KNap to 2-week old bush bean plants Fattah and Wort (1970b) obtained stimulation of vegetative and reproductive growth. Using 5000 ppm KNap solution Wort and Patel (1970) obtained a 23% increase in the yield of bush bean. Khan (1973) reported an increase in pod number of soybean by 22.52 and 21.77% and that in seed weight by 39.75 and 13.63% following an application of 3500 ppm and 5000 ppm KNap respectively. Fattah and Roy (1972) obsered that the grain number in maize increased by 14% and grain weight by 15% folowing foliar spray with 10 ppm KNap. Pasa (1971) obtained 22.85% increase in yield in Irri-8 variety of rice following foliar spray of 10 ppm KNap solution. Following foliar application of 1000 ppm KNap Fattah and Karmaker (1975) obtained 34.38% increase in yield in Seasame. Rahman (1981) reported an increase in yield in Italian millet by 52.28% when 500 and 1000 ppm KNap sprayings were successively made on 35 and 40 days

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Thus the yield was either positively or negetively affected depending upon the time of application, use of appropriate concentration and finally the mode of action of the KNap solution on a particular character or different characters which direcetly or indirectly influenced the yield paramater. So, the results obtained during the present investigations fairely agree with the findings of various workers who obtained enhanced growth and yield in various crop plants following different concentrations of naphthenate treatments (Baivarovoskaya et al, 1963; Ladygina, 1965; Guseinov et al 1956; Shakizade, 1963; Huseinov, 1960; Gianatdinov and Karpilov, 1965; Yor'eva, 1965;Fattah and Wort, 1970a; Wort and Hughes, 1970).

2. Biochamical parameters:

2.1. Leaf pigments:

The results presented in the tables X,XI,XII,XIII and figs 8,9,10,11 indicate that the different treatments have different effects on chlorophyll and carotenoid pigment content of leaves of different varieties of sweetpotato. Results show that in control conditions the maximum chlorophyll a content was found to be present in the Okinawa variety. T_1 treatment increased chlorophyll a significantly in all the varieties of sweetpotato. T_2 treatment also increased this content in all the varieties significantly except in the Local one.

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Among 4 varieties of sweetpotato chlorophyll b content was found to be higher in both local and American 2. Results reported here indicate that T_1 increased significantly chlorophyll b content in all the four varieties of sweetpotato. T_2 treatment on the other hand increased chlorophyll b content in American 2 and Taiwan varieties significantly but nonsignificantly in Okinawa variety. T_3 treatment decreased chlorophyll b content in the Local , American 2 and Okinawa varieties significantly.

Among the four varieties the carotenoid content was found to be highest in Taiwan variety. T_1 treatment increased carotenoid content significantly in American 2, Okinawa and Taiwan varieties. T_2 treatment on the other hand increased the same significantly in American 2 and Okinawa but nonsignificantly in Taiwan. T_3 treatments increased the content significantly in Taiwan but failed to do so in other varieties.

The results are in accordance with the previous findings of different authors (Ladygina, 1965; Bazanova and Akopova 1966; Pasa, 1971; Khatun 1977; Fattah et al, 1979). There are a number of reports available on the effects of KNap on chlorophyll pigments of plants.

Soaking tuber of two species of potatoes in 5 ppm naphthenate before planting Ladygina (1965) obtained an increase in the chlorophyll content of leaves. Spraying cotton plants with 100 ppm KNap solution Bazanova and Akopova (1966) found increased chlorophyll content in the leaves. Pasa (1971) reported that the application of 10 ppm KNap gave more pignents in leaves of IR-8 variety of rice. Khatun (1977) obtained

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23.89% increase in total chlorophyll content of rice by soaking the seeds with 10 ppm KNap with subsequent 1000 ppm foliar spray. Fattah et al (1979) obtained the increased chlorophyll content in maize plant by soaking seeds with 30 ppm KNap solution for 14 hours before sowing.

