NUTRITIONAL STUDIES IN SWEET POTATO

By

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D E C L A R A T I O N

I hereby declare that this thesis entitled "Nutritional studies in sweet potato" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

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Vellayani,

19.7.1987.

C E R T I F I C A T E

Certified that this thesis entitled "Nutritional studies in sweet potato" is a record of research work done independently by Sri. D. BHUVANANDRAN NAIR under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

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C O N T E N T S

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INTRODUCTION

1. INTRODUCTION

Sweet potato is one of the most important root crops cultivated in Asian countries. It is a crop of considerable importance in India also. Eventhough the estimated production potential of sweet potato in India is 37 tonnes per hectare, the average farmer's yield is only around 7 tonnes per hectare. In Kerala the crop is at present being cultivated in an area of 5080 hectares which is too low. It is a short duration root crop adapted to tropical conditions and can be grown year round irrespective of the season. This characteristic of the crop offers considerable scope for increasing its production in our State.

In the quest for food and struggle for human survival, the sweet potato has historically played an important role. It has been accepted as a staple food crop in several countries. Sweet potato is one of the world's highest yielding crops with a high rate of food production per unit area exceeding that of rice, that too with a high food value. Because of its high level of nutrition, high productivity and low input requirement it is a useful component of home and kitchen gardens. Daily consumption of the starchy staple types of sweet potato provides sufficient vitamin 'A' to prevent the debilitating diseases caused by deficiency of this vitamin. Not only the roots are rich in nutrients, the tender shoots of sweet potato also serve as an important source of vegetable and food in many countries. Sweet potato is widely used as an animal feed. It provides considerable amount of vitamin 'C' (20 to 30 mg/100 g). Vitamin B_1 (Thiamin) is also present in adequate amounts, about twice the level required by humans. Iron content is sufficient for sweet potato eaters who consume 2 kg or more per day.

In Kerala the crop which is grown in a limited area is cultivated in low land and up land situations. It is a popular root crop which is widely cultivated in Trivandrum district. The crop is mainly cultivated during the seasons of June-July to September-October as rain fed crop and during October-November as irrigated crop in up lands. But the per hectare productivity of the crop is considerably low as already mentioned. Some of the valid reasons for the low level of productivity may be due to the nonavailability of high yielding varieties of the crop and unscientific methods of cultivation especially with respect to crop nutrition. Sweet potatoes are seldom fertilized or irrigated and are generally neglected in most parts of the State. In order to produce a satisfactory crop the optimum conditions for growth and root development must be provided.

In Kerala probably because of the flexibility in soil and climatic requirements of this tuber crop, work on genetic improvement and environmental modifications for exploiting the yield potential had long been neglected. Three promising high yielding varieties (H-2743, H-4021 and H-4126) have recently been developed at the College of Agriculture, Vellayani. Similarly a variety Cross-5 evolved at Rajendra Agricultural University, Bihar, is also reported to be a promising one. Detailed information on the suitability of these varieties in this region has not been obtained yet.

As noticed in many other root crops, the tuber yield in sweet potato is greatly influenced by the major nutrient elements like, nitrogen and potassium than by any other essential mineral elements. Several fertilizer experiments in sweet potato using nitrogen and potassium have been conducted in different parts of the country and abroad. Experiments conducted at the Central Tuber Crops Research Institute, Trivandrum, clearly demonstrated the scope of improving the level of productivity by nitrogen and potassium nutrition of the crop. Scientists generally agree that for maximising sweet potato yield, the level of potassium in the soil should be considerably higher than that of nitrogen. It is often observed that a high dose of nitrogen favours excessive vegetative growth at the expense of root and tuber development. However, much work on the nutritional requirements of the newly evolved high yielding varieties have not been carried out in Kerala.

Application of these key nutrient elements viz. nitrogen and potassium at critical growth stages of the crop enhances the efficiency of applied nutrients. In this context, the time of application of nutrients assumes considerable practical importance in crop nutrition studies. Application of the entire dose of nutrients basally may be disastrous under the agroclimatic conditions existing in our State, as it will lead to substantial leaching losses of these water soluble nutrients and thereby depriving the crop of these nutrients at later critical growth stages. So split application at the critical growth stages is necessary. Since much information on the aforesaid aspects are lacking with regard to the newly evolved high yielding varieties of sweet potato it was considered worthwhile to investigate in up lands with the following objectives.

1. To study the adaptability and performance of newly evolved hybrid varieties of sweet potato namely Cross-5, H-2743, H-4021 and H-4126, under up land conditions.

2. To assess the optimum levels of nitrogen and potassium for these high yielding varieties of sweet potato under up land conditions.

3. To find out the best time of application of nitrogen and potassium for maximising tuber yield.

4. To estimate the nitrogen and potassium uptake of the four sweet potato varieties under up land conditions.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Nitrogen and potassium are two vitally important plant nutrient elements, the deficiency of which often limits plant growth. The present investigation deals with the effect of nitrogen nutrition in conjunction with potassium on the growth, tuber yield and quality of four different sweet potato varieties to the finely weathered well drained deep to very deep forest soils of Peringammala in Trivandrum district. The available literature on the effect of different levels and times of application of nitrogen and potassium on the growth, yield and quality of sweet potato are reviewed below.

2.1. Nitrogen

2.1.1. Effect of nitrogen on vine growth

Inordinate development of vine at the expense of roots as a consequence of excessive application of nitrogenous matter was observed by Morgan and Rose (1892). Stuckey (1914) observed significant increase in yield of vine as a result of application of nitrogenous fertilizer. Zimmerly (1929) observed that vine growth was more markedly affected by difference in nitrogen content of fertilizer materials than by difference in phosphorus or potassium. Vine growth according to Johnson and Ware (1948) increased as a result of the application of nitrogen. Stino (1953) also obtained similar results. Yuan et al. (1964) reported that heavy nitrogen manuring caused excessive vine growth resulting finally in dense standing. Nambiar et al. (1976) in another experiment observed that increasing rate of applied nitrogen had no effect on the length or weight of vines.

Bourke (1977) after conducting field trials in young volcanic soils reported that increased dose of nitrogen application increased top yields in sweet potato. Jana (1982) found that added nitrogen may increase top growth, that is vine growth, in sweet potato and reduce root yield. Kim (1982) reported that high nitrogen levels caused increased leaf area and this increased the top yield. Navarro and Padda (1983) observed increased vine growth at increased rate of nitrogen application.

2.1.2. Effect of nitrogen on tuber development and yield of tuber

Schermerhon (1924) found that very rough, irregular and slender tubers were produced by the use of excessive amount of nitrogenous fertilizers. Johnson and Ware (1948) observed that high nitrogen application stimulated vine growth as well as tuber production. However when nitrogen needs are satisfied the additional nitrogen goes into vine production. They obtained maximum tuber yields in sweet potato at nitrogen rates ranging from 80 to 120 kg per hectare on four different soil types. Landran and Samuels (1951) reported increased sweet potato yields by the application. However, application of 165 kg nitrogen per hectare was excessive, causing heavy vine growth and resulted in low yields of poor quality tubers.

Narasimha Rao and Narasingha Rao (1954) reported that the size and shape of tubers were controlled by the quality and quantity of manure given to the crop. Long slender and rough tubers were obtained due to the increased dosage of nitrogen. They further observed that influence of nitrogen is exhibited by increasing length of tuber and a corresponding decrease in girth.

From the experiments conducted at Trivandrum for three years from 1954 to 1957, Kunjan (1957) concluded that the optimum dose of nitrogen for sweet potato was 50 kg per hectare. Further increase in nitrogen dose failed to produce significant yield increase. Significant yield increase due to moderate nitrogen fertilization was observed by Mac Donald (1963), but a decrease in tuber yield was noticed at excessive nitrogen levels.

Peterson and Speights (1964) had shown significant positive response to nitrogen fertilizer in terms of yield of sweet potato. When the dose of nitrogen was increased from zero to 50 and 50 to 100 kg per hectare in the case of crop grown in rotation under continuous sweet potato cultivation, significant response was obtained only up to 50 kg nitrogen per hectare.

Greig (1967) reported that nitrogen dose higher than 50 kg per hectare decreased the yield of sweet potato. An increase in number and width of secondary xylem vessels associated with the continuous cambial zone resulting from an application of higher dose of nitrogen has been reported by Speights et al. (1967) in a histological observation of the sweet potato tuber.

Tsuno and Fugise (1968) concluded that to produce a high yield of tuber of high starch content nitrogen application should be moderate in order to prevent excessive development of tops at the expense of tuber growth.

Mandal et al. (1971) observed that in the red loam soils of Kerala maximum tuber yield was obtained at 100 kg nitrogen per hectare, which was not significantly superior to 75 kg. Nambiar et al. (1976) observed that increasing rate of applied nitrogen had no significant effect on the length of individual tubers but the number of tubers per plant was significantly increased, that is tuber yield increased with increasing rate of applied nitrogen.

Bourke (1977) after conducting field trials in young volcanic soils reported that increased dose of nitrogen application increased top yields in sweet potato. Muthuswamy et al. (1981) found that tuber yield increased with increasing nitrogen nates.

It was reported by Jana (1982) that added nitrogen may reduce the tuber yield in sweet potato. In an experiment to study the effects of sulphur, phosphorus and nitrogen application on sweet potato, moderate of nitrogen application increased tuber yield. But tuber yield decreased with heavy doses of nitrogen application by increasing vine yield.

High nitrogen level according to Kim (1982) delayed root enlargement and reduced yield. Hammet et al. (1984) reported that root yields were higher with moderate rates of nitrogen application than with higher rates.

After studying the effect of varying levels of nitrogen on sweet potato yield, Constantin et al. (1984) reported that root weight and percentage of top grade roots increased with nitrogen application. Mascianica et al. (1985) observed that maximum sweet potato tuber yield was obtained at a nitrogen level of 88 kg per hectare.

2.1.3. Effect of nitrogen on the quality of tuber

Mac Donald (1963) noticed that nitrogen fertilization was not associated with the quality and flesh colour of tubers. At the same time Tsuno and Fujise (1968) reported that for producing tubers of high starch content, nitrogen application should be moderate in order to prevent excessive development of the tops at the expense of tuber growth.

As a consequence of increased dose of nitrogen supply Dean and Lasheen (1969) observed significant decline in both total sugars and starch content in sweet potato tubers. Maximum dry matter and carbohydrate content of tubers was noticed at the nitrogen dose of 75 kg per hectare in the studies of Mandal et al. (1971). Constantin et al. (1974) proved by experiment that increasing nitrogen levels up to 100.9 kg per hectare resulted in a lineate increase in protein content of sweet potato.

Muthuswamy et al. (1981) reported that nitrogen had no effect on starch content. Bartoliny (1982) concluded that increasing levels of nitrogen fertilizer seemed to result in an increase in the percentage of starch content of roots. Constantin et al. (1984) found that the crude fibre content decreased with increased rate of nitrogen application.

2.1.4. Effect of nitrogen on the uptake of nitrogen and potassium

As a consequence of nitrogen application an increase in nitrogen content of tubers was resulted in the experiments of Dean and Lasheen (1969). A positive correlation between nutrient contents of tubers and vegetative parts during the growth period was observed by Mica (1969). There was however no significant relation between nutrient content of tuber and rate of fertilizer application.

Nair et al. (1976) observed that tubers and total nitrogen uptake increased with increased rate of nitrogen application. Purcel et al. (1982) observed that the application of nitrogen fertilizer to sweet potato increased the root nitrogen content but did not affect root yield.

2.2. Potassium

2.2.1. Effect of potassium on vine growth

Zimmerly (1929) observed that potassium had less marked effect than nitrogen in sweet potato. Stino (1953) found that the vine growth did not increase as a result of the application of the potassium. Studies by Bautista and Santiago (1981) had shown increased plant growth with increased rate of potassium application.

2.2.2. Effect of potassium on tuber development and yield of tuber

Stino (1953) conducted field experiments in fertile Nile delta and revealed that potash was found to be more essential than either nitrogen or phosphorus for the yield of fleshy roots in sweet potato. Fujise and Tsuno (1962) reported that tuber dry weight on the high potassium plot was 20 per cent higher than that of the control plot, while the top dry weight showed no difference between both plots showing that heavy application of potassium promoted especially the growth of tuber. Morita (1967) stated that a high proportion of potassium as compared to nitrogen was favourable for effective tuber formation. Wang (1975) reported that sweet potato is particularly responsive to potassium application.

Bourke (1977) obtained increased tuber yields with increased rate of potassium application in a trial conducted in New Britain, Bautista and Santiago (1981) also obtained increased tuber yield with increased potassium application. On the contrary Muthuswamy et al. (1981) reported that potassium had no effect on the tuber yield of sweet potato. Similarly Villareal (1982) was of the opinion that for maximum sweet potato yields, the level of potassium in soil should be increased several times more than the level of nitrogen.

At the same time Jana (1982) opined that potassium had little effect in tuber yield of sweet potato.

Tsuno (n.d.) observed that low temperatures and heavy potassium application promote storage root induction. Hammett et al. (1984) found that the marketable tuber yields were higher with higher rates of potassium application. Nicholaides (1985) reported that in sweet potato, total yield increased with increased rate of potassium application especially in soils of low potassium status.

2.2.3. Effect of potassium on tuber quality

While studying the influence of nutrients on protein and phosphorus content of sweet potato tuber, Muthuswamy and Krishnamoorthy (1976) understood that tuber protein content increased with 50 kg K_2O per hectare whereas it decreased with 100 kg K_2O per hectare. Constantin et al. (1977) observed that potassium application from zero to 140 kg per hectare at four locations had more influence on quality of sweet potato than phosphorus applications of zero to 73.9 kg per hectare. Potassium slightly increased crude fibre content on dry weight basis. The crude fibre content increased from 2.96 per cent at 28 kg potassium per hectare to 3.05 per cent at 84 kg potassium per hectare.

Muthuswamy et al. (1981) reported that increased rates of potassium though not significantly increased starch content.

Ashokan et al. (1984) found that the starch content of tuber was increased by higher levels of potash. Sharafuddin and Voican (1984) found that high dose of potassium had increased the protein content and decreased dry matter content. Similarly in another experiment they found that high doses of potassium significantly increased the starch content of sweet potato tuber.

2.2.4. Effect of potassium on the uptake of nitrogen and potassium

Duncas et al. (1958) had experimentally proved that the potassium content of sweet potato increased as the rate of potash application increased. Fujise and Tsuno (1962) observed that increase of tuber dry weight runs parallel with K_2O/N ratio in the tuber. Yield reduction of tuber due to increased K_2O/N ratio in the tuber substantiating the necessity to maintain high K_2O/N ratio in tuber for higher yield. They opined that higher potassium probably might have increased the potassium content in leaves.

A positive correlation between nutrient contents of tubers and vegetative parts during the growth period was observed by Mica (1969). Fujise and Tsuno (1962) reported that higher potassium dose probably might have increased the potassium level in leaves which in turn might have accelerated the photosynthetic rates of leaves resulting in higher starch accumulation in roots. Purcel et al. (1982) had shown that potassium application did not affect nitrogen content but increased root yields significantly. Hammett et al. (1984) obtained a positive response in root potassium content to increased rate of potassium application.

2.3. Effect of combined application of nitrogen and potassium on growth and yield

From the results obtained by single application of mineral fertilizer materials and a complete fertilizer for sweet potatoes Stuckey (1919) found that a complete fertilizer mixture was necessary for high yields. Debaun (1919) recommended the use of 1200 kg per hectare of 3-9-6 fertilizer for securing economic yields in sweet potato.

In an experiment by Hotchkiss (1921) application of 130 kg per hectare of nitrate of soda, 320 kg per hectare of acid phosphate and 80 kg per hectare of sulphate of potash resulted in better yields of sweet potato. Similarly Chung (1923) observed an increase in tuber yield of 42 per cent by application of a mixture of sodium nitrate, potassium sulphate and acid phosphate at the rate of 75, 50 and 400 kg respectively per hectare.

Anderson (1942) got positive response in sweet potato to applications of a 8-8-8 fertilizer mixture at the rate of 600 kg per hectare on a 6-6-6 fertilizer mixture at the rate of 800 kg per hectare in a field experiment. Hollar and Haber (1943) found that a complete NPK fertilizer in the ratio 3 : 9 : 18 at the rate of 500 kg per hectare produced good yields of sweet potato. Hester (1947) observed that for average sweet potato soils an application of 3-9-12 fertilizer mixture at the rate of 1500 kg per hectare produced satisfactory yields. At the same time Landran and Samuels (1951) recommended the use of fertilizer mixture of 6-8-16 at the rate of 600 kg per hectare for getting good yields.

On experimentation Thompson and Kelley (1957) found that on sandy and sandy loam soil 40 to 80 kg of nitrogen, 80 to 120 kg of phosphate and 80 to 160 kg of potash per hectare should be applied for getting the maximum yield of sweet potato. In another experiment by Lantican and Sorino (1961) highest yield of tubers were obtained by the application of 100 kg N, 90 kg P_2O_5 and 90 kg K_2O per hectare. Fujise and Tsuno (1962) observed that increase of the tuber weight runs parallel with the K_2O/N ratio in the tuber. In addition they noticed that combined application of nitrogen and potassium gave considerable yield increase in sweet potato.

