THE EFFECT OF SOME GROWTH REGULATORS ON SPROUTING AND FIELD PERFORMANCE OF THREE WHITE YAM VARIETIES (*Dioscorea rotundata*) Poir.

BY

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DECLARATION.

I hereby declare that, except for references to other researchers' work which have been duly cited, this work is the result of my own original research and that this thesis has neither in whole nor in part been presented for another degree elsewhere.

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DEDICATION

This thesis is dedicated to my dear wife, Patience and to the memory of my father, Mr. J.K. Amponsah, who initiated me into formal education. He was called to eternity while I was studying at the University of Ghana.

ACKNOWLEDGEMENT.

Thanks and praises to the most Holy Trinity for the strength and knowledge to carry out this research. I duly acknowledge the financial support from Root and Tuber Improvement Programme (RTIP) of Ministry of Food and Agriculture and University for Development Studies that enabled me to undertake the study.

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I am extremely grateful to my wife, my mother and my siblings for their moral support during my study at the University of Ghana. I would like to express my immeasurable thanks to my course mates, Messers Kofi Ametepe and Kofi Amoako for their co-operation and advice.

ABSTRACT

A study was carried out at the University of Ghana from January 2001 to January 2002 to find out if Labreko and Pona yam varieties treated exogenously with some growth regulators will respond to yam minisett technique. Six experiments were set up consisting of three yam minisett sprouting studies and three field assessments of the sprouted minisetts. The objective of the study was to use growth regulators to enhance sprouting of Labreko and Pona minisetts and to improve field performance of the sprouted minisetts.

In Experiment 1, different levels of the growth regulators naphthalene acetic acid (0, 50, 100 and 200 mg/l), ethrel (0,100, 500 and 1000 ppm) and coconut milk (water and undiluted coconut milk) were applied to the head, middle and tail sections of Labreko, Pona and Dakpaan white yam varieties (*Dioscorea rotundata*) Poir. The treated minisetts were dusted with dithane M45 fungicide, air-dried and then planted in moist sterile sawdust kept in baskets. They were inspected fortnightly to take data. In Experiment 2, NAA was dropped from the treatments used in Experiment1. In Experiment 3, 500 ppm of ethrel and undiluted coconut milk were applied to Labreko and Pona. The sprouted minisetts from the three experiments were transplanted to the field. In the first field experiment (Experiment 4) the effects of developmental stage of sprouted minisetts from Experiment 1 at transplanting and the growth regulators on field performances were studied. In Experiment 5, the effect of the different concentrations of the growth regulators on field performance was studied. The last experiment looked at the effects of 500 ppm of ethrel and coconut milk on field performances.

It was found that coconut milk and ethrel promoted sprouting while NAA suppressed

sprouting. The improvement of coconut milk over the control in sprouting was in the range of 13-30 % and that of ethrel was 7-8 %. Three months after storage, the highest percentage sprouting of the varieties, 6 and 10 weeks after nursing, were 18.9 and 69 % respectively. Six months after storage, sprouting increased to 88 % for Pona. Therefore, dormancy ought to be sufficiently broken (that is more than 3 months after harvest), before some varieties such as Pona and Labreko could respond to sprouting.

The higher the concentration of NAA, the higher its suppression effects on sprouting. Minisetts from the head and tail sections interacted positively with coconut milk. Lower concentrations of ethrel were required to induce more sprouting in the head and tail sections in the first experiment. However, as the release of dormancy progressed higher levels were required to make a difference between the ethrel levels and the control.

Stage 1 (with vine length of up to 2 cm) and Stage 2 (with vine length of 2.1-4.0 cm) sprouted minisetts survived better than Stage 3 (with vine length of 4.1-6.0 cm, with some having 2 leaves). Stage 2 sprouted minisetts produced the highest tuber yield. Among the three varieties Pona recorded the lowest percentage survival on the field.

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CHAPTER ONE

1.0 INTRODUCTION

Yam constitutes an important component of the diet of many Africans especially West Africans. It constitutes 55.3 % of total root and tuber consumption in West Africa (Gebremeskel and Oyewole, 1987). It has become a source of foreign exchange for some countries in the yam belt. Lev and Shrivel (1998) have reported that Nigeria, Ghana and Ivory Coast account for 95 % of global yam production. Anonymous (2000) report indicates that yam production in Ghana increased from 1,700,100 metric tons in 1994 to 3,332,900 metric tons in the year 2000. In the same period, yam export rose from 5,323 to 9,763 metric tons (Anonymous, 2000b). Its production is however characterised by many problems. These include scarcity of planting material. Farmers save one-fifth of their harvest for planting (Onwueme 1978). Nweke et al. (1991) established that the total cost of yam production is shared almost equally between labour and planting material. The high cost of *Pona* seed yam has been identified to be one of the main factors militating against the increased production of Pona (Acquah and Evange, 1994).

Traditionally, farmers rely on 'pricking' and cutting of ware yam into sections to generate planting material. In addressing this problem the minisett technique, whereby small pieces of yam (25g) are used to generate planting materials was developed (Otoo *et al.*, 1985; Okoli and Akoroda, 1995).

The adoption of the technique in Ghana has not been successful due to many problems. Notable among them is the failure of very important varieties such as Pona and Labreko to respond to sprouting. (Root and Tuber Improvement Programme document, 1996).

Many plant growth promoters have been used to enhance sprouting in yam minisetts. Tiki (1988) reported that phytohormones induced sprouting in yam but sprouting was not uniform. Ndzana et al. (1992) attributed the differential sprouting behaviour of minisetts to different levels of endogenous phytohormones in the different sections of the tuber. They therefore recommended that different sections of the tuber have to be treated with specific levels of exogenous growth promoters to achieve uniform sprouting.

This study aims at promoting quick and uniform sprouting of the elite yam varieties, Labreko and Pona

The objectives of the study are to:

- determine the efficiency of some growth regulators in promoting sprouting in the varieties.
- increase the percentage sprouting of the varieties.
- determine the period after harvesting that the varieties respond to sprout inducement.
- determine if coconut milk can promote sprouting in the yam varieties.
- determine which development stage after sprouting is suitable for field transfer and
- determine if the growth regulators affect field performance.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Classification of yam

Yams, *Dioscorea spp.* belong to the family Dioscoreaceae. The genus Dioscorea contains about 600 species. However, only a small proportion of the species are of any value to man. Yams are dioecious and the fruit is a dry capsule. All the yams that are of economic importance as food crops are tuberous and it is the tuber that forms an article of food for man (Coursey, 1967).

Tetteh and Saakwa (1994) observed that six species are cultivated in Ghana. These are *Discorea rotundata* (white yam), *D. alata* (water yam), *D. cayenensis* (yellow yam), *D. bulbifera* (aerial yam), *D. esculenta* (Chinese yam) and *D. dumetorum* (trifoliate yam). *D. rotundata* is the principal commercial yam and constitutes about 80% of the total yam produced (Coursey, 1967).