Increased production of chlorophyll is important to plants because this will facilitate the increased production of photosynthates. Greater photosynthate production leads to better growth and development of plants and subsequently to higher yield. But the increase in chlorophyll must also be associated with an increase in the quantity of enzymes and co-enzymes necessary for reduction of the products of dark reaction and a lower rate of photorespiration (Salisbury 1969). The pathway of chlorophyll synthesis is thought to be photoreduction of protochlorophyllide to chlorophyllide a followed by phytol esterification to form chlorophyll a. The phytol esterification of chlorophyllide a to chlorophyll a is catalysed by the enzyme chlorophyllase (Devlin, 1978). It is suggested that the chlorophyll b is formed from chlorophyllide a or chlorophyll a (Bogorad, 1966).

The stimulation of different pigment contents of leaves of sweetpotato by potassium naphthenate might be thought of as a stimulation of chlorophyllase enzyme activity by this chemical on the precursor molecule of chlorophyll pigment.

2.2. B-carotene:

In the present investigation two carotene rich varieties of sweetpotato were used. B-carotene content of tuber was measured in

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Okinawa and Taiwan varieties of sweatpotato.

A comparative results of the untreated plants show that the Taiwan variety is rich in β-carotene content. It was seen that both the cultivars of sweetpotato responded well to T_1 treatment. T_3 increased this content in the Taiwan variety significantly.

By the foliar application of 500 ppm potassium naphthenate Fattah and Khan (1977) obtained an increase in β-carotene content of roots of carrot by 18,26% . Spraying the plants with 1000 ppm KNap Ahmed (1981) obtained an increase in β-carotene in snake gourd by 31% .

β-carotene is synthesised locally within the roots of sweetpotato in the course of growth and development of the plant (Miller and Gaafar, 1958). Acetate is a primary precussor in carotenoid synthesis. The first few steps in carotenoid synthesis involve the formation of three acetyl CoA and their condensation into two successive reactions to form first Aceto acetyl CoA and then Hydroxymetheylglutaryl CoA . Hydroxymethylglutaryl CoA is then reduced to Mevalonic acid with the participation of $NADPH_2$. In the next, Mevalonic acid is phosphorylated in two step reaction to form Mevalonic acid pyrophosphate. The decarboxylation of Mevalonic acid pyrophosphate in presence of ATP and decarboxylating enzyme yields Isopentenyl pyrophosphate, which is a five carbon isoprenoid unit and from which all the carotenoids are derived.

In our experiment it was observed that some concentrations of KNap increased the β-carotene content in the tuber of sweetpotato .The machanism by which the KNap stimulated the production of β-carotene is not clearly known. It may be assumed that the KNap in someway stimulated the enzyme activities involved in different steps during formation

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of β-carotene from its precursor.

2.3. Soluble sugar and starch content:

Results of the tables XVI, XVII, XVIII, XIX, XX, XXI, XXII, XXIII and figs 13, 14 indicate that the T_1 decreased the soluble sugar content in all the cultivars nonsignificantly.

A comparison of control data of different varieties indicates that the starch content was found to be higher in Local variety. The T_1 treatment increased the starch content in American 2 and Taiwan significantly. The T_3 also showed a significant increase in the Taiwan.

Starch is the stored food material of sweetpotato tuber. Several workers have reported an increase in starch content in various crops following KNap application. Soaking the seeds of maize plants with 30 ppm KNap before sowing Fattah et al (1978) obtained 54.1% increase in starch content. Rahman (1981) obtained 7.8% increase in starch content by spraying with 1000 ppm KNap on Italian millet.

The increase in yield in sweetpotato is related to the accumulation of starch in its tuber. In this investigation it was observed that the different concentrations of potassium naphthenate stimulate the formation of starch in sweetpotato tuber. This finding agrees unison with the related findings of others (Bano, 1978, Fattah et al, 1977; Fattah et al 1978; Rahman, 1981).

2.4. Possible role of potassium naphthenate on the mobilization of photosynthetic assimilates.

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The partitioning of assimilates from their sites of synthesis to the harvestable regions of the plant is clearly of considerable agronomic importance. The possibility of regulating the translocation of assimilates by geneties or plant growth regulators offers much potential in increasing crop yields (Giaquinta 1980).

Ordinarily sweetpotatoes do not set seed (pearson, 1973). The sweetpotato normally sends all of the photosynthate produced in the leaves to the roots where it is stored and developing embryos following pollination of flowers literally starve to death (Pearson 1973). Thus in sweetpotate maximum priority is given to the storage of the photosynthate rather than to its utilisation to other metabolic activities. (Pearson, 1973).