Based on the experiments conducted at Vellayani, Thomas (1965) concluded that the best fertilizer combination for economic yield was 80 : 50 : 80 of nitrogen, phosphate and potash respectively per hectare. Samuels (1967) observed an increase in sweet potato yield with the N : K fertilizer ratio of 1 : 2 as compared to the ratio of 0 : 2 and 2 : 2 in loamy sands and clay loam soils of Puerto Rico Experiment Station. Spense and Ahmad (1967) reported that inadequate potassium resulted in no storage root formation. Ho (1969) recorded maximum yield of sweet potato at 60 kg nitrogen, 50 kg P_2O_5 and 120 kg K_2O per hectare in Taiwan.

Chew (1970) after conducting experiments came to the conclusion that sweet potato on virgin peat soil should be dressed with 20 to 40 kg per hectare of nitrogen, 20 kg of phosphoric acid and 60 to 120 kg of potash per hectare for maximising tuber yields, for securing higher yields and better quality tubers. Mandal and Singh (1971) recommended an application of 75 kg potash in combination with 10 tonnes of farm yard manure per hectare.

Dean and Knavel (1971) observed that the size of the tuber was influenced by the nitrogen content of the medium and that nitrogen had no effect on the number of tubers per plant. The presence of a high level of nitrogen in the absence of potash was responsible for long tubers while the presence of potash in the medium reduced tuber length considerably.

Li (1971) obtained increased tuber yield with application of 80 kg nitrogen and 200 kg potassium per hectare both under irrigated and rainfed conditions of sweet potato cultivation.

Badillo Feliciano and Lugo Lopez (1976) after conducting field trials in Puerto Rico with different levels of NPK came to the conclusion that with the exception of nitrogen, the amount of a given element absorbed by the plants was not consistently related to the amount applied. The marketable tuber yield from non-fertilized plot was 9.7 tonnes per hectare and the highest marketable tuber yield obtained was 17 tonnes per hectare. They also reported that high yields were not affected by phosphorus and potassium application.

Nair _et al_. (1976) reported that application of nitrogen @ 60 kg per hectare and potash @ 90 kg per hectare was beneficial to get higher tuber yields and good quality tubers. Prabhakar _et al_. (1977) reported that NPK application at the rate of 100 : 75 : 100 kg per hectare recorded maximum tuber yield in sweet potato which was significantly superior to no fertilizer treatment and on par with NPK rate of 75 : 50 : 75 kg per hectare.

Rajaput *et al*. (1981) found that closest spacing, lowest nitrogen level and higher phosphorus and potassium levels were the best of all other treatments. Mishra and Mishra (1982) recommended 40 kg nitrogen, 40 kg K_2O and 40 kg P_2O_5 per hectare as the economic dose of fertilizer for sweet potato cultivation.

Ravindran and Balanambisan (1983) got the highest marketable tuber yield of sweet potato under upland conditions with an NPK dose of 75 : 50 : 70 for the variety Kanhangadu local. Ashokan *et al*. (1984) recorded maximum tuber yield for rainfed sweet potato in Kerala condition by the application of 90 kg nitrogen and 60.4 kg potash per hectare. Nair and Mohan Kumar (1984) found that NPK of 75 : 50 : 75 was superior over other treatments of 25 : 25 : 20, 50 : 25 : 50 and 100 : 75 : 100.

After conducting field experiments in sweet potato with nitrogen and potash each at three levels, Nawale and Salvi (1984) noticed that the tuber yield was significantly increased with highest levels of nitrogen and potash. Interaction effect of nitrogen and potassium was also significant.

2.4. Influence of time of application of nitrogen and potassium on growth and yield

Basal nitrogen application and early nitrogen top dressing were recommended for sweet potato by Yuan et al.(1964)

on the ground that late nitrogen application does not contribute towards tuber enlargement.

Favourable effect of split application of nitrogen, once at planting and again 30 days after planting in moderating top growth during tuber forming period and enhancing top growth during tuber development period has been reported by Morita (1967). Morita (1970) observed vine elongation due to increased nitrogen application.

Alexander et al. (1976) found that nitrogen uptake was significantly higher when 37.5 kg nitrogen per hectare was applied before planting and 57.5 kg nitrogen per hectare 35 days later than when the full nitrogen rate was applied before planting. Godfrey-Sam-Agrrey (1976) reported that two equal split applications of fertilizers are advantageous than single application. At the same time, Nair et al. (1976) observed that the nitrogen uptake by plant was not affected by the time of nitrogen application.

Wargino and Soenorjo (1981) in a cultural management experiment found that the optimum NK fertilizer treatment was 33 per cent, zero to three weeks after planting and 67 per cent at 6 to 9 weeks after planting.

Singh (1982) reported that split application of nitrogen that is 80 kg nitrogen at the time of final land preparation before planting, remaining 50 kg nitrogen in two equal split doses one at six weeks after planting and the other ten weeks after planting increased the tuber yield as compared to single application in sweet potato.

2.5. Effect of nitrogen and potassium in the quality of tuber and uptake of nutrients

Anderson (1936) found no influence by the fertilizer level on the starch content of sweet potato. Studies on the variation in chemical composition of sweet potato under various levels of nitrogen and potash led Izava and Ckamoto (1959) to the conclusion that sugars and nitrogen compounds attained their maximum in the shoots in late summer. They further noticed that potash produced a slight and nitrogen a marked increase in the content of these constituents.

Samuels (1967) got no significant difference in starch content due to any of the N : K or P : N ratio used. A positive correlation between nutrient contents of tubers and vegetative parts during the growth period was observed by Mica (1969).

Prabhakar _et al_. (1977) observed varietal variation in the case of starch content. But they observed no effect on dry matter and starch content according to different fertility levels. Muthuswamy *et al*. (1981) reported that nitrogen had no effect on starch content, while increased rates of potassium though not significant increased starch content.

Ashokan *et al*. (1984) observed that starch content of tuber was increased by higher levels of nitrogen and potash.

2.6. Effect of nutrients on soil nutrient status

Rajendran *et al*. (1971) observed an increase in the available nitrogen content of soil by the application of 100 kg nitrogen per hectare to tapioca.

Rajendran *et al*. (1972) reported increase in available potassium content of soil by the application of higher doses of potassium.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation was undertaken to study the comparative performance of four sweet potato varieties under different levels and times of nitrogen and potassium application.

3.1. Location

The Banana Development Nursery, Peringammala, Trivandrum District, under the Department of Agriculture, Kerala, is situated at 8° 44' north latitude and 77° 2' east longitude at an altitude of 167 metres above mean sea level.

3.2. Experimental site

The experiment was laid out in the up lands of the Banana Development Nursery, Peringammala and the soil type was finely weathered, well drained deep to very deep forest soils that are characterised by a very dark brown to black, surface soils with gravelly loam to gravelly clay loam texture. Mechanical analysis and chemical analysis of the soil was carried out before the commencement of the experiment and the data are given in Table 1.

3.3. Season

The experiment was started on 27th December 1984 and completed by 8th May 1985. The weather data recorded during the crop period are furnished in Appendix I.

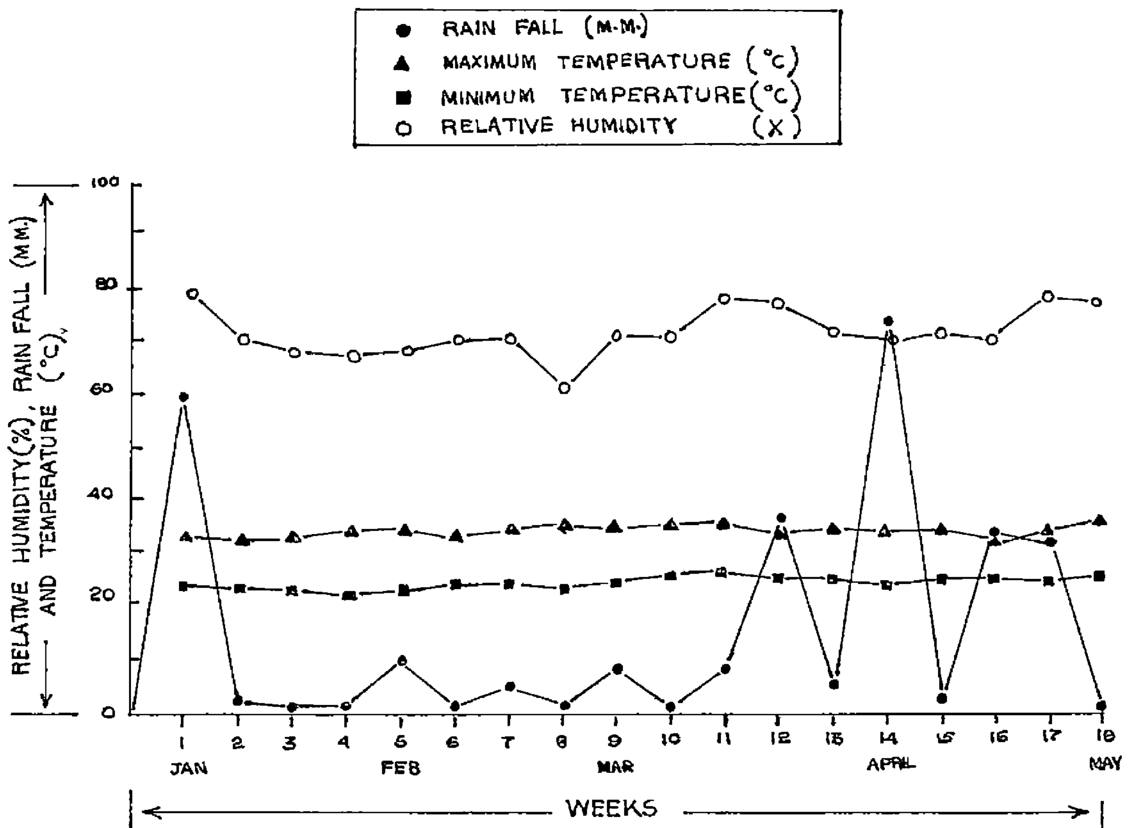


FIG. 1 WEATHER DATA DURING THE CROP SEASON

Table 1. Chemical analysis of the soil before layout of the experiment

Constituent	Content of soil (per cent)	Method used
Total nitrogen	0.215	Modified micro Kjeldahl's method
Available P_2O_5	0.0023	Bray's method
Available K_2O	0.00728	Ammonium acetate method
pH	5.4	Elico pH meter

Mechanical analysis of soil before experiment

Constituent	Content in per cent
Gravel	31.81
Coarse sand	24.05
Fine sand	20.00
Silt	25.40
Clay	26.55

3.4. Variety

The varieties of sweet potato used in the study were H-2743, H-4021, H-4126 and Cross-5. The first three varieties were developed in the Department of Plant Breeding, College of Agriculture, Vellayani, Kerala Agricultural University and Cross-5 is a variety evolved at the Rajendra Agricultural University, Bihar.

3.5. Manures and fertilizers

A basal application of cattle manure at the rate of 10 tonnes per hectare was given uniformly to all the plots. Urea, Mussoriephosphate and muriate of potash were used as sources of nitrogen, phosphorus and potassium respectively. A uniform basal dose of phosphorus at the rate of 50 kg P_2O_5 per hectare was applied in all the plots as per Kerala Agricultural University package of practices.

The chemical analysis of the manures and fertilizers used are given below.

Urea	46 per cent nitrogen
Mussorie phosphate	22 per cent P_2O_5
Muriate of potash	59 per cent K_2O
Cattle manure	0.49% nitrogen 0.25% P_2O_5 0.22% K_2O

3.6.1. Layout of the experiment

Factorial combinations of three levels each of nitrogen and potassium, two timings of fertilizer application and four varieties constituted the treatments.

i) Varieties

V_1	Cross-5
V_2	H-2743
V_3	H-4021
V_4	H-4126

ii) Levels of nitrogen

N_0	50 kg nitrogen per hectare
N_1	75 kg nitrogen per hectare
N_2	100 kg nitrogen per hectare

iii) Levels of potassium

K_0	50 kg K_2O per hectare
K_1	75 kg K_2O per hectare
K_2	100 kg K_2O per hectare

iv) Time of application

T_0	1/2 nitrogen and potassium basal + 1/2 nitrogen and potassium one month after planting
T_1	2/3 nitrogen and potassium basal + 1/3 nitrogen and potassium one month after planting.

Treatment combinations

1)	$N_0K_0T_0V_1$	25)	$N_1K_0T_0V_1$	49)	$N_2K_0T_0V_1$
2)	$N_0K_0T_0V_2$	26)	$N_1K_0T_0V_2$	50)	$N_2K_0T_0V_2$
3)	$N_0K_0T_0V_3$	27)	$N_1K_0T_0V_3$	51)	$N_2K_0T_0V_3$
4)	$N_0K_0T_0V_4$	28)	$N_1K_0T_0V_4$	52)	$N_2K_0T_0V_4$
5)	$N_0K_0T_1V_1$	29)	$N_1K_0T_1V_1$	53)	$N_2K_0T_1V_1$
6)	$N_0K_0T_1V_2$	30)	$N_1K_0T_1V_2$	54)	$N_2K_0T_1V_2$
7)	$N_0K_0T_1V_3$	31)	$N_1K_0T_1V_3$	55)	$N_2K_0T_1V_3$
8)	$N_0K_0T_1V_4$	32)	$N_1K_0T_1V_4$	56)	$N_2K_0T_1V_4$
9)	$N_0K_1T_0V_1$	33)	$N_1K_1T_0V_1$	57)	$N_2K_1T_0V_1$
10)	$N_0K_1T_0V_2$	34)	$N_1K_1T_0V_2$	58)	$N_2K_1T_0V_2$
11)	$N_0K_1T_0V_3$	35)	$N_1K_1T_0V_3$	59)	$N_2K_1T_0V_3$
12)	$N_0K_1T_0V_4$	36)	$N_1K_1T_0V_4$	60)	$N_2K_1T_0V_4$
13)	$N_0K_1T_1V_1$	37)	$N_1K_1T_1V_1$	61)	$N_2K_1T_1V_1$
14)	$N_0K_1T_1V_2$	38)	$N_1K_1T_1V_2$	62)	$N_2K_1T_1V_2$
15)	$N_0K_1T_1V_3$	39)	$N_1K_1T_1V_3$	63)	$N_2K_1T_1V_3$
16)	$N_0K_1T_1V_4$	40)	$N_1K_1T_1V_4$	64)	$N_2K_1T_1V_4$
17)	$N_0K_2T_0V_1$	41)	$N_1K_2T_0V_1$	65)	$N_2K_2T_0V_1$
18)	$N_0K_2T_0V_2$	42)	$N_1K_2T_0V_2$	66)	$N_2K_2T_0V_2$
19)	$N_0K_2T_0V_3$	43)	$N_1K_2T_0V_3$	67)	$N_2K_2T_0V_3$
20)	$N_0K_2T_0V_4$	44)	$N_1K_2T_0V_4$	68)	$N_2K_2T_0V_4$
21)	$N_0K_2T_1V_1$	45)	$N_1K_2T_1V_1$	69)	$N_2K_2T_1V_1$
22)	$N_0K_2T_1V_2$	46)	$N_1K_2T_1V_2$	70)	$N_2K_2T_1V_2$
23)	$N_0K_2T_1V_3$	47)	$N_1K_2T_1V_3$	71)	$N_2K_2T_1V_3$
24)	$N_0K_2T_1V_4$	48)	$N_1K_2T_1V_4$	72)	$N_2K_2T_1V_4$

3.6.2. Layout and design

The experiment was laid out in a split plot cum confounded design with two replications. The main plot treatments were the combinations of 3 x 3 x 2 asymmetrical factorial with the time of application as the factor of asymmetry. The lay out of the main plot was done by converting to a confounded symmetrical factorial of 3 x 3 x 3 and omitting the unwanted factorial combinations. The first replicate is obtained by confounding NKT^2 = NK and second replicate is obtained by confounding NKT.

3.6.3. Size of the plots

Gross plot size	3 m x 3 m
Net plot size	1.8 m x 2.2 m

3.6.4. Spacing

The spacing adopted was 60 cm between rows and 20 cm between plants.

3.6.5. Plant population

Number of plants per gross plot	75
Number of plants per net plot	33

LAYOUT PLAN — SPLIT PLOT CUM CONFOUNDED FACTORIAL EXPERIMENT

SPACING

BETWEEN ROWS	60 cm
BETWEEN PLANTS	20 cm
PLOT SIZE	3 M x 3 M
PLOT AREA	9 Sq M

VARIETIES

V_1	CROSS 5
V_2	H 2743
V_3	H 4021
V_4	H 4126

NITROGEN

N_0	50	Kg / ha
N_1	75	Kg / ha
N_2	100	Kg / ha

POTASSIUM

K_0	50	Kg K_2O / ha
K_1	75	Kg
K_2	100	Kg ..