2.2 Sources of yam planting materials.

2.2.1 Plant material from previous season's harvest.

Most present-day yam farmers simply depend on the previous season's harvest to supply the planting material for the following season. A portion of the previous season's harvest of ware yams, and nearly all of its small unmarketable tubers are set aside as planting material for the next season. The ware yams are cut into small pieces of about 500 g for use as setts while the small tubers are planted as wholes (Onwueme, 1978).

2.2.2 Presprouting of yam

Sprouting occurs on the head of intact tubers and while the sprout grows, apical dominance is established that does not allow sprouting to occur at the middle and tail portions unless the head is severed off. In order to circumvent this problem some farmers cut the yam tubers into pieces and sprout them before they are planted (Onwueme, 1978).

2.2.3 Exclusive use of heads

In order to ensure uniform and rapid emergence of sprout, farmers also usually cut the heads of tubers for planting. If the head is quite large it is cut longitudinally into pieces before planting (Onwueme, 1978).

2.2.4 Pricking

Most farmers prick or milk the yam in order to generate setts for planting. Tubers that are mature but have green leaves on their vines are pricked leaving the corm and roots intact. The corm is able to produce setts that are big enough to be planted whole or split into pieces for planting (Onwueme, 1978).

2.2.5 Minisett technique

Yam minisett is a piece of yam tuber of size about 25 g that is aseptically sprouted in a growth medium. Some farmers rely on small whole yams that have been specially produced. Planting very small setts (25g) cut from a large tuber produces these small tubers. The minisetts are dusted with wood ash or a fungicide and sprouted in a medium. The sprouted yams are transferred to the field where they yield setts of 500 – 1000 g at maturity (Onwueme, 1978).

2.3 Dormancy in yam tuber

Little is known of the mechanism of dormancy in the yam tuber. Campbell *et al.* (1962b) have suggested that dormancy is associated with low levels of glutathione. Glutathione level is high when the dormancy level is low. Gupta *et al* (1979) have reported the presence of abscicin II -like compound as one of the factors controlling tuber dormancy in *D. composita.*

Different species and cultivars have different length of dormancy period. Nweke and Okonkwo (1981) investigated the length of tuber dormancy in *D. rotundata, D. alata, D. dumetorum* and *D. bulbifera.* The results showed that regardless of the storage and planting conditions, tubers of *D. rotundata, D. alata,* and *D. dumetorum* remained dormant for 14 – 16 weeks while aerial bulbils of *D. bulbifera* remained dormant for a longer period of 19 weeks.

Osagie (1985) has suggested the involvement of lipoxygenase in the dormancy release in yam tubers. The high content of this enzyme in early stages of sprouting could indicate the involvement of its products in cell differentiation or its function in cell division or cell enlargement in the sprout as it pushes its way through the tuber tissues to reach sunlight.

2.4 Bud development in yam

Hitherto, it was thought that the yam tuber was like potato (*Solanum tuberosum)* in possessing buds at different points on the surface of the tuber and that sprouting simply involved breaking of dormancy of these buds and their subsequent elongation (Onwueme, 1978). It has, however, been reported by Onwueme (1973) that at harvesting the yam-tuber surface is normally devoid of buds. This conclusion is also upheld by Martin (1976). During storage, one or more buds may develop from the head region of the tuber or from the corm. After planting, even budless tuber pieces from the middle or tail

sections of the tuber are all capable of developing buds (Onwueme, 1978). It is on this basis that the yam minisett technique was developed.

2.5 Sprouting in yam

Onwueme (1973) reviewed the process of sprouting in budless tuber pieces. He reported that first, the layer of meristematic cells just beneath the tuber surface undergoes active cell division, and produces a large mass of undifferentiated cells. This mass of cells soon becomes organized and a shoot apex differentiates within it. At this stage, the overlying tuber skin ruptures, revealing on the surface, a glistening mass of cells produced by the meristematic activity. Such rapture point is called sprouting locus. Soon, the growing point begins to push through the overlying mass of cells and later it becomes visible from the surface as a small bud. The whole process from the onset of cell division till the bud is externally visible lasts 1 – 2 weeks; the time being slightly shorter for *D. alata* than *D. rotundata* and *D. cayenensis*.

If the tuber is in a moist medium, the bud immediately proceeds to elongate and a ring of stout roots forms at the junction of the bud with the tuber. The rapidity with which a piece of yam tuber sprouts depends on which part of the tuber it has been obtained from. If the entire tuber is planted, sprouting invariably occurs at the head-region, and while the head-sprout remains, sprouting in the middle or tail regions of the tuber is suppressed. However, the middle and tail portions of the tuber are able to sprout when severed from the head. Miege (1957) and Coursey (1967) noted that in such cases the tail and middle setts sprout much less rapidly than the head sett. Onwueme (1973) found no differences between the rates of sprouting of middle and tail setts. He observed that when any yam sett sprouts, the sprout tends to arise from the headward (maturer) part of the sett.

2.6 Conditions necessary for sprouting

Temperature affects the sprouting of yam (Onwueme, 1975c). While sprouting occurs readily at 25°C and 30°C, it is considerably delayed at 35°C or 15°C.

Lack of water supply does not affect the rate of bud formation on the yam tuber but the subsequent elongation of the bud is slowed by moisture stress. Intact tubers sprout while in storage or on a table. Also, setts planted in dry sawdust, dry soil or on dry paper are reported to sprout as readily as moistened setts. (Onwueme, 1976). He also found out that setts that were sprouted under dry conditions tended to produce several more sprouting loci than those sprouted in moist media.

The readiness with which a yam tuber sprouts does not depend on the physiological age of the tuber. Okoli (1980) examined the sprouting record after different periods of growth for four yam cultivars and found that the dormancy period is inversely related to the period of growth. Tubers of all cultivars sprouted even after only 14 weeks of growth of plant, although tuberization may have started only two weeks before harvest. Passam *et al.* (1982) also investigated the relationship between maturity and dormancy in tubers of *D. alata*. Mature tubers collected from prematurely senesced plants of *D. alata* and planted at intervals after harvest germinated at about the same time as tubers of the 'normal' crop. They therefore concluded that sprout emergence was independent of age of the tuber at harvest and appeared to be more a genetic function of the tuber than a result of storage time. Onwueme, 1975a, however, said that the readiness with which a yam tuber sprouts depends on the length of time or period after harvesting.

2.7 Sprout-inducing substances

Purseglove (1969) has stated that ethylene-producing materials might induce sprouting in yam. Onwueme (1978) reported that Ethephon has been used to enhance sprouting in

yam. Campbell et al (1962a) stimulated sprouting in dormant *D. alata* yam tubers by dipping them in a 2 – 8% solution of ethylene chlorohydrin. The closer to the period of natural sprouting the lower the concentration needed.

Passam *et al.* (1982) used ethanol and 2 – chloroethanol to promote sprouting in *D. alata* and aerial yam. Mozie (1987) used indole 3 – acetic acid (IAA) and Indolebutyric acid (IBA) to induce sprouting in *D. rotundata* in storage. Ndzama *et al* (1992) used Benzyl aminopurine (BAP), IAA and Napthalene acetic acid (NAA) to induce sprouting on different sections of yam tuber.