The yield of sweetpotato seems dependant on the integration of several physiological processes : First, the primary production in relation to the photosynthetic activity; secondly the transfer of photosynthate from source to sink regions; thirdly the formation of storage tissue and subsequent accumulation of photosynthate in this tissue.

The storage food material in sweetpotato is starch. The mechanism by which potassium naphthenate stimulates the mobilisation of photosynthetic assimilates from source to sink is not well understood. Sucrose is the principal form in which assimilates are transported in higher plants has been clearly demonstrated with the use of radioactive carbon (Devlin, 1978).

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Translocation of assimilates to the importing regions ie dependant on the metabolic etatus of the sink. Treatments with chsmical can change the metabolism of the sink area (Geiger and Sovonik, 1975). Depending on the nsture of the sink, possibls sites of energy expenditure include exit of assimilates from the eieve tubes, accumulation of assimilatee in the consuming cella, biobhemical transformation such as respiration and biosyntheeis and intracellular compartmentation such as assimilate storage in the vacuoles. All of these processes would serve to deplete the concentration of assimilates in the sieve tubs and thus maintain a favourable concentration gradient for translocation (Geiger and Sovonick, 1975).

The mechnanism of assimilate translocation is different in different plants. Sugarcane stores sucrose in its storage tissus. The sucross is translocated to the cane stalk in the pholem followed by its entry into the free spacs where it is hydrolysed by a cell wall invertaes. The regulating hexoses are then actively accumulated in the cytoplasm of the storage cell, phosphorylated and resynthesised to eucrose phosphate (Glaszion and Gaylor, 1972). It was proposed that a epecific sucrose phosphate phosphatase is a part of the sucrocyl carrier mechanism which then catalyses sucrose transfer into vacuole for storage (Hawker and Hatch, 1965).

A different mechanism is observed in the mechanism of unloading and sucrose storage in the sugarbeet root. In sugarbeet sucrose

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accumulation into the storage parenchyma does not involve free space hydrolysis (Giaquinta and Wyse, 1978). In this case sucrose is translocated and accumulated in the storage parenchyma as sucrose.

The storage food material in sweet potato is starch. The photosynthate formed in the source leaf is possibly translocated towards the storage regions via sieve tubes of the phloem cells as has been unmistakably demonstrated in sugarcane and sugarbeet. It may be assumed that the increased rate of assimilate supply from "source to sink" following naphthenate treatment results due to increase in the level of endogenous growth regulators like GA or other phytohormones which in turn increase the rate of mobilization of photoassimilates or KNap may in some other way affect in the rate of mobilization.

There is a general agreement that phloem loading of assimilates requires metabolic energy (Giaquinta, 1980). The rate of translocation is closely coupled with the rate of photosynthesis (Christy and Swanson, 1976; Ho 1976; Servaites and Geiger, 1974; Throughton and Currie, 1977).

It is well known that ATP stimulates membrane transport of many solutes including sucrose translocation, sucrose efflux from the mesophyll, sucrose loading into sieve tubes and biochemical reactions involved in cation partitioning within mesophyll (Christy and Swanson 1976; Ho. 1976; Servaites and Geiger 1974; Throughton and Currie 1977).

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Fattah and Wort (1970 a) reported that KNap increased the rate of respiration and photosynthesis in bush bean following KNap application. Bano (1978) obtained stimulation of several respiratory enzymes following KNap treatment on maize plants.

These observations permit us to think that the action of KNap in sweetpotato would enhance the photosynthetic activity, and this activity might supply more substrate for respiratory process and hence more ATP production.

Fattah (1969) reported that phosphorylase enzyme activity is enhanced in bushbean following KNap treatment. The possible role of KNap in sweetpotato might be to produce increased amount of phosphorylase enzyme to form increased amount of starch in sweetpotato.

Moreover, K^+ stimulates translocation by stimulating cellular process (Ashley and Goodson, 1972; Malek and Baker 1977; Mongel and Haider, 1977 and Daman and Geiger 1978) mostly by changing permeability of cell membrane. Bano (1978) reported enhanced K^+ content in maize plant following KNap treatment. Thus it can be assumed that KNap enhanced the K^+ content which helped in the stimulation of photoassimilates in sweetpotato.