TIME OF APPLICATION

T_0 ½ N & K BASAL + ½ ONE MONTHS AFTER PLANTING

T_1 ⅔ N & K BASAL + ⅓ ONE MONTHS AFTER PLANTING

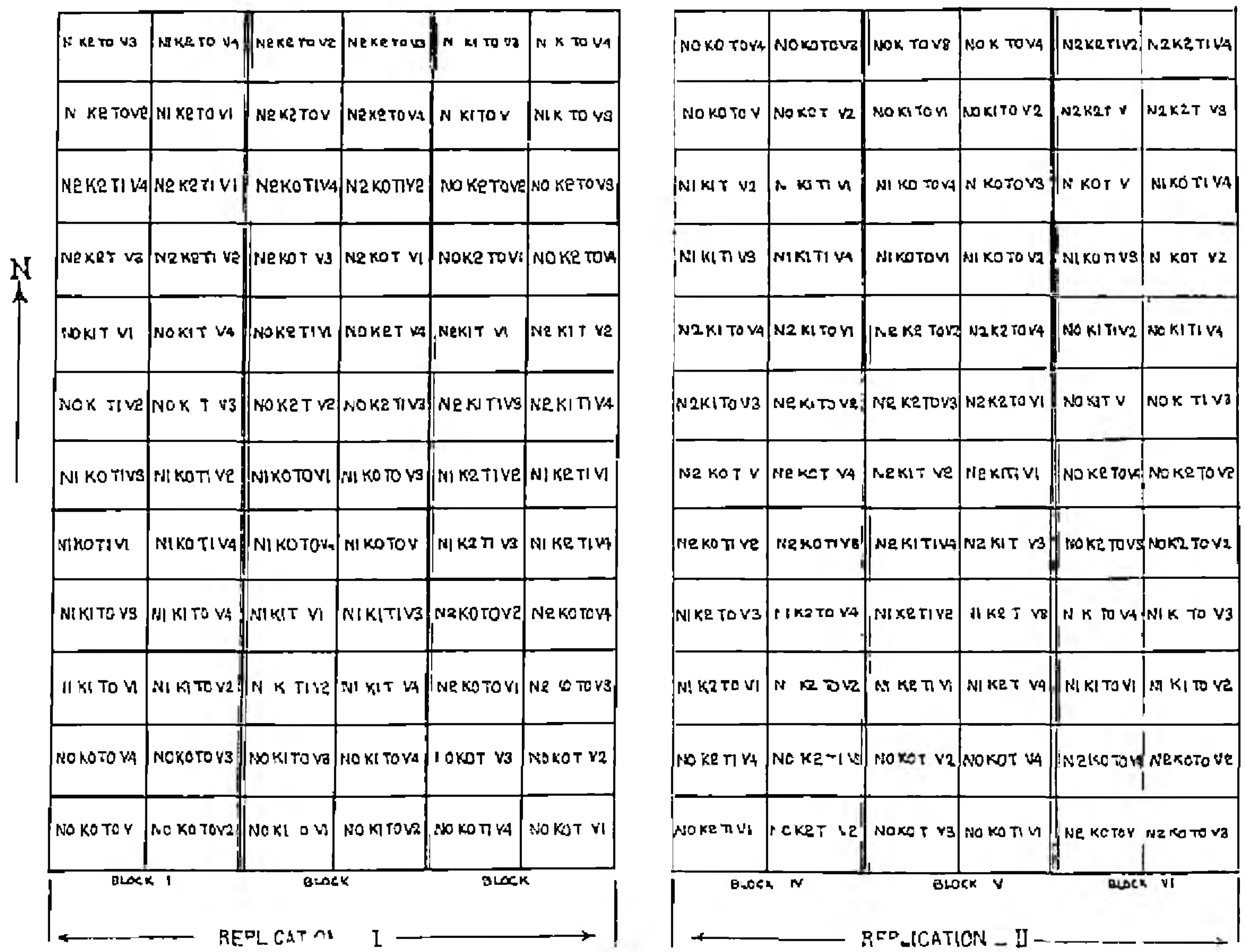


FIG 2

3.7. Details of cultivation

i) Preparation of land

The experimental site was dug twice and levelled during the period from 14-12-1984 to 29-12-1984 by employing manual labourers. The field was then laid out into blocks and plots. Altogether there were six blocks. The plots were well dug with spades and were kept in a weed-free condition. Ridges were formed at a distance of 60 cm after application of cattle manure, basal doses of nitrogen and potassium and the entire quantity of phosphorus. Total number of ridges per plot was five.

ii) Manuring

Well rotton cattle manure was uniformly applied in all the plots and incorporated by digging it on 2-1-1985. The full quantity of mussorie phosphate was applied as basal dose. Urea and muriate of potash were given as per schedule.

iii) Seeds and sowing

The planting materials of the three sweet potato varieties viz. H-2743, H-4021 and H-4126 were received from the Department of Agricultural Botany, College of Agriculture, Vellayani, and the planting material of variety Cross-5 was obtained from the Central Tuber Crops Research Institute, Trivandrum. The planting materials were planted in a seedling nursery for multiplication. The sweet potato vines collected from the seed nursery were cut into vines of length 25 cm with three to four nodes in each. Healthy and vigorous cuttings were selected and dipped in a solution containing 0.05 per cent Lebaycid. The vines were planted on ridges with a spacing of 20 cm. The planting was done on 4-1-1985. The vines were grown under irrigation. Gap filling was done on the tenth day to ensure uniform stand of the crop.

iv) After cultivation

One hand weeding was given on the 25th day. On the 30th day the plots were top dressed with remaining dose of nitrogen and potassium fertilizers. The fertilizer was applied in bands on the two sides of the ridges. All the plots were given an earthing up after fertilizer application. One more hand weeding was given 20 days after top dressing. A second earthing up was given 30 days after the top dressing.

v) Irrigation

The vines were irrigated daily by means of water cans for the first ten days to facilitate establishment of the crop. For the next twenty days irrigation through channels were given once in three days. Thereafter weekly irrigations were given.

vi) Plant protection

During the entire duration of the crop there were no serious incidence of pest and disease attacks. Two sprayings with Ekalux (0.05 per cent) were given as prophylactic measure against sweet potato weevil, one at 40 days after planting and the other at 90 days after planting. Poison baiting with zinc phosphide was also carried out to control field rats.

vii) Harvesting

Appearing of cracks at the base of the plants and fading of green colour of leaves were used as the index of maturity. The crop was harvested on 8th May 1985, 124 days after planting. Observational plants (four in each plot) were uprooted a day prior to harvest. Border plants were removed and separated before harvesting net plots. Tubers were dug out from the net plot area after cutting and removing the vines from the ridges.

3.8.1. Biometric observations

i) Wet and dry weights of vines and tubers

This observation was taken at the time of harvest. Four plants were selected at random from alternate ridges from each plot. The plants were uprooted carefully without disturbing the neighbouring plants and separated into vines and tubers, and their wet weights recorded. The sample plants were oven-dried at 80 $\pm$ 5°C until two consecutive weights agreed. The dry weights were recorded.

ii) Length of vine per plant

The length of vine was measured from the base to the tip of the longest vine of each plant. Observations were taken from the four sample plants at harvest and average worked out.

iii) Number of roots per plant

The sample plants were observed for the number of roots per plant after carefully uprooting the plants.

iv) Number of tuber per plant

The total number of tubers in each plot were counted and their average value recorded. Tubers with less than 2.5 cm diameter were not counted for the purpose.

v) Length of tuber

The length of each tuber from sample plants at harvest was measured and its average value worked out.

vi) Girth of tuber

The average girth of tuber was found out by observing girth at three different portions, one in the middle and the others a quarter distance from both ends of the tuber. The average of these three figures of all the sample tubers was designated as mean girth. This observation was recorded at harvest from sample plants.

vii) Yield of tuber

After removing the border plants the net plots were harvested by digging out tubers. The weight of tuber of sample plants recorded separately was also added to the net plot yield to calculate the yield of tuber.

viii) Yield of vine

The harvested produce from net plots was separated into vines and tubers, and the net weight of vines recorded. Wet weight of vines of sample plants was also added to give final values.

ix) Utilization index

According to Obigbesan (1973) utilisation index is an important yield determinant factor and is the ratio of the tuber weight to the top weight. This was worked out from the observations recorded in tuber weight and top weight of the observational plants.

3.8.2. Chemical analysis

i) Nitrogen content of vine

The nitrogen content of vine of sample plants taken at harvest was estimated by the modified Micro-Kjeldahl's method (Jackson, 1967).

ii) Nitrogen content of tuber

The nitrogen content of tuber at harvest was estimated by modified Micro-Kjeldah's method.

iii) Nitrogen uptake by vine

From the nitrogen content of vine and dry matter yield of sample plants at harvest, the nitrogen uptake of vine was calculated.

iv) Nitrogen uptake of tuber

Nitrogen uptake of tuber was estimated from nitrogen content and sample dry weight of tuber.

v) Total plant uptake of nitrogen

Total nitrogen uptake was obtained by adding nitrogen uptake values by vine and tuber.

vi) Crude protein content of vine and tubers

The crude protein contents of vine and tuber were estimated from the respective nitrogen values by multiplying by the factor 6.25 (A.O.A.C., 1969).

vii) Potassium content of vine

Total potassium content of vine of sample plants taken at harvest was estimated by using flame photometer.

viii) Potassium content of tuber

The total potassium content of tuber at harvest was estimated by using flame photometer.

ix) Potassium uptake by vine

From the potassium content of vine and dry matter yield of sample plants at harvest the potassium uptake of vine was worked out.

x) Potassium uptake by tuber

Potassium uptake of tuber was estimated from potassium content and sample dry weight of tuber.

xi) Total potassium uptake by plant

Potassium uptake values by vine and tuber were added to get the total potassium uptake by plants at harvest.

xii) Phosphorus content of vine

The phosphorus content of vine was determined by vanade-molybdo-phosphoric yellow colour method (Jackson, 1967).

xiii) <u>Phosphorus content of tuber</u>

The phosphorus content of tuber at harvest was determined by vanado-molybdo-phosphoric yellow colour method.

xiv) <u>Starch content of tuber</u>

The starch content was estimated by using potassium ferricyanide method (Ward and Pigman, 1970). The values were expressed as percentage of fresh weight.

xv) <u>Crude fibre content</u>

Crude fibre content of sweet potato tuber was determined by the method of Wright (1939).

xvi) <u>Soil analysis</u>

The mechanical composition, total nitrogen, available phosphorus and available potassium contents of the composite soil sample collected block-wise prior to experiment and total nitrogen and available potassium of soil samples collected from individual plots after experiment were analysed. The mechanical analysis was done by the International Pipette Method (Piper, 1950). Total nitrogen was determined by modified Micro-Kjeldahl's method, available phosphorus by Bray's method and available potassium by Ammonium acetate method (Jackson, 1967).

RESULTS

4. RESULTS

An experiment to study the comparative performance of four sweet potato varieties under three levels each of nitrogen and potash and two times of application was conducted at the Banana Development Nursery, Peringammala, Trivandrum, during 1984-85. Observations on general characters, yield attributes, yield and quality aspects were recorded. The data were statistically analysed and the results are presented in this chapter

4.1. Growth characters

4.1.1. Length of vine

The data on length of vine as influenced by the nutrient levels, time of application, variety and their interaction are presented in Tables 2a, 2b and 3.

The statistical analysis of the data on length of vine showed significant influence of the levels of nitrogen and variety on the length of vine. But the levels of potassium and time of application were not significant on this growth character.

The vine length showed significant variation by the different levels of nitrogen. The maximum vine length was obtained at the level of 100 kg nitrogen per hectare which was significantly superior to the vine growths at 75 kg and 50 kg levels. The vine length at levels of 75 kg and 50 kg nitrogen per hectare were on par.

The different levels of potassium did not exert any significant influence in the vine length of sweet potato. The different times of application also could not produce any significant change in the vine length of sweet potato.

- The varietal effect on vine length was highly significant. The maximum vine length was registered by the variety Cross-5 which was significantly superior to varieties H-2743, H-4021 and H-4126. Varieties H-4126 and H-4021 were on par, both being significantly superior to variety H-2743 in vine length.

Of the various interaction effects, nitrogen x variety (N x V), Potassium x Variety (K x V) and time of application x Variety (T x V) interactions were significant. In N x V interaction the treatment N_1V_1 recorded the maximum vine length. In K x V interaction maximum vine length was recorded by treatment combination V_1K_0. Treatment combination V_1T_1 of the T x V interaction showed the maximum vine length.

Table 2a. Effect of different levels of nitrogen and potassium application on the length of vine, number of tuber per plant and length of tuber per plant.

Treatments	Length of vine per plant (cm)	Number of tuber per plant	Length of tuber per plant (cm)
Levels of Nitrogen			
50 kg per hectare	239.77	2.13	11.74
75 kg per hectare	219.88	2.40	11.85
100 kg per hectare	263.54	2.27	11.52
F. test	S	NS	NS
C.D. (0.05)	22.00		
Levels of potassium			
50 kg per hectare	253.88	2.23	11.86
75 kg per hectare	235.10	2.38	11.40
100 kg per hectare	234.21	2.19	11.84
F. test	NS	NS	NS

S : Significant

NS : Not significant

Table 2b. Effect of different levels of time of application and variety on the length of vine, number of tuber per plant and length of tuber per plant.

Treatments	Length of vine per plant (cm)	Number of tuber per plant	Length of tuber per plant (cm)
<u>Time of application of nutrients</u>			
1/2 N and K basal + 1/2 one month after planting	240.08	2.31	11.56
2/3 N and K basal + 1/3 one month after planting	242.04	2.22	11.84
F. test	NS	NS	NS
<u>Varieties</u>			
Cross-5	318.00	2.11	11.96
H-2743	230.58	2.53	12.39
H-4021	224.08	2.28	10.97
H-4126	191.58	2.14	11.49
F. test	S	S	S
C.D. (0.05)	8.80	0.26	0.33

S : Significant

NS : Not significant

Table 3. Interaction effect of levels of nitrogen, potassium, time of application and variety on the length of vine (cm).

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
Levels of Nitrogen					
50 kg per hectare	309.83	180.33	250.75	218.17	239.77
75 kg per hectare	322.92	169.00	187.75	199.83	219.88
100 kg per hectare	321.25	225.42	233.75	273.75	263.54
Levels of Potassium					
50 kg K_2O per hectare	331.42	191.25	247.08	245.75	253.88
75 kg K_2O per hectare	307.50	187.42	220.17	225.33	235.10
100 kg K_2O per hectare	315.08	196.08	205.00	220.67	234.21
Times of application					
1/2 N and K basal + 1/2 one month after planting	305.50	191.28	227.22	236.33	240.08
2/3 N and K basal + 1/3 one month after planting	330.50	191.89	220.94	224.83	242.04
Mean	318.00	191.58	224.08	230.58	

C.D. (0.05) for comparison of treatments, nitrogen x variety and potassium x variety . 15.25

C.D. (0.05) for comparison of treatment time of application x variety 12.45

4.2. Yield and Yield components

4.2.1. Number of tuber per plant

The data on number of tubers of sweet potato as influenced by the different treatments are given in Tables 2a, 2b and 4.

The statistical analysis of the data on number of tubers per plant revealed that only the varietal effect was significant in this respect. However, the maximum number of tuber was observed in the treatment receiving 75 kg nitrogen and 75 kg K_2O per hectare.

The varieties differed significantly with respect to this yield attribute. The maximum number of tubers were produced by the variety H-2743, which was on par with variety H-4021 and significantly superior to the other two varieties namely Cross-5 and H-4126. Varieties H-4021, H-4126 and Cross-5 were on par. None of the interaction effects was significant.

4.2.2. Length of tuber

The data on length of tuber as influenced by the nutrient levels, time of application, varietal effect and their interactions are presented in Tables 2a and 2b.

The statistical analysis of the data on length of tuber did not show any significant influence by levels of nutrients and time of application. But the varietal effect was significant.

Eventhough the levels of nitrogen did not influence tuber length, maximum tuber length was recorded at the level of 75 kg nitrogen per hectare. But further increase in level of nitrogen showed a trend of decrease in the length of tuber. Similarly maximum tuber length was recorded at the potassium level of 50 kg K_2O per hectare though the effect of potassium was not significant.

It is evident from the results that the influence of the time of application of nitrogen and potassium on the tuber length was also not significant. However, treatment T_1 (2/3 nitrogen and potassium basal + 1/3 of the dose one month after planting) showed a higher tuber length than T_0 (1/2 nitrogen and potassium basal + 1/2 the dose one month after planting).

Varietal effect was significant in this respect. Variety H-2743 recorded the highest tuber length (V_2) which was significantly superior to all the other varieties viz. H-4021, H-4126 and Cross-5. The variety Cross-5 was

Table 4. Interaction effect of levels of nitrogen, potassium, time of application and variety on the length of tuber (cm).

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
<u>Levels of nitrogen</u>					
50 kg per hectare	11.78	12.46	11.90	10.82	11.74
75 kg per hectare	12.47	12.89	10.43	11.60	11.85
100 kg per hectare	11.62	11.83	10.57	12.07	11.52
<u>Levels of potassium</u>					
50 kg K_2O per hectare	12.34	12.08	11.68	11.35	11.86
75 kg K_2O per hectare	11.82	12.32	10.22	11.26	11.40
100 kg K_2O per hectare	11.73	12.78	10.99	11.87	11.84
<u>Times of application</u>					
1/2 N and K basal + 1/2 one month after planting	12.14	12.42	10.80	10.89	11.56
2/3 N and K basal + 1/3 one month after planting	11.78	12.37	11.13	12.01	11.84
Mean	11.96	12.39	10.97	11.49	

C.D. (0.05) for comparison of treatments nitrogen x variety and potassium x variety : 0.57

C.D. (0.05) for comparison of treatment time of application x variety : 0.47

significantly superior to the varieties H-4021 and H-4126 but was inferior to H-2743.

Interaction effect was significant with respect to N x V, K x V and T x V treatment combinations. The variety H-2743 at a nitrogen level of 75 kg per hectare recorded the maximum tuber length (12.89 cm).

In the potassium x variety (K x V) interaction, the variety H-2743 (V_2) at the potassium level of 100 kg K_2O per hectare, recorded the maximum tuber length which was on par with variety H-2743 at 75 kg K_2O per hectare and variety Cross-5 at 50 kg K_2O per hectare but was significantly superior to all other treatment combinations.