In the study, it was found that minisetts from different sections of yam (head, middle and tail) responded differently to the applied phytohormones. They concluded that in order to obtain more uniform sprouting, specific sections of the yam have to be treated with specific levels of various phytohormones.

2.8 Use of coconut milk for promoting the growth of plant tissues and organs

Coconut milk has been used in tissue culture media to promote growth. Agarwal *et al.* (1995) used coconut milk to culture immature embryo of wheat. Mamaril et al (1988) used coconut milk to enhance seedling growth of *Centrosema pubescens*. They extracted a total of 22.35 mg of plant growth hormones from 50 litres of coconut milk. Ultra violet spectra curves of the extracts showed that the growth hormones resemble IAA, GA, ABA, Zeatin and Kinetin. Coconut milk has also been used to induce sucker formation in plantain at Agricultural Research Station of University of Ghana (Personal Communication).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental site

The study was undertaken from October 2000 to January 2002. The sprouting of minisetts was carried out in baskets arranged on platforms under cashew trees in front of Crop and Soil Science Departments, University of Ghana. The field establishment study was performed at the University Farm, Legon.

3.2 Collection of yam varieties

Tubers of Labreko, Pona and Dakpaan varieties of white yam were harvested from a farmer's farm in Salaga District in the Northern Region on October 19, 2000. Dakpaan, which had previously been successfully multiplied by the farmer using the minisett technique, was included as control. The tubers to be used as planting materials were stored in a yam barn at the Crop Science Department, Legon till required.

3.3 Preparation of growth regulators

3.3.1 Naphthalene acetic acid (NAA)

50, 100 and 200 mg of NAA were dissolved in 2.5 ml of NaOH (Gamborg *and* Phillips, 1995). Distilled water was added to make a litre volume.

3.3.2 Ethrel

100, 500 and 1000 ppm of ethrel was prepared by dissolving 0.21, 1.05 and 2.1 ml of 480% active ingredient Ethephon in distilled water.

3.3.3 Coconut milk

Ripe coconut (more than 11 months old) devoid of the fibre were used. Holes were drilled through the germination pores and the water drained through them. The water was heated to 80 °C while stirring. It was allowed to cool, and was then frozen till needed (Gamborg and Phillips, 1995).

3.3.4 Distilled water (control)

Control treatment consisted of minisetts treated with distilled water.

3.4 Minisett preparation

Tubers of each of the three varieties were washed with ordinary water and rinsed with distilled water before they were cut into three sections: heads, middles and tails. Pieces from each section were further cut into minisett sizes of between 25-30 g.

3.5 Sawdust preparation

Sawdust from white wood was collected, steam-sterilized in a metal drum and used to fill the planting baskets.

Plate 1. Baskets containing the minisetts raised on wooden platforms.

3.6 Experiment 1: The Effect of NAA, ethrel and coconut milk on sprouting of three white yam varieties.

The experiment was set up on January 23, 2001 when the yam tubers had been in storage for 3 months, and had just broken dormancy. The treatments used were 0, 50, 100 and 200 mg/l of NAA; 0, 100, 500, 1000 ppm of ethrel and undiluted coconut milk.

Ten minisetts from each section of the yam tuber namely head, middle and tail, were dipped into the treatment solutions for 5 minutes and then dusted with Dithane M45 fungicide. They were air-dried for ten minutes and planted in moist sterile sawdust. Minisetts from the head, middle and tail sections treated with the same level of growth regulator were planted in a common basket partitioned into three chambers, one for minisetts from the same section. The treatments were replicated three times. The baskets were kept on wooden platform covered with water-proofed sheets and placed under a cashew tree shade, (Plate 1).

From 4 weeks after nursing (WAN) the minisetts were examined fortnightly and data taken on number of sprouts and adventitious roots that emerged.

The experimental design used was split -split plot. The yam varieties served as main plot treatment with the concentrations of the growth regulators and yam sections being sub plot and sub-sub plot treatments respectively.

3.7 Experiment 2: The effect of ethrel and coconut milk on sprouting of three white yam varieties.

The experiment was set up on April 11, 2001, six months after the harvest of tubers. The set up was the same as in Experiment 1 except that NAA that induced the formation of mainly adventitious roots in experiment 1 was eliminated in Experiment 2. The experimental design and data taken were the same as Experiment 1.

3.8 Experiment 3: The effect of ethrel and coconut milk on sprouting of Labreko and Pona.

The experiment was set up on July 4, 2001. In this experiment, only one level of ethrel, (500 ppm), coconut milk and the control treatments were examined in the two yam varieties. The Dakpaan variety was also not included. The tubers used were full season grown yams that had not been pricked and were harvested in December. The tubers were stored for six months prior to treatments. Thirty minisetts per section of the tuber were kept in a basket as a treatment. The procedure was the same as Experiment 1.

Data were taken once at week 6 on percentage sprouting, rotten and non-sprouting minisetts. The Experimental design used was Split -split plot. Yam varieties served as main plot treatment while growth regulator and yam section served as sub-plot and sub-sub plot treatments respectively.

3.9 Experiment 4: Type of growth regulator and development stage of sprouted minisett at transplanting on field performance of three white yam varieties.

The experiment was set up on April 18, 2001. The sprouted minisetts of Labreko, Pona and Dakpaan from Experiment 1 were used in this experiment. Minisetts with sprout length of up to 2 cm constituted Stage 1 sprouted minisetts, (Plate 2).

The more developed sprouts were grouped into two namely, Stages 2 and 3, (Plates 3 and 4). Sprouted minisetts for Stage 2 were allowed to remain in the sawdust for one more week after sprouting until the vines had reached a height of 2.1-4.0 cm. The Stage 3 sprouted minisetts remained in the sawdust for two more weeks during which period the vines reached a height of 4.1-6.0 cm with some having 2 leaves.

The growth promoter treatments were NAA, ethrel and coconut milk. NAA treated minisetts that sprouted in Experiment 1 were few and were eliminated from the field

study. Minisetts treated with the different levels of each growth promoter were lumped together.

The sprouted minisetts were planted on 50 cm wide ridges of 1m apart with intra-row spacing of 25 cm. Seven sprouted minisetts per treatment were planted and these were replicated three times. The left over sprouted minisetts for each treatment were planted separately on different ridges. The vines were staked by the trellis method.

Data were taken on:

a. the numbers of nodes, leaves, and vine length ten weeks after planting.

b. mean tuber weight per treatment at harvest and

b. percentage survival at harvest based on the seven sprouted minisetts planted.

The experimental design used was split- split plot. The Stages were the main plot treatments. The varieties served as sub plot while the growth regulators were used as sub-sub plot treatments. The tubers were harvested in the first week of December 2001.

3.10 Experiment 5:The effect of ethrel and coconut milk on field performance of Labreko, Pona and Dakpaan sprouted minisetts.