2.5. Protein.

Protein content of tubers was found to be affected by the application of KNap. Results of the comparison of untreated plants of different varieties of sweetpotato show that the protein

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content was found to be higher in the case of Local variety. The T_1 treatment increased the protein content in the Okinawa and in the Taiwan varieties significantly. The T_2 also increased this content in the Okinawa variety significantly.

By soaking seeds or spraying in vegetative period with 50 ppm naphthenate, Yur'eva (1965) obtained more protein in sugarbeet leaves. Soaking potato tubers with 50 ppm KNap before sowing Gruodienne and Buciene (1967) obtained increased nitrogen and nitrogenous substances in leaves. Peterburygsky and Karamete(1969) observed that a foliar spray of 70 ppm naphthenate treatment increased the synthesis of the ten amino acids at the beginning and at the end of the vegetative period in maize and increased the synthesis of protein and non-protein nitrogenous substances in the leaves and roots. Concentration of naphthenates ranging from 50 to 100 ppm considerably increased the total and protein nitrogen in the leaves of tomato, carrot and beet following treatments (Zhukova 1965).

Since KNap is reported to increase the transaminase and Nitrate reductase activities in different plants (Fattah & Wort 1970 a,Bano 1978), a corrilation exists between these enzyme activities and the increase in grain protein. Nitrogen used in grain protein synthesis is either mobilized from vegetative tissue where it was assimilated or is newly assimilated from the soils after synthesis (Simmons and Moss 1978). The works of Wort et al (1973) and Bano (1978) showed that enhanced activity of nitrate reductase following KNap treatment. In the present

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experiment the nitrate reductase activity was enhanced following KNap application.

Fattah (1971) has reported an increased R.N.A. synthesis following KNap treatments in bushbean plants. Increased activity of nitrate reductase observed in sweetpotato following KNap treatment may account for the increased amount of protein in tubers of sweetpotato.

2.6. Nitrate reductase.

It was observed that different concentration of KNap have different activities in four cultivars of sweetpotato. In the nontreated plants the nitrate reductase activity was found to be higher in case of Local and Taiwan varieties of sweetpotato. The T_1 treatment increased the nitrate reductase activity in the Okinawa and in the Taiwan significantly. It was observed that T_2 treatment alone increased the nitrate reductase activity in the Okinawa variety significantly. Results also indicate that the Local cultivar responded negatively with T_3 treatment.

The application of $2x10^{-2}$M KNap to 14-day-old bean plants resulted in increases in the specific activity of several leaf enzymes involved in nitrogen assimilation measured seven days after treatment (Wort et al 1971). It was suggested that the stimulation of plant metabolism by naphthenates must be general (Wort et al 1971). By the application of 2500 ppm KNap on Maize plant Bano (1978) obtained an increase in nitrate reductase activity

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in the leaves of the treated plants. Beevers and Hageman (1969) stated that the nitrate reductase activity can be induced by temperature, intensity of illumination and supply of nitrate. The nitrate level needed for optimal induction varies between species (Beevers, Schrader, Fleshes and Hageman 1965).

3. Effects of ionising radiation on the storage quality of sweetpotato.

This investigation was an attempt to use ionising radiation for the preservation of sweetpotato in local climatic conditions. The aim was to check up growth and to evaluate other associated physical and biochemical effects of tuber during storage. During the present investigation four varieties of sweetpotato namely Local, American 2, Okinawa and Taiwan were used to see their storage quality after irradiating them to ionising radiation. The level of radiation used during the experiment was 7 and 9 krad.

3.1. Physical changes :

3.1.1. Initiation of sprout growth.

The 9 krad treatment almost completely inhibited sprout growth in all varieties of sweetpotato used during the investigation It is clear from the results (Tables XXXII, XXXIII, XXXIV, XXXV) that the 9 kr treatment completely inhibited the sprout growth in Local and Taiwan varieties. It has been observed that during the storage period the sprouts that initiated in the tubers after 9 krad treatment were dried up with the progress of the experiment.