Out of the various combinations of time of application x variety interaction, the variety H-2743 with the split application of nitrogen and potassium as 1/2 basal + 1/2 one month after planting (T_0) secured the maximum tuber length. This was on par with T_0V_1, T_1V_2 and T_1V_4 and significantly superior to all other treatment combinations.

4.2.3. Girth of tuber

The data on tuber girth of sweet potato as influenced by the nutrient levels, time of application, varietal effect and their interactions are presented in Tables 5a, 5b, 6 and 7.

The statistical analysis of the data on tuber girth did not show any significant influence on the levels of nitrogen and time of application. But the varietal effect and levels of potassium exerted significant influence.

Eventhough the effect of nitrogen was not significant treatment N_2 (100 kg nitrogen per hectare) showed the highest tuber girth value.

The different levels of potassium showed significant influence on the girth of tuber. The maximum girth was recorded at K_2 (100 kg K_2O per hectare) level which was on par with K_1 (75 kg K_2O per hectare) and significantly superior to K_0 (50 kg K_2O per hectare). An increase in the rate of application of potassium showed a trend of increase in the girth of tuber.

The time of application of nitrogen and potassium did not show any significant difference in the girth of tuber. The results showed that varieties differed significantly in girth of tuber. The variety H-4126 (V_4) recorded the maximum tuber girth which was significantly superior to variety H-2743 (V_2) and Cross-5 (V_1) but was on par with H-4021 (V_3).

Interactions N x K and K x T were significant in this respect. The maximum tuber girth was recorded in the treatment combination of 100 kg nitrogen and 100 kg K_2O per

Table 5a. Effect of different levels of nitrogen and potassium application on girth of tuber, utilization index, tuber yield and vine yield.

Treatments	Girth of tuber (cm)	Utilization index	Tuber yield (Tonnes/ha)	Vine yield (Tonnes/ha)
<u>Levels of nitrogen</u>				
50 kg per hectare	12.75	0.54	15.36	29.42
75 kg per hectare	12.36	0.50	14.75	30.40
100 kg per hectare	12.88	0.44	14.41	32.63
F. test	NS	NS	NS	NS
<u>Levels of potassium</u>				
50 kg K_2O per hectare	12.26	0.44	13.45	31.72
75 kg K_2O per hectare	12.61	0.52	15.74	30.96
100 kg K_2O per hectare	13.11	0.52	15.40	29.77
F. test	S	NS	NS	NS
C.D. (0.05)	0.61			

S : Significant

NS : Not significant

Table 5b. Effect of different levels of time of application and variety on the girth of tuber, utilization index, tuber yield and vine yield.

Treatments	Girth of tuber (cm)	Utilization index	Tuber yield (Tonnes/ha)	Vine yield (Tonnes/ha)
<u>Time of application of nutrients</u>				
1/2 N and K basal + 1/2 one month after planting	12.73	0.48	14.52	31.06
2/3 N and K basal + 1/3 one month after planting	12.58	0.51	15.20	30.58
F. test	NS	NS	NS	NS
<u>Varieties</u>				
Cross-5	11.45	0.47	11.74	25.30
H-2743	12.14	0.49	15.78	33.23
H-4021	13.12	0.50	15.93	32.65
H-4126	13.95	0.52	15.98	32.12
F. test	S	NS	S	S
C.D. (0.05)	0.89		0.72	2.18

S : Significant

NS : Not significant

Table 6. Interaction effect between levels of nitrogen and potassium application on the girth of tuber (cm).

Treatments	Levels of potassium			Mean
	50 kg K_2O per hectare	75 kg K_2O per hectare	100 kg K_2O per hectare	
Levels of Nitrogen				
50 kg per hectare	12.56	12.92	12.73	12.74
75 kg per hectare	12.45	11.99	12.64	12.36
100 kg per hectare	11.78	12.90	13.96	12.88
Mean	12.26	12.61	13.11	

C.D. (0.05) for comparison of treatment Nitrogen x Potassium : 1.06

Table 7. Interaction effect between levels of potassium and times of application on the girth of tuber (cm).

Treatments	Times of application of nutrients		Mean
	1/2 N and K basal + 1/2 one month after planting	2/3 N and K basal + 1/3 one month after planting	
<u>Levels of potassium</u>			
50 kg K_2O per hectare	11.69	12.84	12.26
75 kg K_2O per hectare	12.89	12.33	12.61
100 kg K_2O per hectare	13.62	12.59	13.11
Mean	12.73	12.58	

C.D. (0.05) for comparison of treatment potassium x times of application : 0.86

hectare. This was significantly superior to all other N x K treatment combinations except the treatment combination of 50 kg nitrogen and 75 kg K_2O per hectare which was on par with it.

Of the potassium x time of application (K x T) interaction, treatment combination T_1K_1 recorded the highest tuber girth which was significantly superior to T_0K_0, T_1K_0 and T_1K_1 and on par with the remaining T x K treatment combinations.

4.2.4. Utilization Index

The data on utilization index of sweet potato as influenced by the nutrient levels, time of application, varietal effect and their interactions are presented in Tables 5a and 5b.

The statistical analysis of the data on utilization index did not show any significant influence by the levels of nutrients, time of application and varietal effects. However, the utilization index showed a decreasing trend with increasing levels of nitrogen and an increasing trend with increasing levels of potassium. The utilization index value tended to be high when nitrogen and potassium were applied as 2/3 basal + 1/3 one month after planting though not significant.

4.2.5. Tuber Yield

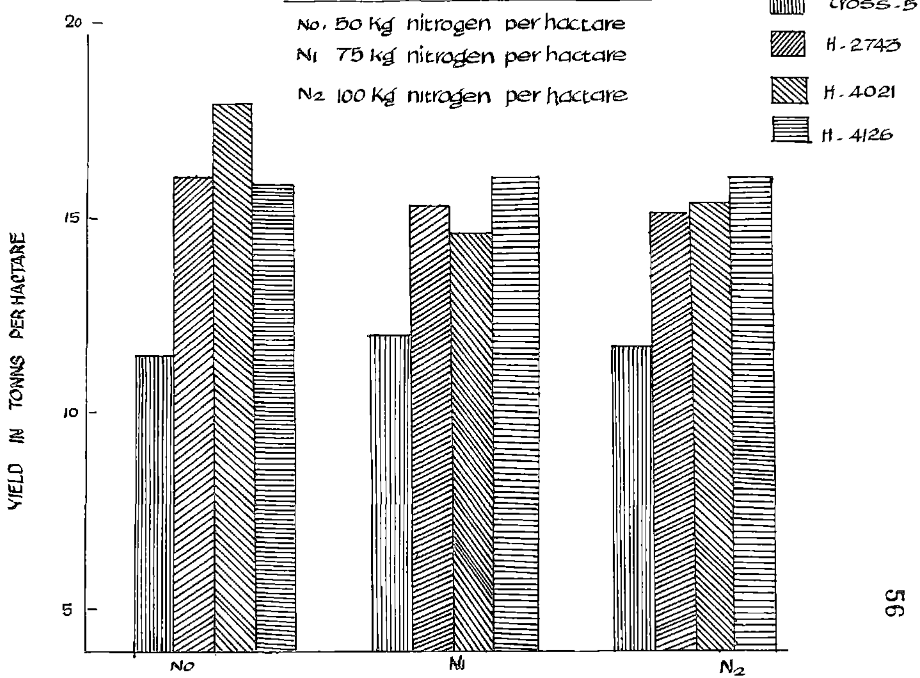
The data on tuber yield of sweet potato as influenced by the nutrient levels, time of application and varietal effect and their interactions are presented in Tables 5a, 5b and 8 and illustrated graphically in Figures 2 and 4.

The levels of nitrogen did not show any significant effect on tuber yield. Treatment N_0 (50 kg nitrogen per hectare) showed the highest tuber yield of 15.3 tonnes per hectare, though not significantly superior to other levels. The yield showed a decreasing trend with increasing levels of nitrogen though not significant.

The different levels of potassium also did not show any significant difference in yield. The tuber yield (15.7 tonnes/hectare) at K_1 level (75 kg K_2O per hectare) was higher than that (13.5 tonnes/hectare) at K_0 (50 kg K_2O per hectare) level, though the difference was not significant. But the yield (15.4 tonnes/hectare) declined at the highest level of potassium (100 kg K_2O per hectare) application.

It is evident from the data that the influence of the time of application of nitrogen and potassium on tuber yield

FIG 3 TUBER YIELD OF SWEET POTATO VARIETIES UNDER DIFFERENT LEVELS OF NITROGEN APPLICATION



was also not significant. However, treatment T_1 (2/3 nitrogen and potassium as basal + 1/3 of the dose one month after planting) showed a higher yield (15.2 tonnes/hectare) than T_0 (1/2 nitrogen and potassium basal + 1/2 of the dose one month after planting).

The varietal effect was significant in tuber yield. The variety H-4126 (V_4) with an yield of 15.9 tonnes per hectare was significantly superior to Cross-5 (V_1) and was on par with other two varieties H-2743 (V_2) and H-4021 (V_3). The variety Cross-5 performed significantly inferior to all other varieties in respect of tuber yield.

Interactions such as N x V, K x V and T x V showed significant influence in tuber yield. As far as the variety x nitrogen interactions are concerned the treatment combination V_3N_0 (variety H-4021 at 50 kg nitrogen per hectare) recorded the maximum tuber yield (17.9 tonnes per hectare) which was significantly superior to all other variety x nitrogen combinations.

In respect of potassium x variety (K x V) interactions the treatment combination V_3K_2 recorded the highest tuber yield of 17.2 tonnes per hectare which was significantly superior to treatment combinations of K_0V_1, K_0V_2, K_0V_3, K_0V_4, K_1V_1 and K_2V_1 and on par with the remaining combinations.

FIG-4

TUBER YIELD OF SWEET POTATO VARIETIES (TONNS/HACTARE) UNDER DIFFERENT LEVELS OF POTASSIUM APPLICATION

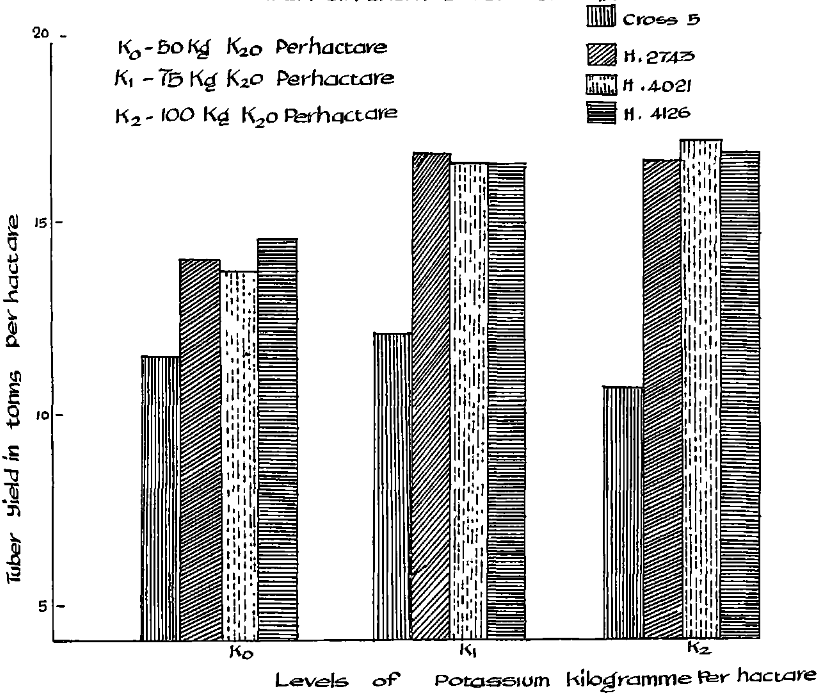


Table 8. Interaction effect of levels of nitrogen, potassium, time of application and variety on tuber yield (Tonnes/hectare)

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
<u>Levels of Nitrogen</u>					
50 kg per hectare	11.58	16.02	17.93	15.91	15.36
75 kg per hectare	12.03	16.26	14.62	16.06	14.74
100 kg per hectare	11.65	15.06	15.29	15.96	14.49
<u>Levels of potassium</u>					
50 kg K_2O per hectare	11.58	13.94	13.74	14.54	13.45
75 kg K_2O per hectare	12.85	16.76	16.85	16.51	15.74
100 kg K_2O per hectare	10.82	16.64	17.24	16.88	15.40
<u>Times of application</u>					
1/2 N and K basal + 1/2 one month after planting	12.09	15.24	15.08	15.71	14.53
2/3 N and K basal + 1/3 one month after planting	11.42	16.32	16.81	16.24	15.50
Mean	11.75	15.78	15.94	15.97	

C.D. (0.05) for comparison of treatments nitrogen x variety and potassium x variety : 1.25

C.D. (0.05) for comparison of treatment time of application x variety : 1.02

Out of the various combinations of Time of application x Variety interactions (T x V) the treatment combination V_3T_1 recorded the highest tuber yield of 16.8 tonnes per hectare. This treatment combination was significantly superior to the combinations of T_0V_1, T_0V_2, T_0V_3, T_0V_4 and T_1V_1 and on par with the remaining two treatment combinations of T_1V_2 and T_1V_4.

4.2.6. Vine Yield

The data on vine yield of sweet potato as influenced by the nutrient levels, times of application and varietal effect and their interactions are presented in Tables 5a, 5b and 9 and illustrated graphically in Fig. 5.

The statistical analysis of the data revealed that neither the levels of nutrients nor the time of application exerted any significant influence on vine yield. But the varietal effect was significant in this aspect.

The levels of nitrogen did not show any significant effect on vine yield. Treatment N_2 (100 kg nitrogen per hectare) produced the highest vine yield of 32.6 tonnes per hectare, though not significantly superior to other levels. The yield showed a trend of increase with increasing levels of nitrogen application.

VINE YIELD OF SWEET POTATO VARIETIES (TONNS/HACTARE) UNDER DIFFERENT LEVELS OF NITROGEN APPLICATION

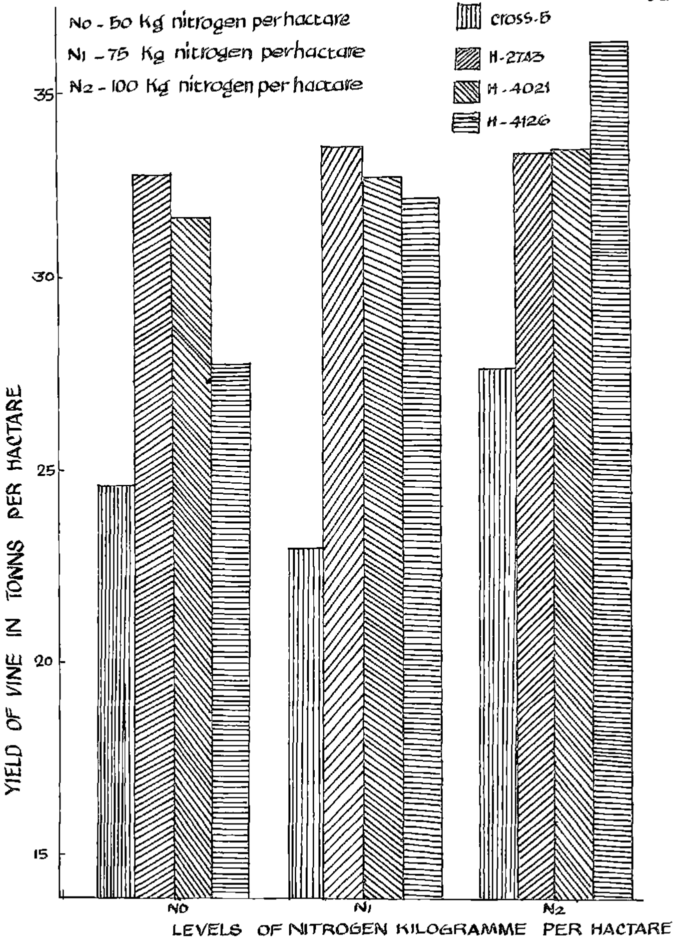


FIG. 5.

Table 9. Interaction effect of levels of Nitrogen and Variety on the vine yield of sweet potato (Tonnes/ha).

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
Levels of Nitrogen					
50 kg per hectare	25.00	32.93	31.77	27.94	29.41
75 kg per hectare	23.12	33.50	32.78	32.25	30.41
100 kg per hectare	27.78	33.27	33.75	36.15	32.64
Mean	25.30	33.23	32.64	32.11	

C.D. (0.05) for comparison of treatment Nitrogen x Variety : 3.77

The different levels of potassium also did not exert any significant influence in the yield of vine. The vine yield of 31.7 tonnes/hectare at 50 kg K_2O per hectare (K_0) was higher than that at levels of 75 and 100 kg K_2O per hectare, though the difference was not significant.

The influence of time of application of nitrogen and potassium on vine yield was also not significant. However, treatment T_0 (1/2 nitrogen and potassium basal + 1/2 the dose one month after planting) registered a higher yield (31.05 tonnes per hectare) than T_1 (2/3 nitrogen and potassium basal + 1/3 the dose one month after planting).

The varietal effect was significant in vine yield. The variety H-2743 (V_2) with a vine yield of 33.2 tonne per hectare was significantly superior to the variety (V_1) Cross-5 (25.3 tonnes per hectare) but was on par with the other two varieties H-4021 (V_3) and H-4126 (V_4).