This experiment was set up on May 29, 2001. The sprouted minisetts from Experiment Two were used for this study. The different levels of the ethrel, 0, 100, 500 and 1000 ppm were maintained. The number of sprouted minisetts per treatment was 30. The experimental procedure as well as the data taken was the same as in Experiment 4. The growing vines were individually staked. The tubers were harvested in the last week of December 2001.

Plate 2. Stage 1 sprouted minisetts. a and b are vines and adventitious roots respectively

Plate 3. Stage 2 sprouted minisetts a and b are vines and adventitious roots respectively

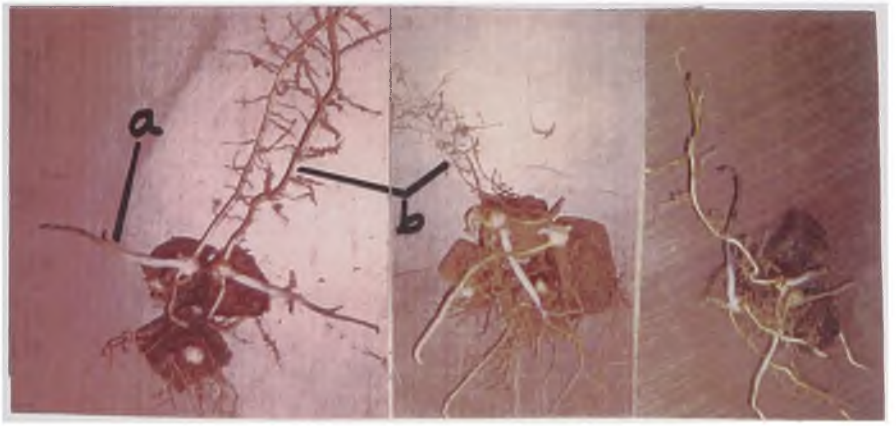


Plate 4. Stage 3 sprouted minisetts a and b are vines and adventitious roots respectively

3.11 Experiment 6: The effect of ethrel and coconut milk on the field performance of Labreko and Pona.

This experiment was set up on July 7, 2001. Sprouted minisetts from Experiment 3 were used. The Head, Middle and Tail sections of the Labreko and Pona varieties treated with ethrel and coconut milk served as the treatments for this experiment. The procedure and data taken was the same as Experiment 4. The growing vines were individually staked. The tubers were harvested in the second week of January 2002.

CHAPTER FOUR

4.0 RESULTS

4.1 Results of Experiment 1: The Effect of NAA, ethrel and coconut milk on sprouting of three white yam varieties.

4.1.1. Effect of growth regulators on cumulative percentage sprouting of yam varieties

Figures 1 a, b and c show the cumulative percentage sprouting of yam varieties due to (a) NAA, (b) Coconut milk and (c) Ethrel, 4-10 weeks after nursing.

4.1.1.1 Effect of NAA on cumulative percentage sprouting of yam varieties

Percentage sprouting was generally lower in NAA-treated varieties than coconut milk and ethrel-treated varieties (Figure 1a). NAA induced profuse adventitious roots instead of sprouting, (Plate 5). The differences in percentage sprouting in NAA-treated yam varieties were significant ($P<0.05$) from the sixth week after nursing. At week six, percentage sprouting in Labreko was not significantly different from that in Pona. However, differences emerged from the eighth week onwards. Dakpaan recorded significantly lower percentage sprouting than Labreko and Pona in the ten weeks.

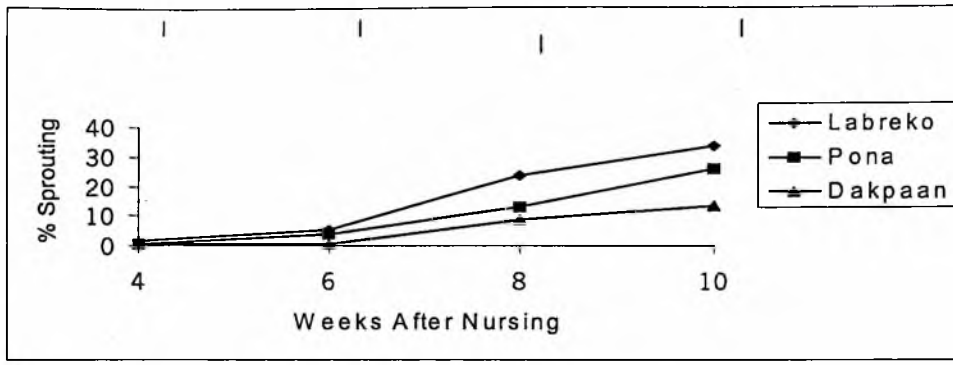
4.1.1.2 Effect of coconut milk on cumulative percentage sprouting of yam varieties.

There was no significant difference ($P<0.05$) in percentage sprouting in the varieties until ten weeks after nursing (Figure 1b). At week ten, sprouting in Labreko was not significantly different from Pona and both produced significantly more sprouting than Dakpaan.

4.1.1.3. Effect of ethrel on cumulative percentage sprouting of yam varieties

Ethrel-treated varieties showed significant difference ($P<0.05$) throughout the period of the study (Figure 1c). In the beginning, sprouting was significantly higher in Pona than Labreko and Dakpaan but by the sixth and eighth week, sprouting in Labreko was statistically not different from that in Pona. At the tenth week, Labreko had overtaken Pona in sprouting. Dakpaan persistently recorded lower percentage sprouting throughout the ten weeks.

(a)



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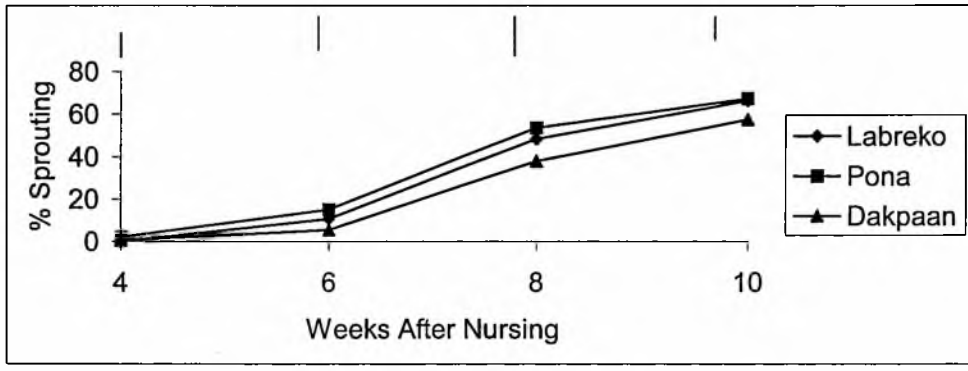

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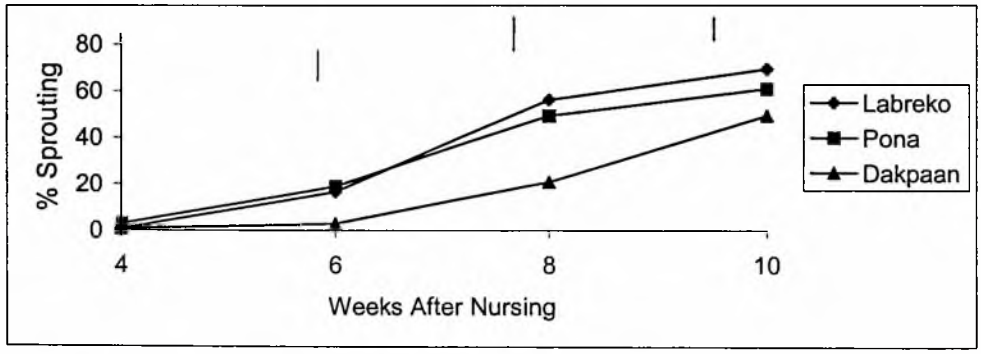


Figures 1 a, b and c. Cumulative percentage sprouting of yam varieties due to (a) NAA, (b) Coconut milk and (c) Ethrel from 4-10 WAN in Experiment 1.