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Siddiqui et al (1973) working on potato tuber showed that 4-6 krad inhibited completely the sprout growth of potato tuber. The same author (Siddiqui et al 1979) has shown that 4,6 and 8 krad treatment completely inhibited the sprout growth of onions. Khan and Wahid (1977) have shown that 10 krad treatments completely inhibited sprout growth in onion bulbs. It is throught that radiation inactivates the biologically active mitotic cells and this is achieved by the reactions originating from the cell nucleus. The plausible idea is the the primary effects of radiation are seen perhaps in the minute structural changes of DNA molecule initiating "amplified" change in the cells metabolism and thus lead to inactivation.

3.1.2. Weight loss.

The percentage of weight loss due to drying up and sprout growth for various treatments are shown in tables XXXVI, XXXVII, XXXVIII and XXXIX. It is evident from the results that the weight loss was found to be higher in case of control tuber. This holds true for all the varieties of sweetpotato. The loss of weight was comparatively lower in Taiwan variety when irradiated with both 7 and 9 krad. Working on the storage quality of onion bulbs subjected to gamma radiation Siddiqui et al (1979) have shown that the sprouted bulbs were found to loose weight at higher rates than non-sprouted ones. Loss in weight of control tubers that had sprouted was higher than that of the irradiated tubers (Kahan, 1968). These results are in agreement with the present work on sweetpotato irradiated with gamma radiation.

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3.1.3. Rot incidence:

During the storage period of 75 days the number of tubers was discarded due to rot in various treatments. The cases of rot incidence were found in all varieties of sweetpotato. The tubers discarded due to rot were slightly lower in case of treated tubers. (Tables XL, XLI, XLII, XLIII).

Siddiqui et al (1979) reported that the rot incidence was higher in case of control onion bulbs. These results are in agreement with this investigation on sweetpotato tuber. Working on potato tuber Khan and Wahid (1977) have shown that the tendency of rotting was slightly higher in irradiated tubers than in the control. The studies of Ulman (1969) and Urbain(1973) show that irradiation does not increase rot if healthy, cleaned and well-healed tubers are used for the study.

Kalman (1978) are of opinion that two conditions affect the rot incidence in the stored onion bulbs: storage temperature and physiological state of the bulbs. Sprouted bulbs were found to be more susceptible to storage rots than the non sprouted ones. The physiological process responsible for germination are retarded by irradiation. This conclusion has been widely accepted by many other workers (Farkas, 1971, Kalman 1978).

3.2. Biochemical changes:

It is clear from the experiments (Tables XLIV, XLV, XLVI, XLVII) that the total sugar content was found to increase in the control tubers of all varieties to a considerable extent at the end of the storage period . It has already been mentioned earlier that sprouting

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occurs in the control tubers at a higher rate than the gamma irradiated tubers.

Sprout initiation requires a good amount of energy. This energy is derived from hexose following the breakdown of previously accumulated starch in the tuber.

As regards changes in the starch contents these registered a slight decrease in the control tubers with the progress of the experiment. In irradiated tubers these molecules show a tendency to remain unchanged during the whole period of the experiment. This difference between the control and irradiated (9 kr) at the end of the experiment became pronounced. Local and American 2 varieties showed this difference sharply. It is clear from the result (Table XLVIII,XLIX, L and LI) that in the 9 krad treated materials no change in the amount of starch grains was observed.

4. Conclusion.

The yield of a crop is a most important parameter,the expression of which requirs the association of many other physiological and biochemical characteristics. Out of four varieties of sweetpotato used in the experiment the Taiwan is considered to be the best in yield potential. The expression of other parameters like carotenoid pigments, β-carotene and nitrate reductase activity were also found to be maximum in this variety. It is evident from the experiment that the four varieties of sweetpotato show differences in their physiological and biochemical characteristics. For example, parameters

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like fresh weight, dry weight, leaf area and chlorophyll a content were found to be maximum in the Okinawa. The starch and protein content were found to be higher in the Local variety. The nitrate-reductase activity was also maximum in this variety. It was found that the American 2 is characterised by the maximum number of leaves and by the presence of maximum amount of chlorophyll b content.