Of the various interactions only nitrogen x variety (N x V) interaction was significant. The variety H-4126 with the application of 100 kg nitrogen per hectare recorded the highest vine yield (36.15 tonnes per hectare) which was significantly superior to the variety x nitrogen treatment combinations N_0V_1, N_0V_3, N_0V_4, N_1V_1, N_1V_4, N_2V_1 and on par with N_0V_2, N_1V_2, N_1V_3, N_2V_2 and N_2V_3.

4.3. Quality attributes

4.3.1. Starch content of tuber

The data on starch content of tuber as influenced by the treatments are presented in Tables 10a, 10b and 11, and illustrated graphically in Fig. 6.

The statistical analysis of the data on starch content of tuber did not show any significant influence of levels of nutrients and time of application. But the varietal effect was significant.

The levels of nitrogen did not show any significant effect on the starch content of tuber. Treatment N_1 (75 kg nitrogen per hectare) showed the highest starch content of 22.86 per cent though not significant. But further increase in the level of nitrogen showed a decreasing trend in starch content.

The different levels of potassium also did not show any significant difference in starch content. The maximum starch content was recorded at the highest level of potassium of 100 kg K_2O per hectare (K_2) though not significantly superior to other treatments.

Varieties exhibited significant difference in starch content of tubers. Maximum starch content was noticed in variety H-4021 which was significantly superior to variety H-2743 and H-4126, but was on par with variety Cross-5.

Of the various interactions N x V, K x V and T x V were significant in influencing the starch content.

The N x V interaction table revealed that maximum starch content was obtained at the treatment combination of 50 kg nitrogen per hectare for the variety H-4021. This was significantly superior to all other nitrogen x variety treatment combinations.

Potassium x variety interaction significantly influenced the starch content of tuber. Of the various combinations the variety H-4021 at the potassium level of 50 kg K_2O per hectare recorded the maximum starch content which was on par with variety H-2743 at 100 kg K_2O per hectare which in turn was significantly superior to other potassium x variety treatment combinations.

As regards the interaction between time of application and variety when nitrogen and potassium were applied as 2/3 basal + 1/3 one month after planting, for the variety H-4021 the starch content was maximum which was significantly superior to all other T x V treatment combinations.

Table 10a. Effect of different levels of nitrogen and potassium application on starch content, crude fibre content and crude protein content of tuber.

Treatments	Starch content of fibre (%)	Crude fibre content of tuber (%)	Crude protein content of tuber (%)
Levels of nitrogen			
50 kg per hectare	22.63	4.23	7.84
75 kg per hectare	22.86	4.26	9.25
100 kg per hectare	22.55	4.28	11.20
F. test	NS	NS	S
C.D. (0.05)			0.43
Levels of potassium			
50 kg K_2O per hectare	22.73	4.05	9.23
75 kg K_2O per hectare	22.38	4.26	9.50
100 kg K_2O per hectare	22.93	4.45	9.56
F. test	NS	S	NS
C.D. (0.05)		0.06	

S : Significant

NS : Not significant

FIG.6 EFFECT OF VARIETIES ON STARCH YIELD OF TUBER

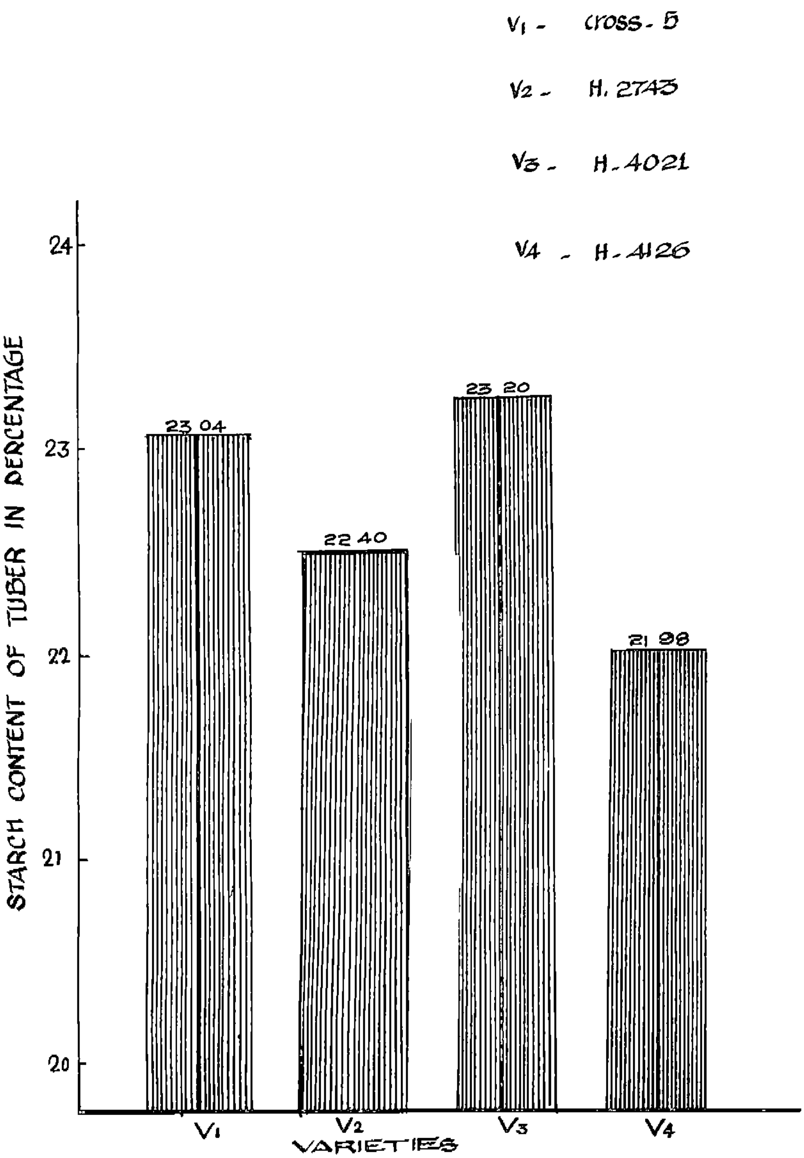


Table 10b. Effect of different levels of time of application and variety on starch content, crude fibre content and crude protein content of tuber.

Treatments	Starch content of fibre (%)	Crude fibre content of tuber (%)	Crude protein content of tuber (%)
<u>Time of application of nutrients</u>			
1/2 N and K basal + 1/2 one month after planting	22.66	4.25	9.43
2/3 N and K basal + 1/3 one month after planting	22.69	4.26	9.42
F. test	NS	NS	NS
<u>Varieties</u>			
Cross-5	23.04	4.39	9.30
H-2743	22.49	3.94	9.68
H-4021	23.20	4.38	9.34
H-4126	21.98	4.31	9.40
F. test	S	S	S
C.D. (0.05)	0.26	0.04	0.21

S : Significant

NS : Not significant

Table 11. Interaction effect of levels of nitrogen, potassium, time of application and variety on starch content of tuber (%).

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
Level of nitrogen					
50 kg per hectare	23.42	20.99	24.11	22.40	22.73
75 kg per hectare	22.68	22.73	23.12	20.98	22.38
100 kg per hectare	23.03	23.75	22.38	22.58	22.93
Levels of potassium					
50 kg K_2O per hectare	23.36	21.73	23.95	21.48	22.63
75 kg K_2O per hectare	23.00	23.40	23.03	22.01	22.86
100 kg K_2O per hectare	22.77	22.34	22.63	22.46	22.55
Times of application					
1/2 N and K basal + 1/2 one month after planting	22.90	23.11	22.76	21.88	22.66
2/3 N and K basal + 1/3 one month after planting	23.18	21.87	23.64	22.09	22.69
Mean	23.04	22.49	23.20	21.98	

C.D. (0.05) for comparison of treatments nitrogen x variety and potassium x variety : 0.45

C.D. (0.05) for comparison of treatment time of application x variety : 0.37

4.3.2. Crude fibre content of tuber

The data on crude fibre content of sweet potato tuber as influenced by the nutrient levels, time of application, varietal effect and their interactions are presented in Tables 10a, 10b and 12, and illustrated graphically in Fig. 7.

The statistical analysis of the data on crude fibre content revealed no significant influence by levels of nitrogen and time of application. But the varietal effect and effect of levels of potassium were significant.

The levels of nitrogen did not show any significant effect on crude fibre content of tuber. Treatment N_2 (100 kg nitrogen per hectare) registered the highest crude fibre content though not significant. Crude fibre content exhibited an increasing trend with higher rates of nitrogen application.

The effect of levels of potassium was significant in the crude fibre content of sweet potato tuber. The highest level of potassium (100 kg K_2O per hectare) recorded maximum crude fibre content of 4.45 per cent which was significantly superior to the other two levels. The potassium level of 75 kg K_2O per hectare was significantly superior to 50 kg level.

FIG 7 CRUDE FIBRE CONTENT OF SWEET POTATO VARIETIES UNDER DIFFERENT LEVELS OF POTASSIUM APPLICATION

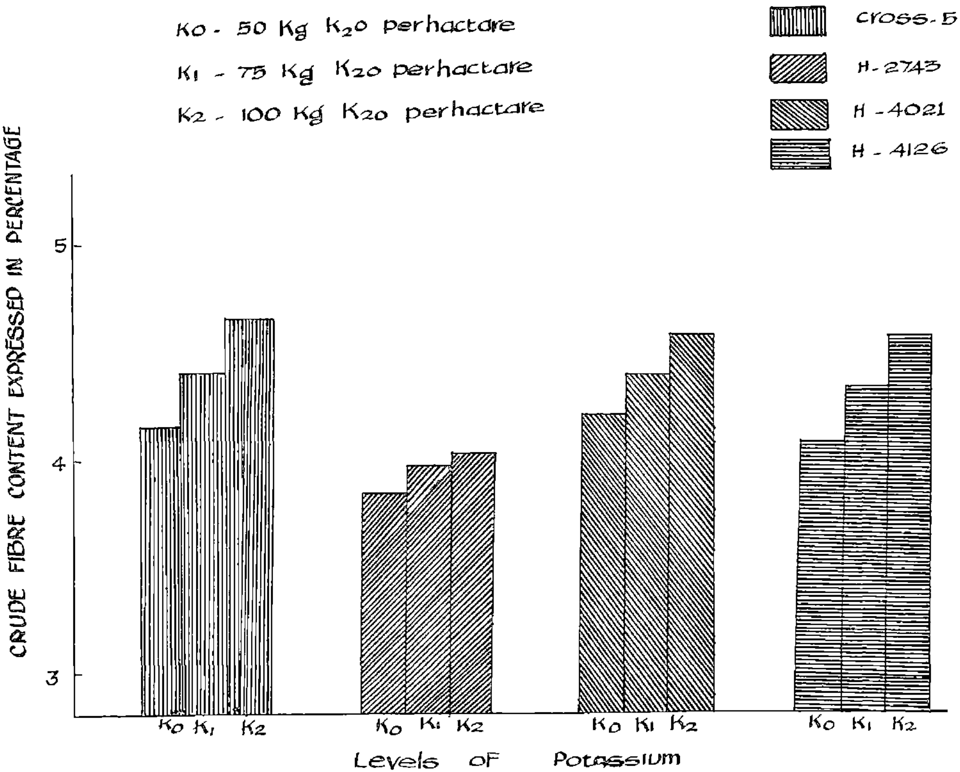


Table 12. Interaction effect of levels of potassium and variety (K x V) on the crude fibre content of tuber (%).

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
<u>Levels of Potassium</u>					
50 kg K_2O per hectare	4.14	3.81	4.18	4.07	4.05
75 kg K_2O per hectare	4.40	3.94	4.38	4.33	4.26
100 kg K_2O per hectare	4.63	4.07	4.58	4.54	4.45
Mean	4.39	3.94	4.38	4.31	

C.D. (0.05) for comparison of treatment potassium x variety : 0.07

The varieties differed significantly in crude fibre content of tuber. The variety Cross-5 recorded the maximum crude fibre content which was on par with H-4021 and significantly superior to varieties H-4126 and H-2743.

Of the various interactions only K x V interaction was significant. The variety Cross-5 at the level of 100 kg K_2O per hectare recorded the maximum crude fibre content in the tuber which was on par with variety H-4021 at the same level of potassium application. The least fibre content was recorded by the variety H-2743 at the level of application of 50 kg K_2O per hectare.

4.3.3. Crude protein content of tuber

The data on crude protein content of tuber as influenced by the levels of nutrients, time of application, variety and their interaction are presented in Tables 10a, 10b and 13, and illustrated graphically in Fig. 8.

The statistical analysis of the data on crude protein content of tuber revealed the significant influence of the levels of nitrogen and varieties. Neither the levels of potassium nor the time of application exhibited significant influence in this aspect.

CRUDE PROTEIN CONTENT OF TUBER IN DIFFERENT VARIETIES UNDER DIFFERENT LEVELS OF NITROGEN

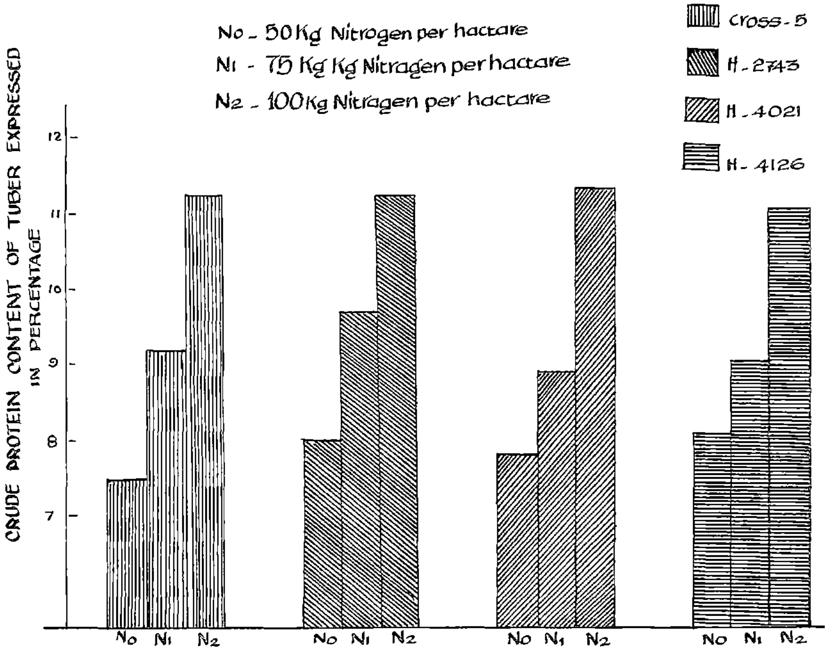


FIG 8

Table 13. Interaction effects of levels of nitrogen, potassium and variety on the crude protein content of tuber (%)

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
<u>Levels of nitrogen</u>					
50 kg per hectare	7.44	8.03	7.80	8.08	7.84
75 kg per hectare	9.28	9.83	8.94	9.07	9.25
100 kg per hectare	11.19	11.28	11.29	11.03	11.20
<u>Levels of potassium</u>					
50 kg K_2O per hectare	8.57	9.63	9.30	9.43	9.23
75 kg K_2O per hectare	9.46	10.05	9.22	9.27	9.50
100 kg K_2O per hectare	9.87	9.37	9.51	9.48	9.56
Mean	9.30	9.68	9.34	9.39	

C.D. (0.05) for comparison of treatments nitrogen x variety and potassium x variety : 0.36

The effect of different levels of nitrogen on crude protein content of tuber was significant. The maximum crude protein was recorded by the nitrogen level of 100 kg per hectare which was significantly superior to levels of 50 kg and 75 kg per hectare. The levels of 75 kg nitrogen per hectare was proved significantly superior to 50 kg level.

Though not significant there was a trend of increase in crude protein content with increasing levels of potassium. The maximum crude protein content in a tuber was registered at the potassium level of 100 kg K_2O per hectare.

The varietal effect revealed significant influence in the crude protein content of tuber. The variety H-2743 recorded the maximum crude protein content of tuber which was significantly superior to varieties Cross-5, H-4021 and H-4126. The varieties Cross-5, H-4021 and H-4126 were on par in this respect. The variety Cross-5 registered the lowest crude protein content of tuber.

Of the various interaction effects, interactions between nitrogen and variety and potassium and variety were significant.

In the N x V interaction the variety H-4021 at the nitrogen level of 100 kg per hectare (N_2V_3) registered the maximum crude protein content of tuber. As regards to the K x V interaction the variety H-4021 at the potassium level of 100 kg per hectare (K_2V_3) recorded the maximum crude protein content of tuber.

4.4. Growth analysis

4.4.1. Dry matter yield of tuber

The data on dry matter yield of tuber as influenced by the nutrient levels, time of application, varietal effect and their interactions are presented in Tables 14a, 14b and 15.

The statistical analysis of the data on dry matter yield of tuber did not show any significant influence by the levels of nutrients and time of application, but the varietal effect was significant.

The levels of nitrogen did not show any significant influence in the dry matter yield of tuber. Treatment N_0 (50 kg nitrogen per hectare) showed the highest dry matter yield (4.14 tonnes per hectare) though not significant, the increase in levels of nitrogen showed a decreasing trend in the dry matter yield of tuber.

The dry matter yield was not affected by the different levels of potassium also. However, the maximum dry matter yield of tuber was recorded by the potassium level of 75 kg K_2O per hectare.

The varietal effect was significant in the dry matter yield of tuber. The variety H-4021 scored the maximum dry matter yield (4.67 tonnes per hectare) which was significantly superior to all the other varieties viz. H-4126, H-2743 and Cross-5. Variety H-4126 ranked second (4.44 tonnes per hectare) in dry matter yield of tuber. The lowest dry matter yield of 2.95 tonnes per hectare was recorded by the variety Cross-5 which in turn was significantly inferior to the other three varieties.