(Percentage values used to draw the graphs were not different from arcsine transformed values).

4.1.2. Effect of growth regulator levels on cumulative percentage sprouting.

Figures 2 a, b and c show the cumulative percentage sprouting of yam minisetts due to levels of (a) NAA, (b) Coconut milk and (c) Ethrel, 4-10 weeks after nursing.

4.1.2.1 Effect of NAA levels on cumulative percentage sprouting.

The different levels of NAA showed significant differences ($P<0.05$) on percentage sprouting from six weeks after nursing (Figure 2a). The different levels of NAA suppressed sprouting as compared to the control treatment. The suppression ranges from 100-50 %. Among the levels of NAA, 50 mg/l did better than the rest.

4.1.2.2 Effect of coconut milk levels on cumulated percentage sprouting.

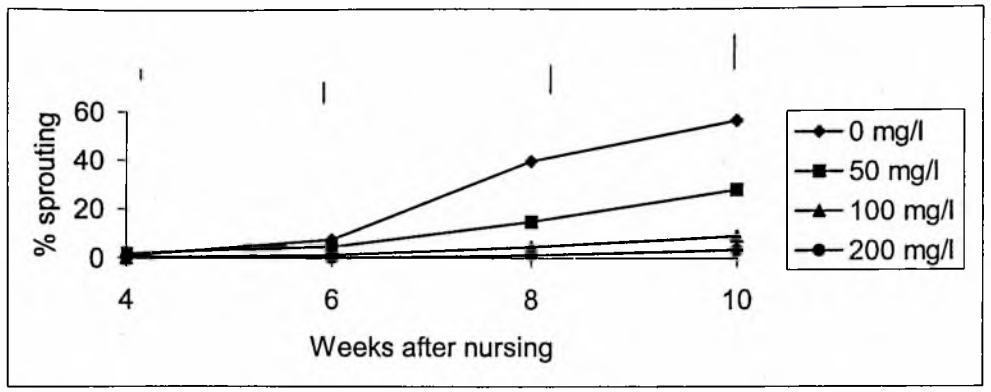
Coconut milk produced significantly higher percentage sprouting in the minisetts ($P<0.05$) than the control treatment from the sixth week after nursing (Figure 2b). The percentage improvement over the control at weeks six, eight and ten were 200,30 and 35 respectively.

4.1.2.3. Effect of ethrel levels on cumulative percentage sprouting.

Significant differences ($P<0.05$) in percentage sprouting due to ethrel levels emerged from six weeks after nursing (Figure 2c). At week six, all the levels of ethrel induced significantly higher percentage sprouting than the control treatment although the percentage sprouting were numerically very low. At week 8, only 1000 ppm recorded significantly lower percentage sprouting than the control treatment.

The 100 and 500 ppm ethrel recorded 7 and 22 % improvement over the control treatment respectively. Similar pattern was observed in the tenth week. 1000 ppm and the control treatments recorded 54.1 % sprouting while the 100 and 500 ppm treatments recorded 13 % and 28 % more sprouting than the control treatment.

(a)



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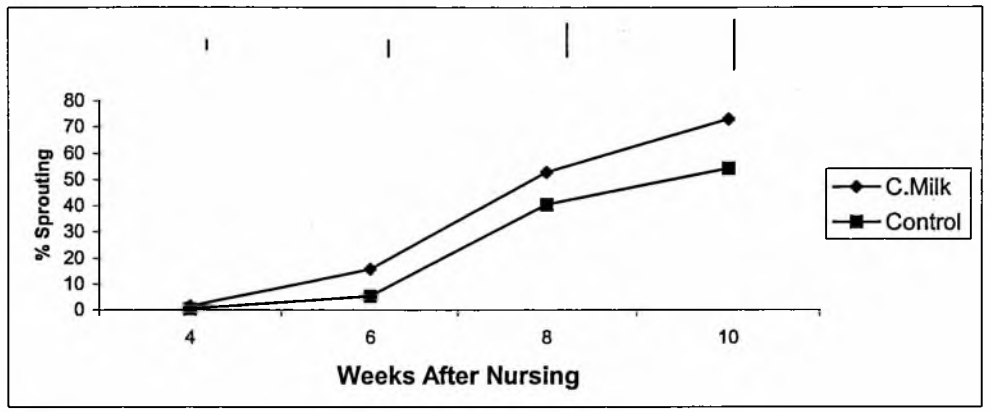
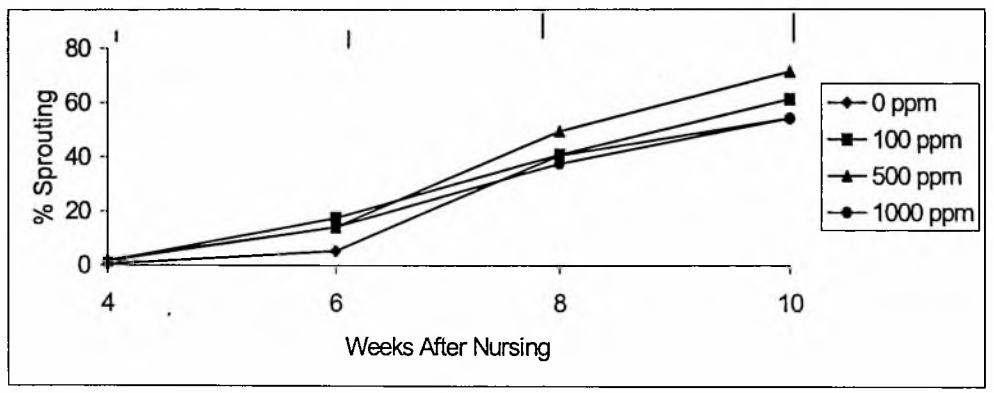


(c)



Figures 2 a, b and c. Cumulative percentage sprouting of yam minisetts due to levels of (a) NAA, (b) Coconut milk and (c) Ethrel, 4-10 WAN in Experiment 1.