Among the three different concentrations of potassium naphthenate used during the present investigation, it was seen that the treatment T_1 was found to be most effective in stimulating the maximum parameters (Figs LVI, LVII and LVIII). This treatment showed increasing effects in parameters like leaf number, branch number, fresh weight, dry weight, leaf area, yield, chlorophyll a and b contents, carotenoid content (except Local), β-carotene content, starch content, protein content and nitrate-reductase activity. In only one case the activity of this treatment was negative and that was in the parameter-soluble sugar content. Regardless of the varieties and the parameters considered (except soluble sugar) the T_1 treatment showed a most stimulatory effect in bringing about changes in physiological and biochemical characteristics. The second best treatment was found to be T_2. This treatment showed stimulation in leaf number, fresh weight, dry weight, chlorophyll a and b contents in all the varieties (Figs LVI, LVII & LVIII).

As regards stimulation of different parameters in one particular variety, the effects of T_1 treatment on the Taiwan variety were found to be maximum . The second best variety was found to be Okinawa in relation to T_1 treatment.

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Table LII : Relationship between leaf area and yield of four varieties of sweetpotato.

Varieties	Correlation co-efficient
Local	0.80
American 2	0.91
Okinawa	0.86
Taiwan	0.93

Table LIII : Relationship between chlorophyll a content of leaf and yield of four varieties of sweetpotato.

Varieties	Correlation co-efficient
Local	0.99
American 2	0.98
Okinawa	0.89
Taiwan	0.99

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Table L IV : Relationship between starch content of tuber and yeild of four varieties of sweetpotato .

Varieties	Correlation co-efficiant
Local	0.74
American 2	0.99
Okinawa	0.90
Taiwan	0.83

Table L V : Relationship between nitrate reductase activity of leaf and protein content of tuber of four varieties of sweetpotato

Varieties	correlation co-efficient
Local	0.95
American 2	0.96
Okinawa	0.99
Taiwan	0.76

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Table LVI : Increase* or decrease (ascompared to control) in the physiological parameters following KNap treatments in four varieties of sweetpotato.

Parameters	Treatment	Variety			
		Local	American 2	Okinawa	Taiwan
Leaf No.	T_1	+	+++	+++	+++
	T_2	+	+	++	++
	T_3	-	---	+	++
Branch No.	T_1	+	+	++	+
	T_2	---	+	++	+
	T_3	-	+	++	-
Fresh Weight of areial part.	T_1	+++	+++	+++	+++
	T_2	+	++	+++	+++
	T_3	+	-	-	+++
Dry weight of aerial part.	T_1	+++	+++	+	+++
	T_2	++	+	+++	+++
	T_3	+	-	---	+++
Leaf area	T_1	+++	++	++	+++
	T_2	-	++	+++	+++
	T_3	+	++	+++	++
Yield	T_1	++	++	++	+++
	T_2	-	++	+++	+
	T_3	-	+	+++	+

* Increase or decrease = + or - (non significant)
Increase or decrease =++ or --(significant at 5% level)
Increase or decrease=+++ or ---(significant at 1% level)

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Table LVII : Increase* or decrease (as compared to control) in the biochemical parameters (chlorephyll a, b, carotenoid pigment and β- carotene content) following KNap treatments in four varieties of sweet potato.

Parameter	Treatment	Variety			
		Local	American 2	Okinawa	Taiwan
Chlorophyll a	T_1	+++	+++	+++	+++
	T_2	+	+++	+++	+++
	T_3	-	-	+++	+++
Chlorophyll b	T_1	+++	+++	++	+++
	T_2	+++	++++	+	++
	T_3	+++	---	--	+
Carotenoid	T_1	-	+++	+++	+++
	T_2	-	++	+++	+
	T_3	-	---	+	+++
β-carotene	T_1			+++	+++
	T_2			+	-
	T_3			+	+++

* Increase or decrease = + or - (non significant)

Increase or decrease =++ or -- (significant at 5% level)

Increase or decrease = +++ or ---(significant at 1% level)

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Table LVIII : Increase * or decrease (as compared to control) in the biochemical parameters (soluble sugar, starch, protein content and nitrate reductase activity) following KNap treatments in four varieties of sweetpotato.