Of the various interactions, the interaction between nitrogen and variety (N x V), potassium and variety (K x V) had shown significance.

As to the nitrogen x variety interaction, the variety H-4021 at the nitrogen level of 50 kg per hectare (N_0V_3) registered the maximum dry matter yield of 5.21 tonnes per hectare. In the potassium x variety interaction the variety H-4021 at the potassium level of 100 kg K_2O per hectare (K_2V_3) gave the maximum dry matter yield of tuber (5.04 tonnes per hectare).

Table 14 a. Effect of different levels of nitrogen and potassium application on dry matter yield of tuber, dry matter yield of vine, nitrogen uptake by plant and potassium uptake by plant

Treatments	Dry matter yield of tuber (tonnes/ha)	Dry matter yield of vine (tonnes/ha)	Nitrogen uptake by plant (kg/ha)	Potassium uptake by plant (kg/ha)
<u>Levels of nitrogen</u>				
50 kg per hectare	4.41	3.24	120.85	157.78
75 kg per hectare	3.96	3.35	138.05	162.10
100 kg per hectare	3.91	3.59	161.41	170.54
F. test	NS	NS	S	NS
C.D. (0.05)			14.31	
<u>Levels of potassium</u>				
50 kg K_2O per hectare	3.64	3.49	133.38	144.70
75 kg K_2O per hectare	4.24	3.41	142.86	168.75
100 kg K_2O per hectare	4.17	3.27	144.09	177.26
F. test	NS	NS	NS	S
C.D. (0.05)				13.05

S : Significant

NS : Not significant

Table 14b. Effect of different levels of time of application and variety on dry matter yield of tuber, dry matter yield of vine, nitrogen uptake by plant and potassium uptake by plant

Treatments	Dry matter yield of tuber (tonnes/ha)	Dry matter yield of vine (tonnes/ha)	Nitrogen uptake by plant (kg/ha)	Potassium uptake by plant (kg/ha)
<u>Time of application</u>				
1/2 N and K basal + 1/2 one month after planting	3.91	3.42	139.49	162.50
2/3 N and K basal + 1/3 one month after planting	4.12	3.37	140.72	164.64
F. test	NS	NS	NS	NS
<u>Varieties</u>				
Cross-5	2.95	2.79	109.92	131.38
H-2743	3.96	3.66	146.71	167.46
H-4021	4.67	3.59	152.92	178.46
H-4126	4.44	3.53	150.88	176.99
F. test	S	S	S	S
C.D. (0.05)	0.20	0.24	7.01	8.35

S : Significant

NS : Not significant

Table 15. Effects of levels of nitrogen, potassium, time of application and variety on the dry matter yield of tuber (Tonne/hectare).

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
<u>Levels of nitrogen</u>					
50 kg per hectare	2.91	4.04	5.21	4.42	4.15
75 kg per hectare	3.03	4.10	4.27	4.46	3.96
100 kg per hectare	2.93	3.79	4.48	4.44	3.91
<u>Levels of potassium</u>					
50 kg K_2O per hectare	2.92	3.51	4.03	4.04	3.63
75 kg K_2O per hectare	3.24	4.22	4.89	4.59	4.23
100 kg K_2O per hectare	2.72	4.19	5.04	4.70	4.16
<u>Times of application</u>					
1/2 N and K basal + 1/2 one month after planting	3.04	3.84	4.38	4.37	3.91
2/3 N and K basal + 1/3 one month after planting	2.88	4.11	4.93	4.52	4.11

C.D. (0.05) for comparison of treatments nitrogen x variety and potassium x variety : 0.13

C.D. (0.05) for comparison of treatment time of application x variety : 0.11

Among the various treatment combinations of time of application x variety interaction effects the variety H-4021 when applied with 2/3 nitrogen and potassium as basal and 1/3 the dose one month after planting (T_1V_3) recorded the maximum dry matter yield of tuber (4.93 tonnes per hectare).

4.4.2. Dry matter yield of vine

The data on dry matter yield of vine as influenced by the nutrient levels, time of application, varietal effect and their interactions are presented in Tables 14a, 14b and 16.

The statistical analysis of the data on dry matter yield of vine did not show any significant influence by levels of nutrients and time of application. But the varietal effect was significant in the dry matter yield of vine.

The levels of nitrogen did not show any significant effect on the dry matter yield of vine. Treatment N_2 (100 kg nitrogen per hectare) showed maximum dry weight yield of vine (3.59 tonne per hectare) though not significantly superior to other two levels of nitrogen (50 kg and 75 kg per hectare) tried. Increase in levels of nitrogen showed an increasing trend in the dry matter yield of vine.

The different levels of potassium also did not show any significant difference in the dry matter yield of vine. However, the maximum dry matter yield of vine (3.49 tonnes per hectare) was obtained at the lowest level of potassium (50 kg K_2O per hectare) though not significantly superior to other two levels of potassium (75 kg and 100 kg K_2O per hectare). An increase in levels of potassium showed a decreasing trend in the dry matter yield of vine.

The varieties differed significantly in the dry matter yield of vine. Variety H-2743 recorded the highest dry matter yield of vine (3.66 tonnes per hectare) which was significantly superior to variety Cross-5 but on par with varieties H-4021 and H-4126. Variety Cross-5 registered the lowest dry matter yield of vine (2.79 tonnes per hectare).

Of the various interactions, only N x V interaction was significant in this respect. Maximum dry matter yield of vine (3.98 tonnes per hectare) was recorded by the variety H-4126 at the level of 100 kg nitrogen per hectare (N_2V_4). This was significantly superior to treatment combinations

Table 16. Interaction effect of levels of nitrogen and variety on the dry matter yield of vine (Tonnes/hectare).

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
<u>Levels of nitrogen</u>					
50 kg nitrogen per hectare	2.78	3.62	3.49	3.07	3.24
75 kg nitrogen per hectare	2.54	3.68	3.61	3.55	3.35
100 kg nitrogen per hectare	3.06	3.66	3.67	3.98	3.59
Mean	2.79	3.66	3.59	3.53	

C.D. (0.05) for comparison of treatment levels of nitrogen x variety : 0.16

of N_1V_4, N_0V_4, N_0V_3, N_0V_1, N_1V_1 and N_2V_1 but was on par with N_0V_2, N_1V_2, N_1V_3, N_2V_2 and N_2V_3.

4.5. Nutrient uptake

4.5.1. Nitrogen uptake by plant (kilogram/hectare)

The data on total nitrogen uptake by plant as influenced by the levels of nutrients, time of application, variety and their interactions are presented in Tables 14a, 14b and 17, and illustrated graphically in Fig. 9 and 10.

The statistical analysis of the data on total nitrogen uptake by plant did not reveal any significant influence by levels of potassium and time of application. But the levels of nitrogen and varieties significantly influenced the total nitrogen uptake by plant.

The total nitrogen uptake by plant was significantly influenced by the different levels of nitrogen tried. The total uptake increased with increasing levels of nitrogen application. The total nitrogen uptake was maximum at the level of 100 kg nitrogen per hectare which was significantly superior to 75 kg and 50 kg nitrogen per hectare. The lowest rate of uptake was noticed by the level of 50 kg nitrogen per hectare which was significantly inferior to the other two levels.

FIG. 9. DIFFERENT VARIETIES OF SWEET POTATO

NITROGEN UPTAKE BY NITROGEN APPLICATION (Kg/hactare) UNDER DIFFERENT LEVELS

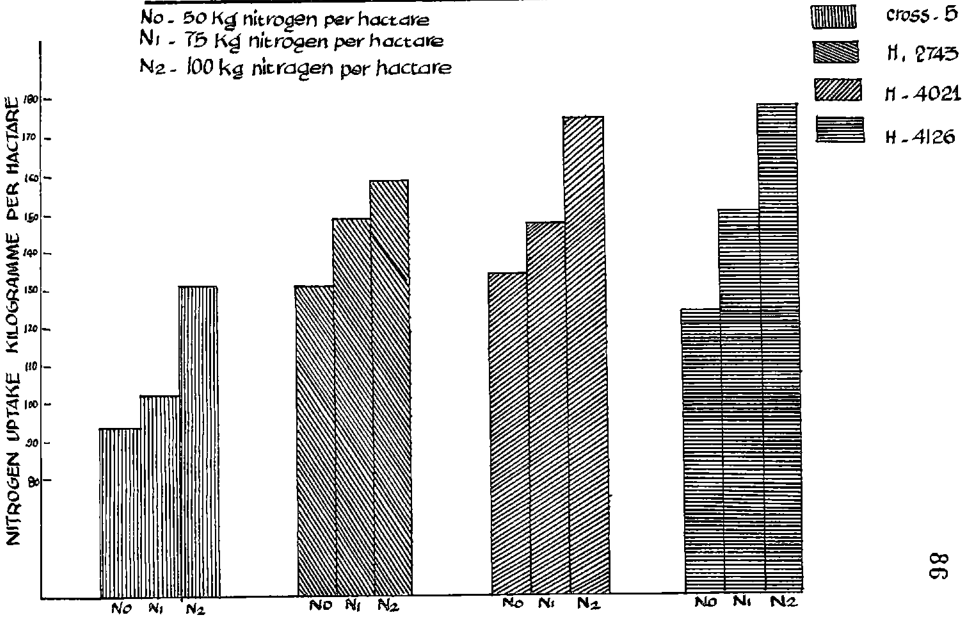


Table 17. Interaction effect of levels of nitrogen and variety (N x V) on the nitrogen uptake by plant (kg/hectare).

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
Levels of nitrogen					
50 kg per hectare	94.09	130.92	135.19	123.21	120.85
75 kg per hectare	103.04	149.95	147.99	151.24	138.04
100 kg per hectare	132.63	159.25	175.58	178.19	161.41
Mean	109.92	146.71	152.92	150.88	

C.D. (0.05) for comparison of treatment levels of nitrogen x variety : 12.15

NITROGEN UPTAKE BY DIFFERENT VARIETIES OF SWEET POTATO (Kg/Per hactare) UNDER DIFFERENT LEVELS OF NITROGEN APPLICATION

No- 50 kg nitrogen per hactare

N1 -75 kg nitrogen per hactare

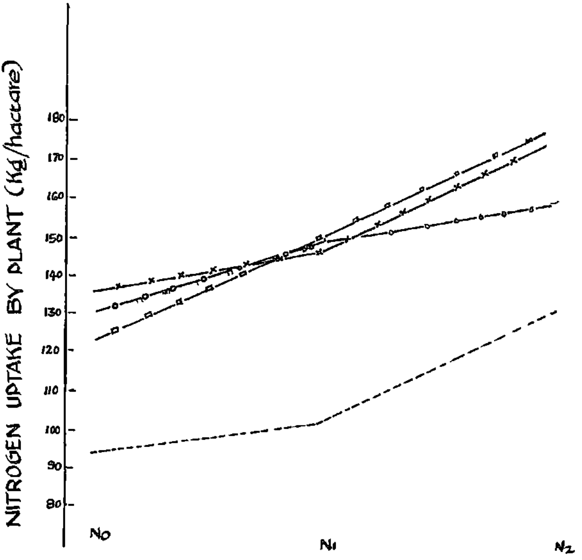
N2- 100 kg nitrogen per hactare

----- Cross-5

-o-o- H-2743

-x-x- H-4021

-□-□- H-4126



LEVELS OF NITROGEN (Kg/hactare)

FIG-10

The different levels of potassium did not exert any significant influence in the total uptake of nitrogen by plant. However the highest nitrogen uptake was recorded at the level of 100 kg K_2O per hectare (K_2). An increase in levels of potassium showed an increasing trend in the total nitrogen uptake by plant though not significant.

The varietal effect was significant on the total nitrogen uptake by plants. The maximum total nitrogen uptake was registered by the variety H-4021 which was significantly superior to varieties H-2743 and Cross-5. But varieties H-4021 and H-4126 were on par. The lowest rate of total uptake of nitrogen was registered by the variety Cross-5.

Among the various interaction effects the interaction between nitrogen and variety alone was found significant. The treatment combination V_4N_2 showed the highest nitrogen uptake.

4.5.2. Potassium uptake by plant (kg/hectare)

The data on potassium uptake by plant as influenced by the nutrient levels, time of application, variety and their interactions are presented in Tables 14a, 14b and 18.

Table 18. Interaction effect of levels of nitrogen and varieties (N x V) on the potassium uptake by plants (kg/hectare).

Treatments	Varieties				Mean
	Cross-5	H-2743	H-4021	H-4126	
<u>Levels of nitrogen</u>					
50 kg per hectare	127.01	164.35	178.59	161.18	157.79
75 kg per hectare	123.31	172.31	175.65	177.11	162.10
100 kg per hectare	143.80	165.71	181.14	192.69	170.84
Mean	131.38	167.46	178.46	176.99	

C.D. (0.05) for comparison of treatment levels of nitrogen x variety : 14.46

The statistical analysis of the data on potassium uptake by plant did not show any significant influence of levels of nitrogen and time of application of nutrients. But the levels of potassium and varieties exerted significant influence on the potassium uptake by plant.

The levels of nitrogen did not exert any significant influence in the potassium uptake by plant. But maximum uptake of potassium was recorded at the highest level of 100 kg nitrogen per hectare. There was an increasing trend in the plant uptake of potassium with incremental doses of nitrogen application.

The different levels of potassium significantly influenced the potassium uptake by plant. The highest rate of uptake was registered by the potassium level of 100 kg K_2O per hectare which was on par with 75 kg K_2O per hectare and significantly superior to 50 kg level.

The varietal effect was significant in the plant uptake of potassium. The maximum uptake was shown by the variety H-4021 which was on par with variety H-4126 which in turn was significantly superior to the other two varieties viz. H-2743 and Cross-5.

Of the various interactions only the interaction between nitrogen and variety was found significant. The variety H-4126 at the level of 100 kg nitrogen per hectare (N_2V_4) registered the maximum potassium uptake by plant (192 kg K_2O per hectare).

4.6. Soil nutrients

4.6.1. Nitrogen content of soil after experiment

The data on nitrogen content of soil after experiment as influenced by the nutrient levels, time of application and varietal effect are presented in Tables 19a and 19b. The different levels of nitrogen applied in the soil did not exert any significant influence in the nitrogen content of soil. However, the nitrogen content of soil showed an increasing trend with increase in levels of nitrogen applied. Treatment N_2 (100 kg nitrogen per hectare) recorded the maximum soil nitrogen content of 0.225 per cent.

The different levels of potassium also did not affect the soil nitrogen status. But the soil nitrogen content showed a decreasing trend with increase in doses of potassium application, though not significant. The maximum soil nitrogen was obtained from the soil of K_0 treatment (50 kg K_2O per hectare).

Table 19a. Effect of different levels of nitrogen and potassium application on the total nitrogen content and available potassium content of soil after experiment

Treatments	Total nitrogen content of soil after experiment (%)	Available potassium content of soil after experiment (kg/hectare)
Levels of nitrogen		
50 kg nitrogen per hectare	0.21	116.60
75 kg nitrogen per hectare	0.22	110.40
100 kg nitrogen per hectare	0.23	107.27
F. test	NS	NS
Levels of potassium		
50 kg K_2O per hectare	0.22	107.67
75 kg K_2O per hectare	0.22	110.50
100 kg K_2O per hectare	0.21	116.10
F. test	NS	NS

NS : Not significant

Table 19b. Effect of different levels of time of application and varieties on the total nitrogen content and available potassium content of soil after experiment.

Treatments	Total nitrogen content of soil after experiment (%)	Available potassium content of soil after experiment (kg/hectare)
Time of application of nutrients		
1/2 N and K basal + 1/2 one month after planting	0.22	111.47
2/3 N and K basal + 1/3 one month after planting	0.22	111.38
F. test	NS	NS
Varieties		
Cross-5	0.21	113.33
H-2743	0.21	108.40
H-4021	0.22	111.16
H-4126	0.23	112.80
F. test	S	NS
C.D. (0.05)	0.01	

S : Significant

NS : Not significant

Varietal effect on the soil nitrogen content was significant. The plots cultivated with variety H-4021 (V_2) registered the maximum soil nitrogen content of 0.23 per cent which was significantly superior to the other three varieties (H-4126, H-2743 and Cross-5) tried. The lowest soil nitrogen was recorded by variety Cross-5 (V_1).

4.6.2. Potassium content of soil after experiment

The data on potassium content of soil after experiment as influenced by the levels of nutrients, time of application and varietal effects are presented in Tables 19a and 19b.

The levels of nitrogen did not affect the potassium content of soil significantly. However, a decreasing trend in potassium content was noticed with increase in level of nitrogen. The maximum potassium content of 116.6 kg per hectare was observed when the level of nitrogen applied was 50 kg per hectare.

The effect of potassium was also not significant in the soil potassium content of soil. But the soil potassium content showed an increasing trend with increase in levels of potassium. The maximum soil potassium content of 116.1 kg per hectare was noticed at the potassium level of 100 kg per hectare.

The different times of application and different varieties tried did not have any significant influence on the soil potassium content of soil.

DISCUSSION

DISCUSSION

The results of the investigation on the comparative performance of four sweet potato varieties to three levels of N and K and two times of application grown on the forest soils of Peringammala, are discussed below.

5.1. Growth characters

5.1.1. Length of vine

The data on the length of vine clearly showed significant difference in vine length by the different levels of nitrogen application. The length of vine was the highest at 100 kg nitrogen per hectare. This may probably due to the influence of higher levels of nitrogen on the vegetative growth of plants which is a very well established phenomenon. Nambiar et al. (1976) also obtained similar results in sweet potato.