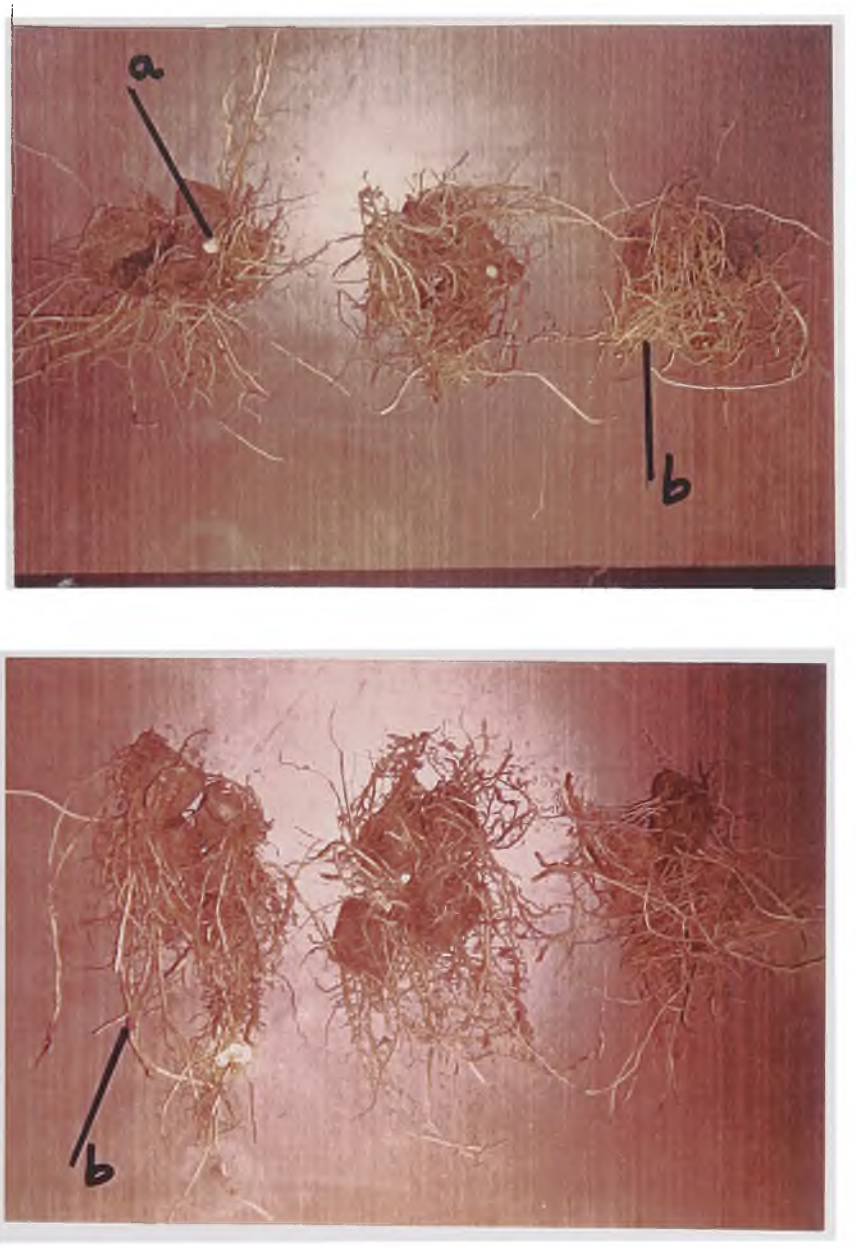


Plate 5. Profuse adventitious roots induced by NAA. a and b are vine bud and adventitious roots respectively

4.1.3 Effect of growth regulator on cumulative percentage sprouting of yam sections.

Figures 3 a, b and c show the cumulative percentage sprouting of yam sections due to NAA, coconut milk and ethrel respectively, 4-10 weeks after nursing.

4.1.3.1 Effect of NAA on cumulative percentage sprouting of yam sections.

The three sections of the yam (head, middle and tail) varieties showed significant differences in sprouting from six weeks after nursing (Figure 3 a). At week six, sprouting increased proximally. At the eighth week, the head and the middle sections were statistically at par with only the tail being significantly different from the head. By the tenth week there were no significant differences among the sections.

4.1.3.2 Effect of coconut milk on cumulative percentage sprouting of yam sections.

The different sections showed significant differences in sprouting at the sixth and eighth weeks after planting ($P<0.05$) (Figure 3 b). Unlike NAA that achieved uniform percentage sprouting in the sections at the tenth week, coconut milk induced uniform sprouting earlier (eight weeks after nursing).

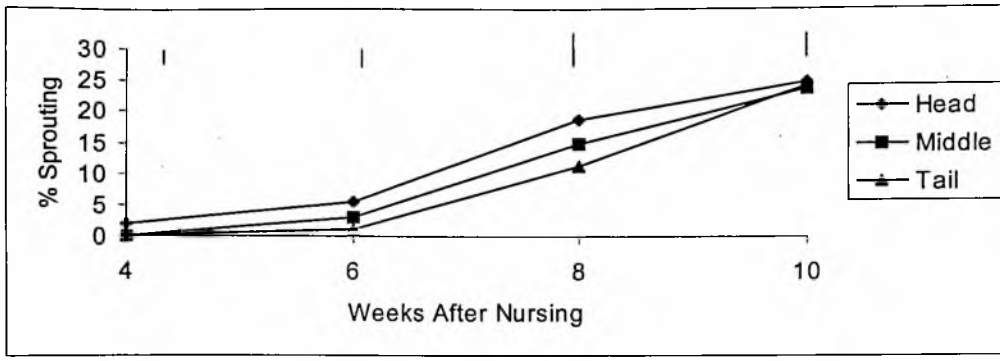
In the earlier weeks when sprouting was not even, sprouting increased in this order: tail, middle and head, with head showing the highest percentage sprouting.

4.1.3.3 Effect of ethrel on cumulative percentage sprouting of yam sections.

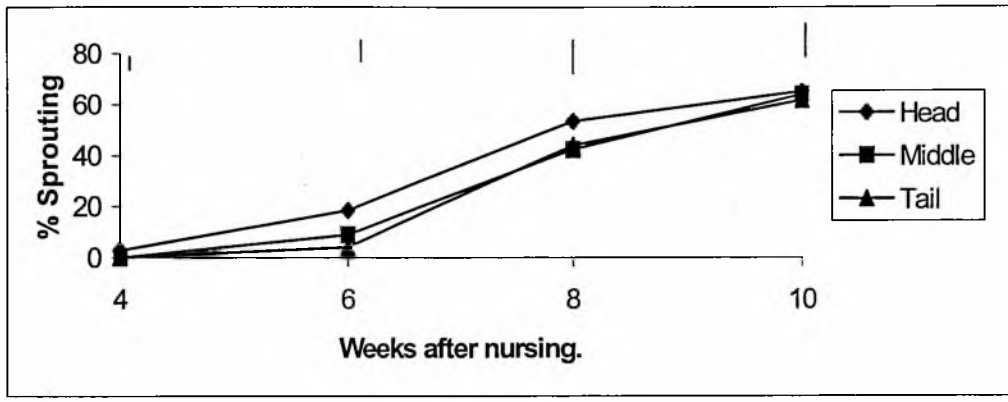
The sections showed significant differences ($P<0.05$) in percentage sprouting from week six to eight. Thereafter, sprouting became uniform as observed in NAA treated sections (Figure 3 c). The head section showed significantly higher sprouting than the middle and tail sections in weeks 4-8.