Parameter	Treatment	Variety			
		Local	American 2	Okinawa	Taiwan
Soluble Sugar	T_1	-	-	-	-
	T_2	+	+	-	-
	T_3	-	+	-	+
Starch	T_1	+	+++	+	+++
	T_2	+	0	--	+
	T_3	+	++	+	++
Protein	T_1	+	+	++	+++
	T_2	-	+	+++	-
	T_3	-	+	+	+
Nitrate reductase	T_1	+	+	++	++
	T_2	-	+	++	-
	T_3	---	+	+	+

* Increase or decrease = + or - (non significant)

Increase or decrease = ++ or -- (significant at 5% level)

Increase or decrease = +++or --- (significant at 1% level)

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As has been mentioned earlier that yield is dependent on various different physiological and biochemical parameters. In the experiment it was found that physiological parameter like leaf area and biochemical parameters like chlorophyll a and starch were positively correlated with the yield of sweetpotato plants (Figs LII,LIII & LIV). Similar positive correlation was observed in the protein content of tubers and nitrate-reductase activities of leaves(Fig LV).

The stimulations of physiological and biochemical activities of sweetpotato plant by KNap during the present investigations suggest that the action of this synthetic growth regulator is possibly mediated through a number of steps:

i) Stimulation of respiratory enzymes, which in turn increase the available energy needed for mineral uptake by the plant and a number of synthetic reactions involved in plants.

ii) Stimulation of amino acid synthesis (Wort et al 1973).

iii) Stimulation of the synthesis of RNA'S (Pakhomova, 1965, Fattah 1971).

iv) Stimulation of leaf area and also the pigment content of leaves.

v) Stimulation of the enzymes necessary for the reduction of Co_2 leading to more carbohydrate production.

Thus, more carbohydrate and protein content in plant parts supply raw materials for building new plant organs and also necessary energy requirements.

vi) Stimulation of synthesis and activities of some growth regulators e.g. Indole acetic acid (Loh, 1974) and gibberellic acid.

An answer to the action of KNap may lie in the control of the mechanism by which enzymes are made in the cell e.g. at the transcription or at the translation level. Pakhomova (1965) reported an increase in the content of α-nucleoprotein complex in leaves

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and vegetative apices of naphthenate treated plants.

From the above reports it could be inferred that an appropriate concentration of naphttenate has stimulative effect at the physiological, enzymic and molecular level and as a result of which treated plants have better growth, development and yield.

The second aspect of the study included the physical and biochemical changes of stored tubers following radiation treatment. The results recorded were as follows :

i) The 9Kr treatment was effective in inhibiting almost completely the sprout growth in all the varieties of sweetpotato. The complete inhibition of sprout due to this treatment was found in the Local and in the Taiwan varieties.

ii) The rot incidence was observed in all the varieties regardless of the control and treated tubers. However, the incidence of rot was slightly lower in the treated tubers.

iii) In control tubers of all the varieties of sweetpotato the soluble sugar content was found to be augmented at the end of the experiment. There was a very slight increase in this content in irradiated tubers during the whole period of the experiment.

iv) In 9 Kr treated tubers practically no change in the amount of starch was observed in all the four varieties. In the control tubers of all those varieties, on the other hand, the starch content registered a slight fall with the progress of the experiment.

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Fattah and Wort (1970 a) reported that KNap increased the rate of respiration and photosynthesis in bush bean following KNap application. Bano (1978) obtained stimulation of several respiratory enzymes following KNap treatment on maize plants.

These observations permit us to think that the action of KNap in sweetpotato would enhance the photosynthetic activity, and this activity might supply more substrate for respiratory process and hence more ATP production.

Fattah (1969) reported that phosphorylase enzyme activity is enhanced in bushbean following KNap treatment. The possible role of KNap in sweetpotato might be to produce increased amount of phosphorylase enzyme to form increased amount of starch in sweetpotato.

Moreover, K^+ stimulates translocation by stimulating cellular process (Ashley and Goodson, 1972; Malek and Baker 1977; Mongel and Haider, 1977 and Daman and Geiger 1978) mostly by changing permeability of cell membrane. Bano (1978) reported enhanced K^+ content in maize plant following KNap treatment. Thus it can be assumed that KNap enhanced the K^+ content which helped in the stimulation of photoassimilates in sweetpotato.

2.5. Protein.

Protein content of tubers was found to be affected by the application of KNap. Results of the comparison of untreated plants of different varieties of sweetpotato show that the protein