Neither the levels of potassium nor the times of application exerted significant influence on the growth character. The nutrient element potassium is proved to show only a lesser influence on the vegetative growth characters.

The vine length was the highest in variety Cross-5 and lowest in H-2743. The conspicuous difference in vine length would be attributed to the varietal character.

5.2. Yield and yield components

5.2.1. Number of tuber per plant

The data on mean tuber number as influenced by various treatments revealed that the varietal effect alone was significant in this yield attribute. The soil of the experimental area was comparatively rich forest soil. This may probably be the reason for the lack of response to N and K levels in the present investigation. However, the tuber number was the highest at N_2 and K_2 levels.

The variety H-2743 produced the highest number of tubers which was on par with H-4021 and significantly superior to H-4126 and Cross-5. The variety Cross-5 produced the lowest number of tubers. It seems that this variety which was evolved at Bihar could not perform well under the agroclimatic conditions existing in Peringammala. So the significant difference in tuber number between the varieties can be attributed to the varietal effect. Similar results were reported earlier by Alexander (1973).

5.2.2. Length of tuber

The results showed that the different levels of nutrients did not significantly influence the length of tuher. However, the length of tuber was maximum at 75 kg nitrogen and 50 kg K_2O per hectare. The various levels of nutrients could not influence this character as the soil of the experimental area was comparatively rich in nutrients. Similar results were reported by several workers, namely, Nambiar et al. (1976) and Jana (1982).

The varietal effect was significant. The tuber growth was the highest in variety H-2743 which was significantly superior to all others. Variety H-4021 registered the lowest tuber length. The length of tuber is mostly a varietal character and hence the difference between different varieties. The conclusion arrived by Alexander (1973) also support the observations in the present investigation.

5.2.3. Girth of tuber

The data on girth of tuber presented in the mean table showed that the different levels of nitrogen and times of application of nutrients did not exert significant influence on the tuber girth. The lack of response of nitrogen levels may probably be due to the lesser influence of nitrogen on this, yield attribute especially in a tuber crop like sweet potato. However, the girth was maximum at the highest levels of nitrogen application.

The different levels of potassium exhibited significant difference in tuber girth of sweet potato in the present investigation. The girth was maximum at the highest potassium level which was significantly superior to the lowest level (K_1) and on par with K_2 level. The positive role of K nutrition in tuber development of tuber crops was highlighted by several workers like Fujise and Tsuno (1962), Wang (1975), etc. High values of tuber girth indicates better tuber development. The results of the present investigation also showed higher tuber girth values at the higher levels of K application. Similar results of better tuber development by higher rates of potassium nutrition were reported by several workers. namely Bourke (1977), Hammet et al. (1984), Morita (1967), Nicholaides (1985), Villareal (1982), etc.

The varietal effect was significant and the highest tuber girth was produced by H-4126 which was on par with H-4021 and significantly superior to H-2743 and Cross-5. Though level of nutrition can alter tuber girth values to some extent, it is considered mostly a varietal character. So, the significant difference between varieties shown in the present study can also be attributed to varietal effect. The result obtained by Alexander (1973) is in accordance with the observation made in the present investigation.

5.2.4. Tuber yield

The data on tuber yield showed that (Table 5a, 5b and 8) the various levels of nitrogen applied did not significantly influence tuber yield. The tuber yield was the highest at the lowest level of nitrogen (N_0) application, though not significant. Moreover yield showed a trend of decline with increasing rates of nitrogen application. Kunjan (1957), Paterson and Speights (1964) and Areigh (1967) also found that yield was not significantly increased beyond 50 kg nitrogen per hectare. Usually higher rates of nitrogen application increases vine growth considerably at the expense of tuber growth. The table on vine yield (Table 5a and 5b) clearly showed this trend. This result in a decrease in tuber yield with increase in levels of nitrogen, which was observed in the present field experiment also. Several workers like Bourke (1977), Jana (1982), Kim (1982), Macdonald (1963), Morita (1967) and Padda (1983) have proved this phenomenon beyond doubt. Higher root yield with 101 kg nitrogen per hectare than with 202 kg was observed by Hammett _et al_. (1984). The results obtained by the above workers are sufficient to substantiate the inference arrived at in the present investigation. But, on the contrary, Nambiar _et al_. (1976) obtained increased tuber yield with increase in levels of nitrogen.

The data on the analysis of soil before commencing the experiment, presented in Table 1 showed a high status of nitrogen in the forest soil of experimental area. This may probably be one of the most important reasons for the lack of response to different levels of nitrogen in the present study.

The effect of different levels of potassium tried in the study also did not show any significant influence in tuber yield. But the tuber yield was the highest at K_1 level (75 kg K_2O per hectare). The yield at the highest level of potassium application (100 kg K_2O per hectare) showed a trend of decline. Fujise and Tsuno (1962) reported that the photosynthetic rate of sweet potato leaves containing higher potassium was higher than the photosynthetic rate of leaves having lesser potassium. Wang (1975), Godfrey-Sam-Agrrey (1976), Bautista and Santiago (1981) and Nicholaides et al. (1985) obtained increased tuber yield with increase in levels of potassium application. But, Hammet et al. (1984) observed higher root yield with 140 kg potassium than with 70 or 280 kg potassium per hectare. Here among the three levels tried promising yield was scored by the moderate level of potassium than with the lowest and highest levels. In the present investigation also the yield was maximum at the moderate level of potassium application (K_1) than K_0 and K_2 levels.

In this connection it can be seen from the table for number of tubers per plant (Table 2a and 2b) that the highest tuber number was noticed in the treatment receiving 75 kg K_2O per hectare (K_1). Moreover the mean number of tubers declined when the level of potassium was raised to K_2 (100 kg K_2O per hectare). The data on tuber girth (Table 5a) also showed that the highest girth was recorded at the higher levels of potassium application (75 and 100 kg K_2O per hectare). It can also be seen that the dry matter yield of tuber (Table 14a) was the highest at K_1 level (75 kg K_2O per hectare). The individual effect of each of the yield components coupled with the cumulative effect of all these factors might have resulted in the highest yield at K_1 (75 kg K_2O per hectare) level, though the yield was not significant. The lack of response to the levels of potassium might probably be due to the comparatively high potash status of soil as is seen in the table for soil potassium (Table 1).

The effect of time of application was also not significant in respect of tuber yield. However, application of 2/3 the dose of nitrogen and potassium basally followed by 1/3 one month after planting (T_1) was found superior to the treatment T_0 wherein 1/2 the dose of N and K applied basally and other 1/2 one month after planting. Yuan et al. (1964), Godfrey-Sam-Agrrey (1976) and Singh (1982) have reported the beneficial effect of split application of fertilizers. The data on various growth characters such as length of tuber, dry matter yield of tuber and length of vine per plant showed higher values in treatment T_1 as compared to T_0. The data on the dry matter yield of vine (Table 14a) showed higher values for T_0 as compared to T_1.

The higher yield of vine in this treatment might have resulted in a poor yield of tuber as is seen in the table of tuber yield. The data on the uptake of nutrients such as N and K also showed higher values for T_1 as compared to T_0. The higher uptake resulting from the better efficient absorption of nutrients by plant also might have led to a higher tuber yield for the treatment T_1. The application of 2/3 the dose of nitrogen and potassium to plants might have led to an early development of the root system which have resulted in better growth and higher uptake of nutrients. On the other hand the plants in treatment T_0 received only 1/2 the dose of nitrogen and potassium basally which were in a disadvantageous position as compared to plants in treatment T_1.

The data on tuber yield clearly revealed the significant effect of varieties. The variety H-4126 (V_4) produced the highest yield of 15.9 tonnes per hectare. This was on par with the other two varieties H-2743 (V_2) and H-4021 (V_3). The variety Cross-5 (V_1) was significantly inferior to all the other varieties with a mean yield of 11.74 tonnes per hectare.

The data on vine yield (Table 5a and 5b) also showed significantly lower yield of Cross-5 as compared to other varieties. This shows that the general growth performance of the variety was not satisfactory in the agroclimatic conditions of Peringammala which was reflected in tuber yield also. Similarly in respect of characters such as girth of tuber and dry matter yield of tuber the variety Cross-5 seemed definitely inferior to other varieties (Tables 5, 6 and 14a). The data on utilization index (Table 5b) also revealed the conspicuous inferiority of Cross-5 as compared to other varieties. The data on the plant uptake of nitrogen and potassium as shown in tables (Table 14b) also showed the poor uptake values of these nutrients by the variety Cross-5.

The poor performance of the variety Cross-5 which was developed at the Rajendra Agricultural University of Bihar might probably due to the poor adoption of the variety to the agroclimatic conditions existing in the State. On the contrary the other three varieties tried in the experiment were developed at the College of Agriculture, Vellayani. These varieties hence proved their superiority in the agro-climatic conditions under which they were developed.

The three varieties H-4126, H-4021 and H-2743 which were on par were found to perform well with a dose of 50 kg nitrogen per hectare and 75 kg K_2O per hectare when applied 2/3 as basal dose and 1/3 one month after planting.

5.2.5. Vine yield

As noticed in the yield of tuber the levels of nitrogen did not influence the vine yield in the present investigation. But the data furnished in Table 5a and 5b show that the vine yield was increased with the incremental dose of nitrogen application, though not significant. The maximum vine yield was noticed at N_2 level (100 kg nitrogen per hectare) of nitrogen. The lowest vine yield was obtained at N_0 level of (50 kg per hectare) nitrogen. The influence of nitrogen in enhancing the vegetative growth was already discussed in detail. Inordinate development of vine at the expense of tubers as a consequence of excessive application of nitrogen was reported in one of early experiments by Morgan and Rose (1892). Significant increase in yield of vine as a result of application of higher levels of nitrogen fertilizer was observed by several other workers also, (Stuckey, 1914; Johnson and Ware, 1948; Stino, 1953; Ynan et al., 1964 and Samuels, 1967). Morita (1967) observed that a higher proportion of nitrogen resulted in vigorous top growth. The lack of response of nitrogen can be attributed to the higher nitrogen status of the rich forest soil in which the present study was conducted.

The data provided in Table 5a showed that the levels of potassium and the times of application did not exert any significant influence in the yield of vine. But the yield of vine showed a decreasing trend with increase in levels of potassium though not significant. The maximum vine yield was obtained at K_0 level (50 kg K_2O per hectare) of potassium. It may be probable that at higher levels of potassium application, more of the nutrient would have been utilized for tuber bulking rather than for top growth of the plant. The maximum tuber yield obtained at the highest level of potassium is in support of this.

In this connection it can be seen from the table for length of vine (Table 2a) that the highest vine length was noticed in the treatment receiving 50 kg K_2O per hectare (K_0). The data on utilization index also showed (Table 5a) a low value at 50 kg K_2O per hectare (K_0). The individual effect of each of the yield components coupled with the cumulative effect of all these factors might have resulted in the highest vine yield obtained at K_0 level, though not significant. Stino (1953) obtained no increase in vine yield with increase in levels of potassium. Morita (1967) found that a higher K/N ratio increased tuber yield while a lower K/N ratio enhanced vine yield. The result obtained in the present work is in conformity with these earlier reports.

The data on vine yield clearly revealed the significant effect of varieties. The variety H-2743 produced the highest yield of vine which was on par with H-4021 and H-4126 but was significantly superior to Cross-5. All the three varieties which were evolved at Vellayani showed satisfactory growth performance at Peringammala also and hence results a higher vine yield and tuber yield. So this difference can be considered as due to varietal behaviour.

5.2.6. Utilization index

The effect of nitrogen on the utilization index was not significant (Table 5a). However, the utilization index showed a decreasing trend with increasing levels of nitrogen. The maximum value of utilization index was recorded at the nitrogen level of 50 kg per hectare (N_0). The lowest value was recorded at 100 kg nitrogen per hectare (N_2). The data on tuber yield (Table 5a) and vine yield (Table 5a) showed that with increasing levels of nitrogen, tuber yield decreased whereas vine yield increased. Utilization index being the ratio of tuber yield to top yield have hence decreased with increasing levels of nitrogen.

Application of potassium enhanced utilization index though not significant and the highest value was obtained at the highest level of 100 kg K_2O per hectare (K_2). The least value of utilization index was obtained at the lowest level of potassium i.e. 50 kg K_2O per hectare (K_0). With higher levels of potassium application tuber yield showed an increasing trend whereas vine yield a trend of decline. This can be considered as the reason for the increase in the value of utilization index, with higher doses of potassium. Similar result was obtained by Nair (1982) in tapioca.

Neither the time of application of nutrient nor the varietal effect was significant in this respect.

5.3. Quality attributes

5.3.1. Starch content of tuber

The influence of levels of nutrients and times of application was not significant in this aspect in the present investigation. However, though not significant, the treatment N_1 (75 kg nitrogen per hectare) showed the highest starch content. Increase in starch content of tubers by nitrogen nutrition has been reported by Asokan _et al_. (1984) in sweet potato.

But further increase in the level of nitrogen application to 100 kg per hectare (N_2) tended to decrease the starch content and recorded the lowest value. Tsuno and Fujise (1968) concluded that to produce a higher starch content of tuber the nitrogen application should be moderate in order to prevent excessive development of the tops at the expense of tuber growth. As the supply of nitrogen to plants increases there is a tendency for the carbohydrate content to decrease (Black, 1973). This may be due to the increased protein production at this level with a corresponding decrease in the starch content. At higher levels of nitrogen the balance between carbohydrates and protein might have been shifted in favour of protein synthesis resulting in higher percentage of protein as is seen in the table (Table 10a) of crude protein content. The result in the present investigation is also in conformity with the above finding.

The data on starch yield (Table 10a) showed a steady increase with the increased levels of potassium application, though not significant. The highest starch content was obtained by the treatment K_2 (100 kg K_2O per hectare) and lowest by the treatment K_0 (50 kg K_2O per hectare). This clearly shows a direct relationship between the influence of potassium nutrition and starch content of tubers. Higher potassium doses probably might have increased the potassium level in leaves which in turn might have accelerated the phytosynthetic rates of leaves resulting in higher starch accumulation in roots (Fujise and Tsuno, 1962). The results obtained in the present investigation is in conformity with the conclusion drawn by Asokan et al. (1984) and Sharfuddin and Voican (1984) in sweet potato.

Varieties exhibited significant difference in starch content of tuber. Maximum starch content was noticed in variety H-4021 (V_3) which was significantly superior to varieties H-2743 (V_2) and H-4126 (V_4) but on par with variety Cross-5. The lowest starch content was recorded by variety H-4126 (V_4). This may be probably due to the inherent varietal difference in this quality attribute.

5.3.2. Crude fibre content of tuber

The data provided in table (Table 10a) clearly show that the levels of nitrogen could not influence the crude fibre content of tuber in the present investigation. The effect of levels of potassium (Table 10a) was significant in crude fibre content of sweet potato tuber. The treatment K_2 (100 kg K_2O per hectare) recorded the maximum crude fibre content which was significantly superior to the other two levels of potassium. Constantin et al. (1977) observed that crude fibre content increased with increasing levels of potassium application on dry weight basis.

The varieties showed significant difference in crude fibre content. The variety Cross-5 recorded the maximum crude fibre content which was on par with H-4021 and significantly higher than varieties H-4126 and H-2743. The difference between varieties noticed in respect of crude fibre content can also be attributed to varietal characteristics.

5.3.3. Crude protein content of tuber

The data (Table 10a) showed the significant influence of nitrogen on crude protein content of tuber. The crude protein content showed a trend of steady increase with increasing levels of nitrogen. The maximum crude protein was recorded by the nitrogen level of 100 kg per hectare which was significantly superior to the other levels of 50 kg and 75 kg per hectare. The favourable effect of nitrogen nutrition on protein synthesis has already been discussed.

Similar results were reported earlier by Constantin *et al.* (1984), Liliang (1975), Dean and Lasheen (1969) and Mandal *et al.* (1971).

The different levels of potassium did not influence the crude protein content. This may probably be due to the lesser influence of potassium on protein synthesis. The times of application of nutrient also did not influence the crude protein content of tuber.

The varietal effect was significant in the crude protein content of tuber (Table 10b). The variety H-2743 recorded the maximum crude protein content of tuber which was significantly superior to varieties Cross-5, H-4021 and H-4126. The variety Cross-5 registered the lowest crude protein content. The difference can also be attributed to the variation in the varietal characteristics.

5.4. Growth analysis

5.4.1. Dry matter yield of tuber

The data (Table 14a) show that the different levels of nitrogen did not influence the dry matter yield. However, treatment N_0 (50 kg nitrogen per hectare) showed the highest dry matter yield. Though not significant the increasing levels of nitrogen showed a decreasing trend in the dry matter yield of tuber. The data on tuber yield (Table 5a) which was discussed earlier showed a decreasing trend in tuber yield with higher rates of nitrogen application. This may be the reason for the observed trend in dry matter yield. This result conforms with the findings of Liliang (1975).

The different levels of potassium and times of application of nutrients also could not show any significant influence in the dry matter yield of tuber (Table 14a). However, the tuber dry weight increased when the levels of potassium was raised from 50 kg per hectare (K_0) to 75 kg per hectare (K_1). Fujise and Tsuno (1962) observed 20% increase of tuber dry weight in high potassium plot than the control plot. But further increase in potassium from 75 kg K_2O per hectare to 100 kg K_2O per hectare showed a decrease in tuber dry weight. Prabhakar *et al*. (1977) also reported that there was no response in tuber dry weight by the different fertility levels of soil.