Sprouting in the middle and tail sections were not significantly different.

(a)



(b)



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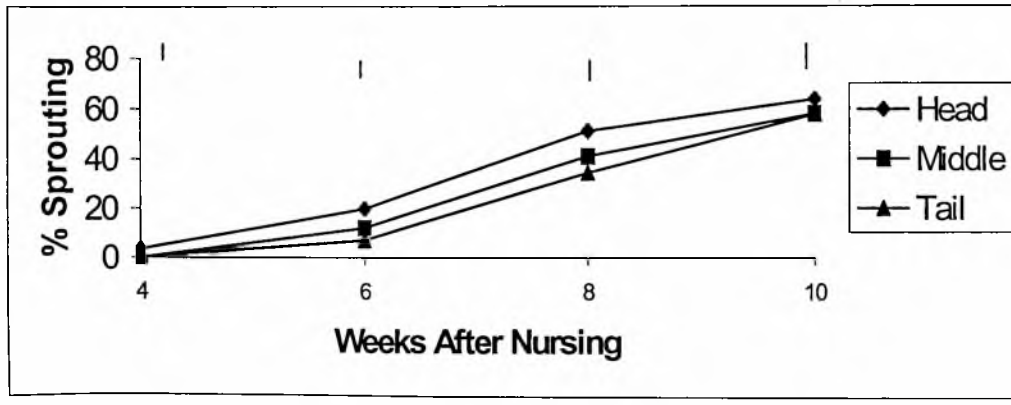


Figures 3 a, b and c. Cumulative percentage sprouting of yam sections due to NAA, (b) Coconut milk and (c) Ethrel, 4-10 weeks after nursing.

4.1.3.4 Mean effect of the growth regulators on sprouting.

Significant differences ($P<0.05$) among the growth regulators were exhibited from the sixth week after nursing (Table 1). In the sixth week, ethrel and coconut milk were not significantly different, so also were the differences between NAA and the control treatment. Mean sprouting induced by coconut milk and ethrel were significantly different from NAA and the control.

Table 1. The mean effect of growth regulators on percentage sprouting, 4-10 WAN

	% Sprouting			
Growth Regulators	4 Weeks	6 Weeks	8 Weeks	10 Weeks
NAA	0.6	1.9	6.8	13.5
Ethrel	1.6	15.2	42.5	61.5
Coconut milk	1.5	15.6	52.6	73.0
Control	0.7	7.4	39.6	56.3
LSD (0.05)	**NS**	**6.4**	**7.3**	**9.7**

In the eighth week, coconut milk induced significantly more sprouting than the other growth regulators. Ethrel and the control did not show significant differences between them. On the other hand, the two significantly induced more sprouting than NAA. A similar pattern was observed in week ten. Coconut milk recorded 30 % improvement over the control while ethrel recorded 7 % although the latter was not significantly different from the control. NAA suppressed sprouting by 76 % in the tenth week.

4.1.4. Effect of the interaction of the different levels of growth regulator and yam varieties on cumulative percentage sprouting.

4.1.4.1 Effect of the interaction of the different levels of NAA and yam varieties on cumulative sprouting.

Table 2 shows the interaction effect of NAA levels and Yam varieties on percentage sprouting, 4 -10 weeks after nursing.

Labreko and the NAA levels showed significant interaction ($P<0.05$) from week four up to ten. In week four, 50 mg/l induced higher percentage sprouting in Labreko than the other levels. In week six, percentage sprouting due to 50 mg/l and the control treatment was not statistically different; so also was that between 100 mg/l and 200 mg/l.

Table 2. The effect of interaction of coconut milk levels and different yam varieties on cumulative sprouting , 4-10 WAN in Experiment 1.

% Sprouting					
Week	Concentration (mg/l)	Variety			
		Labreko	Pona	Dakpaan	**LSD(0.05)**
4	0	0 (0)	1.1 (0.011)	1.1 (0.011)	
	50	5.6 (0.057)	0 (0)	0 (0)	
	100	0 (0)	0 (0)	0 (0)	**3.4**
	200	0 (0)	0 (0)	0 (0)	(0.035)
6	0	6.7 (0.067)	13.3 (0.135)	2.2 (0.022)	
	50	11.1 (0.114)	2.2 (0.022)	0 (0)	
	100	3.3 (0.033)	0 (0)	0 (0)	**8.9**
	200	0 (0)	0 (0)	0 (0)	(0.092)
8	0	46.7 (0.494)	40.0 (0.424)	32.2 (0.337)	
	50	34.4 (0.354)	7.8 (0.079)	2.2 (0.022)	
	100	10.0 (0.101)	3.3 (0.034)	0 (0)	**9.6**
	200	3.3 (0.033)	0 (0)	0 (0)	(0.106)
10	0	53.3 (0.579)	63.3 (0.708)	52.2 (0.560)	**13.3**
	50	50.6 (0.529)	26.7 (0.275)	2.2 (0.022)	(0.149)
	100	16.7 (0.168)	10 (0.102)	0 (0)	
	200	8.9 (0.089)	1.1 (0.011)	0 (0)	

(Values in brackets are transformed by arcsine)

In the eighth week, the control treatment induced significantly more sprouting than that due to the levels of NAA. In week ten, the control treatment and 50 mg/l induced

statistically the same percentage of sprouting, which was significantly higher than sprouting due to 100 and 200 mg/l. The differences in sprouting between 100 and 200 mg/l were not significant. Suppression of sprouting by NAA levels ranged from 5-83 % in Labreko.

Pona and NAA levels showed significant interaction ($P<0.05$) from the sixth week on. The control treatment induced significantly more sprouting than the levels of NAA. The differences in sprouting among the different levels of growth regulators were not significant. In week ten, the control treatment, once again recorded significantly more sprouting than the NAA levels. 50 mg/l recorded significantly higher percentage sprouting than the two other levels. Suppression of sprouting by NAA levels ranged from 57-98 %.

Dakpaan showed significant interaction with NAA levels in weeks eight and ten. It is important to note that as at the eighth week, the highest percentage sprouting 12.2 % produced by NAA levels was observed in the 50 mg/l. This was significantly higher than the sprouting produced by 100 mg/l and 200 mg/l treatments. The control treatment produced significantly more sprouting than any of the NAA treatments. In week ten, the control treatment significantly outperformed the sprouting induced by the different NAA levels. The NAA treatments produced between 96-100 % suppression in sprouting compared to the control.

4.1.4.2. The effect of interaction of different levels of coconut milk and yam varieties on cumulative percentage sprouting.