The varietal effect on the dry weight yield of tuber was significant. The variety H-4021 recorded the maximum tuber dry weight which was significantly superior to all the other varieties tried. The genetic variation of the different varieties may be the probable reason for the observed differences in this quality characteristic.

5.4.2. Dry matter yield of vine

Dry matter yield of vine did not show any significant difference with different levels of nitrogen. However, the highest level of nitrogen (100 kg nitrogen per hectare) showed maximum dry weight yield of vine. This might have been achieved by the increased vine yield obtained at the highest level of (Table 14a) 100 kg nitrogen per hectare.

The different levels of potassium and times of application also did not show significant difference in the dry weight yield of vine. But the dry matter yield of vine showed a decreasing trend with increase in the levels of potassium. The data on vine yield (Table 5a) discussed earlier also showed a similar trend of decline in yield and hence the observed decrease in dry matter yield of vine with increasing levels of potassium.

The varieties showed significant difference in this quality characteristic which may be considered as due to varietal difference.

5.5. Nutrient uptake

5.5.1. Nitrogen uptake by plant

The data provided in Table 14a reveal that the nitrogen uptake by plant increased significantly with incremental doses of nitrogen application. The maximum nitrogen uptake was recorded at 100 kg nitrogen per hectare (N_2) which was significantly superior to the other two levels. With increasing levels of application of nitrogen, it is probable that the plant uptake of the element will also be correspondingly increased. Knavel and Yasheen (1969), Constantin et al. (1974), Liliang (1975), Nair et al. (1976) and Purcel et al. (1982) obtained increased nitrogen uptake with increased levels of nitrogen application.

The different levels of potassium did not significantly influence the nitrogen uptake by plant. Purcel et al. (1982) also obtained similar results in sweet potato.

The times of application of nitrogen and potassium also could not exert any significant influence on the total nitrogen uptake by plant. Nair et al. (1976) opined that time of nitrogen application did not affect the nitrogen uptake. The varietal effect was significant in the total nitrogen uptake by plants. Varieties differ in their capacity to absorb nutrients from the soil. This varietal difference is reflected in the quantum of nutrients absorbed by the plants belonging to different varieties.

5.5.2. Potassium uptake by plant

As shown in table (Table 14a) the levels of nitrogen did not exert significant influence in the total potassium uptake by plant. However, an increasing trend in potassium uptake was noticed with increase in nitrogen application.

But potassium uptake was significantly influenced by the increased levels of potassium application. At 100 kg K_2O per hectare (K_2) potassium uptake recorded the peak value. This was significantly superior to 50 kg K_2O per hectare (K_0) and on par with 75 kg K_2O per hectare (K_1). Duncas (1958) and Hammel et al. (1984) also obtained increased potassium uptake with the increased levels of potassium application, which is conforming with the observations made in the present investigation. Fujise and Tsuno (1962) found increased potassium uptake by leaves with increased levels of potassium application. Similar observation was made by Hammot et al. (1984) also.

The different times of application of nutrients did not influence the potassium uptake by plants significantly. The varietal effect was significant in the plant uptake of potassium. As discussed earlier the varietal difference may be the reason for this also.

5.6. Soil nutrients

5.6.1. Total nitrogen content of soil

The different levels of nitrogen application did not affect the total nitrogen content of soil after experiment. But the total nitrogen content of soil showed a trend of increase by the application of higher doses of nitrogen in the present investigation (Table 19a). The chemical analysis of soil (Table 1) before commencement of the experiment showed high nitrogen status of soil. It can be assumed that at high levels of nitrogen application even after plant removal of the element, the soil was enriched by the applied nitrogen and hence the observation. Rajendran et al. (1971) observed an increase in the available nitrogen content of soil by the application of 100 kg nitrogen per hectare to tapioca.

The different levels of potassium also did not influence the final soil nitrogen status. But the soil nitrogen content showed a decreasing trend with increase in doses of potassium application. The maximum soil nitrogen was observed in the plots in which the potassium was applied at 50 kg K_2O per hectare (K_0). The enhanced rate of uptake of nitrogen by plant at higher levels of potassium application (Table 14a) can be attributed to be a probable reason for the decreasing trend in the nitrogen content of soil observed in the investigation.

The varietal effect on the soil nitrogen content was significant. The variety H-4021 (V_3) showed the maximum soil nitrogen content after crop growth, which was significantly superior to the other three varieties. This can be explained as due to varietal difference.

5.6.2. Available potassium content of soil

The data provided in the table for soil potassium content after experiment (Table 19a) showed that the available soil potassium was not significantly influenced by the different levels of nitrogen application. However, a decreasing trend in available potassium content with increasing levels of nitrogen was observed. In this connection it is worthwhile to note that the plant uptake of potassium in the present investigation was higher at higher levels of nitrogen application (Table 14a). This might have resulted in lower available potassium status after crop growth in plots receiving higher doses of nitrogen.

Eventhough there was no significant influence of the levels of potassium on available potassium status of soil there was an increasing trend in soil potassium status with increasing levels of potassium application. The maximum soil potassium content was noticed at the highest level of potassium application (100 kg K_2O per hectare. Kumar _et al_. (1971) and Rajendran _et al_. (1972) also observed an increase in available potassium content of soil by the application of higher doses of potassium.

The influence at the two times of application of nutrients and different varieties tried were not significant in the present investigation.

SUMMARY

SUMMARY

An investigation was undertaken in the upland soils of Banana Nursery, Peringammala to study the comparative performance of four sweet potato varieties (Cross-5, H-2743, H-4021 and H-4126) under different levels and times of nitrogen (50, 75 and 100 kg N/ha) and potassium (50, 75 and 100 kg K_2O/ha) application. The experiment was laid out in a split plot cum confounded design with two replications. The main plot treatments were the combinations of 3 x 3 x 2 asymmetrical factorial with the time of application as the factor of asymmetry. The lay out of the main plot was done by converting to a confounded symmetrical factorial of 3 x 3 x 3 and omitting the unwanted factorial combinations. The results of the investigation are summarised below.

1. The application of 100 kg N/ha resulted the maximum vine length. There was no influence by the levels of potassium and times of application in this aspect. Among the four varieties, Cross-5 recorded the maximum vine length.

2. Maximum number of tubers were found in variety H-2743. Levels of nutrients and time of applications had no effect.

3. Variety H-2743 recorded the highest tuber length. Influence of levels of nutrients and time of application was not significant.

4. The application of 100 kg N/ha + 100 kg K_2O/ha resulted the maximum tuber girth. There was no effect by the different times of application. Variety H-4126 was superior to other varieties in tuber girth.

5. The utilization index was not altered by levels of nutrients, times of application and varieties.

6. Though not significant, the application of 50 kg N/ha + 75 kg K_2O/ha, 2/3 of the doses basal and 1/3 one month after planting gave the maximum tuber yield. Variety H-4126 was superior to other three varieties.

7. Levels of nutrients and times of application did not influence the vine yield. Variety H-2743 recorded the maximum vine yield.

8. Maximum starch content was noticed in variety H-4021. Starch content was high at the nutrient level of 75 kg N/ha and 100 kg K_2O/hectare.

9. Crude fibre content was at its peak when potassium was applied @ 100 kg K_2O/ha. But this character was not influenced much by levels of nitrogen. Times of application had also no effect. The variety Cross-5 recorded the maximum crude fibre content.

10. The application of 100 kg N/ha resulted the maximum crude protein content in sweet potato tuber. The different levels of potassium application and times of application of nutrient had no effect in this character. Among the four varieties, H-2743 recorded the maximum crude protein content in tuber.

11. The variety H-4021 registered the maximum dry matter yield of tuber which was significantly superior to the other three varieties tried. The levels of nutrient and time of application had no effect.

12. The dry matter yield of vine was maximum for the variety H-2743. The levels of nutrients and times of application had no effect in the dry matter yield of vine.

13. The application of 100 kg N/ha resulted the maximum nitrogen uptake by plant. Levels of potassium and times of application have no effect. The maximum total nitrogen uptake was registered by the variety H-4021.

14. The highest rate of plant uptake of potassium was registered by the potassium level of 100 kg K_2O/ha. The uptake was not influenced by the levels of nitrogen and different times of application of nutrients. Among the four varieties the maximum uptake was shown by the variety H-4021.

15. The soil nitrogen content after the experiment was not influenced by the levels of nutrients and time of application. But the plots cultivated with variety H-4021 registered the maximum soil nitrogen content after the experiment.

16. The potassium content of soil after the experiment was not influenced by the levels of nutrients, time of application of nutrients and varieties.

The salient findings of the present investigation that can be communicated to the farmers for adoption are as follows

In the upland situations of Kerala the optimum dose of NPK that can be recommended for sweet potato crop is 50 kg N, 50 kg P_2O_5 and 50 kg K_2O per hectare as against the general recommendation of 75 kg N, 50 kg P_2O_5 and 75 kg K_2O given in the package of practices recommendations 1986, of Kerala Agricultural University.

The best time of application of nutrients recommended is 1/2 the dose of N and K and full dose of P as basal and remaining 1/2 N and K dose one month after planting as against N in equal split doses, the first at the time of planting and second 4 to 5 weeks after planting and entire phosphorus and potassium at the time of planting, given in the package of practices recommendations 1986, of Kerala Agricultural University.

Among the four varieties (Cross-5, H-2743, H-4021 and H-4126) tried, the best performed variety is H-4126.

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APPENDICES

APPENDIX I

Meteorological data for the crop period (4th January 1985 to 9th May 1985) at Banana Development Nursery, Peringammala

Number of weeks	Period	Total weekly rainfall (mm)	Number of rainy days	Temperature °C weekly average		Weekly average relative humidity (%)
				Maximum	Minimum	
1	4-1-1985 - 10-1-1985	58.0	3	31.75	22.97	79
2	11-1-1985 - 17-1-1985	1.8	1	31.29	21.79	70
3	18-1-1985 - 24-1-1985	Nil	Nil	32.89	21.72	68
4	25-1-1985 - 31-1-1985	Nil	Nil	33.21	21.33	67
5	1-2-1985 - 7-2-1985	11.8	2	33.32	22.15	67
6	8-2-1985 - 14-2-1985	Nil	Nil	33.10	22.90	70
7	15-2-1985 - 21-2-1985	4.6	1	33.71	23.15	70
8	22-2-1985 - 28-2-1985	Nil	Nil	34.57	21.19	61
9	1-3-1985 - 7-3-1985	8.8	1	34.75	24.78	72
10	8-3-1985 - 14-3-1985	Nil	Nil	34.72	25.10	71
11	15-3-1985 - 21-3-1985	7.6	1	34.90	25.24	74
12	22-3-1985 - 28-3-1985	36.8	2	34.12	25.16	73
13	29-3-1985 - 4-4-1985	4.2	1	33.86	25.32	72
14	5-4-1985 - 11-4-1985	73.4	3	33.75	25.12	72
15	12-4-1985 - 18-4-1985	Nil	Nil	34.00	25.97	71
16	19-4-1985 - 25-4-1985	33.8	4	33.68	26.11	77
17	26-4-1985 - 2-5-1985	32.6	2	33.64	25.94	76
18	3-5-1985 - 9-5-1985	Nil	Nil	35.13	26.15	67

APPENDIX II

Analysis of variance for length of vine, number of tuber per plant, length of tuber and girth of tuber per plant.

Source	Degree of freedom	Variance			
		Length of vine per plant	Number of tuber per plant	Length of tuber	Girth of tuber
Block	5	1962.20**	0.91	3.44	13.37
Nitrogen (N)	2	22941.25	0.88	1.34	3.44
Potassium (K)	2	5919.50	0.47	3.23	8.69
Time of application (T)	1	138.00	0.25	2.88	0.79
N x K	4	132.25	0.06	0.40	12.40*
K x T	2	2728.50	0.44	0.45	15.84*
N x T	2	710.50	0.44	1.09	0.21
Error - 1	13	2490.60	0.40	5.09	1.91
Variety (V)	3	105187.80**	1.31**	13.53**	44.04*
N x V	6	6293.92**	0.19	5.77**	3.36
K x V	6	1228.83**	0.77*	2.41**	1.82
T x V	3	2345.33**	0.16	4.17**	0.84
Error - 2	54	346.46	0.30	0.49	3.54

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX III

Analysis of variance for utilization index, tuber yield and vine yield per hectare.

Source	Degree of freedom	Variance		
		Utilization index	Tuber yield per hectare	Vine yield per hectare
Block	5	0.07	11.14	6.68
Nitrogen (N)	2	0.12	1.52	20.51
Potassium (K)	2	0.10	11.48	7.24
Time of application (T)	1	0.03	2.50	1.21
N x K	4	0.02	1.96	2.17
K x T	2	0.09	7.91	1.44
N x T	2	0.13	5.93	10.37
Error - 1	13	0.05	5.83	5.40
Variety (V)	3	0.01	24.33**	77.67**
N x V	6	0.02	1.71**	7.62*
K x V	6	0.02	1.72**	1.78
T x V	3	0.01	1.45	0.05
Error - 2	54	0.01	0.36	3.32

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX IV

Analysis of variance for starch content of tuber, crude fibre content of tuber and crude protein content of tuber

Source	Degrees of freedom	Variance		
		Starch content of tuber	Crude fibre content of tuber	Crude protein content of tuber
Block	5	8.57	0.016	0.14
Nitrogen (N)	2	1.22	0.035	136.88
Potassium (K)	2	3.82	1.960**	1.44
Time of application (T)	1	0.01	0.005	0.002
N x K	4	10.16	0.002	0.07
K x T	2	0.82	0.004	0.67
N x T	2	1.52	0.024	0.95
Error - 1	13	4.20	0.018	0.95
Variety (V)	3	11.08**	1.646**	1.07
N x V	6	5.56**	0.017**	0.79
K x V	6	13.17**	0.034	1.91
T x V	3	7.34**	0.011	0.40
Error - 2	54	0.30	0.008	0.19

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX V

Analysis of variance for dry matter yield of tuber, dry matter yield of vine and nitrogen uptake by plant.

Source	Degree of freedom	Variance		
		Dry matter yield of tuber	Dry matter yield of vine	Nitrogen uptake by plant
Block	5	0.83	0.08	1458.60
Nitrogen (N)	2	0.11	0.24	19891.50**
Potassium (K)	2	0.84	0.09	1648.88
Time of application (T)	1	0.23	0.02	54.50
N x K	4	0.15	0.03	138.13
K x T	2	0.62	0.02	1002.38
N x T	2	0.48	0.13	22.88
Error - 1	13	0.41	0.07	1053.77
Variety (V)	3	3.21**	0.92**	14822.75**
N x V	6	0.13**	0.09*	558.08
K x V	6	0.13**	0.02	263.83
T x V	3	0.12**	0.01	275.00
Error - 2	54	0.026	0.04	219.94

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX VI

Analysis of variance for potassium uptake by plant, total nitrogen content of soil and available potassium content of soil after experiment

Source	Degrees of freedom	Variance		
		Potassium uptake by plant	Total nitrogen content of soil after experiment	Available potassium content of soil after experiment.
Block	5	1539.80	0.0033	254.43
Nitrogen (N)	2	2121.63	0.0051	1083.06
Potassium (K)	2	13691.13**	0.0035	884.19
Time of application (T)	1	163.00	0.0002	0.50
N x K	4	487.31	0.0014	285.41
K x T	2	279.00	0.0002	485.09
N x T	2	546.75	0.0001	253.56
Error - 1	13	875.65	0.0015	434.66
Variety (V)	3	17441.58**	0.0030*	177.13
N x V	6	865.63*	0.0022*	276.44*
K x V	6	318.13	0.0007	277.23*
T x V	3	633.42	0.0013	475.38**
Error - 2	54	311.81	0.0007	105.21

* Significant at 5 per cent level

** Significant at 1 per cent level

NUTRITIONAL STUDIES IN SWEET POTATO

By

D BHUVANANDRAN NAIR B Sc (Ag)

ABSTRACT OF A THESIS
submitted in partial fulfilment of
the requirement for the degree of

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COLLEGE OF AGRICULTURE
Vellayani, Trivandrum
1987

ABSTRACT

An investigation was conducted in the upland soils of Banana nursery, Peringammala to study the comparative performance of four sweet potato varieties under different levels and times of nitrogen and potassium application. The treatments consisted of three levels of nitrogen (50, 75 and 100 kg N/ha) and three levels of potassium (50, 75 and 100 kg K_2O/ha) at two times of application. Four varieties (Cross-5, H-2743, H-4021 and H-4126) were studied in the experiment. The experiment was laid out in a split plot cum confounded design with two replications.

Application of nitrogen enhanced the vine length while levels of potassium and times of application had no effect. Tuber girth increased with increased doses of potassium application. The varietal effect on the above characters was significant. Maximum tuber yield of sweet potato was obtained when nitrogen and potassium were applied @ 50 kg N/ha and 75 kg K_2O/ha as 2/3 the dose basal and 1/3 one month after planting. Variety H-4126 was superior in tuber yield. Starch content was maximum in variety H-4021. Crude fibre content increased with increased doses of potassium application. Application of 100 kg N/ha recorded the maximum crude protein content of tuber. The maximum dry matter yield of tuber, plant uptake of nitrogen and plant uptake of potassium were recorded by variety H-4021. Nitrogen uptake by plant was

maximum at the level of nitrogen application of 100 kg N/ha. Potassium uptake by plant also increased with increase in dose of potassium application. Application of nutrients as 2/3 dose basal + 1/3 one month after planting was found to be the best at Peringammala condition.