Table 3 shows the effect of the interaction of different levels of coconut milk and yam varieties on percentage sprouting in the minisetts from four to ten weeks after nursing. There was no significant interaction between Labreko and Dakpaan yam varieties and

coconut milk (P<0.05) on sprouting throughout the period of the study. Pona, on the other hand, showed significant interaction effect with the coconut milk from week four to eight during which coconut milk induced more sprouting than the control treatment. At week ten, the percentage improvement of coconut milk over the control treatment was 35, 37 and 19 for Labreko, Pona and Dakpaan respectively

Table 3. The effect of interaction of coconut milk levels and different yam varieties on cumulative sprouting , 4-10 WAN in Experiment 1.

Week	Concentration	% sprouting			LSD(0.05)
		Variety			
		Labreko	Pona	Dakpaan	
4	0 (control)	0 (0)	0 (0)	1.1 (0.11)	**NS**
	C. Milk	0 (0)	4.4 (0.045)	0 (0)	
6	0 (control)	6.7 (0.067)	6.7 (0.067)	2.2 (0.022)	**15.2 (0.158)**
	C. Milk	14.4 (0.147)	23.3 (0.242)	8.9 (0.090)	
8	0 (control)	46.7 (0.497)	42.2 (0.447)	32.2 (0.337)	**20.8 (0.250)**
	C. Milk	50.0 (0.546)	64.4 (0.716)	43.3 (0.457)	
10	0 (control)	58.3 (0.632	56.7 (0.628)	52.2 (0.560)	**22.2 (0.347)**
	C. Milk	78.9 (0.962)	77.8 (0.951)	62.2 (0.750)	

4.1.4.3. The effect of interaction of different levels of ethrel and yam varieties on cumulative percentage sprouting.

Table 4 shows the effect of interaction of ethrel levels and Yam varieties on percentage sprouting, 4-10 weeks after nursing. Labreko showed significant interaction (P<0.05) with ethrel levels in the sixth and tenth weeks. The ethrel treatments induced statistically the same percentage sprouting in Labreko and these were higher than that of the control

treatment. The control treatment produced similar percentage sprouting to those produced by the ethrel treatments in the eighth week . In the tenth week, 100 ppm and 500 ppm treatments of ethrel did not show significant difference between them, both outperformed the control treatment in influencing sprouting by 40 and 48 % respectively. Even though the 1000 ppm ethrel treatment also produced higher percentage sprouting than the control the difference was not significant.

1 **Table 4. The effect of interaction of different levels of ethrel and yam varieties on cumulative sprouting,4-10 WAN in Experiment 1.**

% Sprouting					
Week	Concentration (ppm)	Variety			LSD(0.05)
		Labreko	Pona	Dakpaan	
4	0	0 (0)	0 (0)	1.1 (0.01)	**3.8 (0.04)**
	100	53.3 (0.579)	56.7 (0.628)	52.2 (0.560)	
	500	1.1 (0.01)	4.4 (0.05)	0 (0)	
	1000	1.1 (0.01)	4.4 (0.05)	0 (0)	
6	0	6.7 (0.067)	6.7 (0.067)	2.2 (0.022)	**14.8 (0.156)**
	100	24.4 (0.251)	25.6 (0.273)	2.2 (0.022)	
	500	17.8 (0.18)	20.0 (0.21)	4.4 (0.045)	
	1000	16.7 (0.169)	23.3 (0.251)	2.2 (0.022)	
8	0	46.7 (0.494)	42.2 (0.447)	32.2 (0.337)	**14.7 (0.202)**
	100	56.7 (0.657)	54.4 (0.608)	11.1 (0.113)	
	500	62.2 (0.688)	56.7 (0.712)	28.9 (0.219)	
	1000	58.9 (0.643)	43.3 (0.473)	10.0 (0.101)	
10	0	53.3 (0.579)	56.7 (0.628)	52.2 (0.560)	**19.3 (0.309)**
	100	74.4 (0.883)	62.2 (0.700)	46.7 (0.492)	
	500	78.9 (1.005)	66.7 (0.844)	62.2 (0.727)	
	1000	70.0 (0.846)	56.7 (0.625)	35.6 (0.370)	

Pona showed significant interaction with ethrel levels up to the sixth week after nursing. In the fourth and sixth weeks, the three levels of ethrel induced significantly more sprouting than the control treatment. Thereafter, the level of sprouting in minisetts that received the control treatment caught up with those treated with the different levels of ethrel. The 19 % sprouting difference between 500 ppm treatment and the control treatment in the tenth week was not significant statistically.

In Dakpaan, the interaction was manifested eight weeks after nursing. In the eighth week, the difference in sprouting between the control treatment and 500 ppm treatment was not significant but both were significantly better than 100 and 1000 ppm ethrel treated minisetts in terms of sprouting. By the tenth week, 100 ppm treated minisetts had caught up with the control treatment and 500 ppm. All three treatments produced more sprouting than 1000 ppm treatment.

4.1.5 Effect of interaction of different growth regulators levels and yam sections on cumulative percentage sprouting

4.1.5.1 Effect of interaction of different NAA levels and yam sections on cumulative percentage sprouting

Table 5 shows the interaction of NAA concentrations and Yam sections in cumulative percentage sprouting, 4-10 weeks after nursing.

The head section showed significant interaction ($P<0.05$) with the levels of NAA during the 10 weeks. Apart from the sixth week when 50 mg/l and the control treatments were not significantly different; the control treatment was significantly better than the NAA levels throughout the study period. The range of suppression in sprouting due to NAA levels in the head section was 41-89 %.

Suppression of sprouting by NAA observed in the head section was also observed in the middle and tail sections. The middle and tail recorded a range of 63-95 % and 44-98 % respectively.

Table 5. The effect of interaction of different levels of coconut milk and sections of yam on cumulative sprouting, 4-10 WAN in Experiment 1

% Sprouting					
Week	Concentration (mg/l)	Section			LSD(0.05)
		Head	Middle	Tail	
4	0	2.2 (0.022)	0 (0)	0 (0)	**3.5 (0.036)**
	50	5.6 (0.057)	0 (0)	0 (0)	
	100	0 (0)	0 (0)	0 (0)	
	200	0 (0)	0 (0)	0 (0)	
6	0	10.0 (0.101)	10.0 (0.101)	2.2 (0.022)	**6.9 (0.071)**
	50	10.0 (0.103)	2.2 (0.022)	1.1 (0.011)	
	100	2.2 (0.022)	0 (0)	1.1 (0.011)	
	200	0 (0)	0 (0)	0 (0)	
8	0	46.7 (0.494)	42.2 (0.453)	30.0 (0.308)	**9.9 (0.108)**
	50	16.7 (0.171)	15.6 (0.161)	12.2 (0.124)	
	100	8.9 (0.090)	2.2 (0.022)	2.2 (0.022)	
	200	2.2 (0.022)	0 (0)	1.1 (0.011)	
10	0	51.1 (0.544)	62.2 (0.705)	55.6 (0.599)	**11.8 (0.133)**
	50	30.0 (0.610)	23.3 (0.564)	31.1 (0.604)	
	100	12.2 (0.124)	5.6 (0.056)	8.9 (0.090)	
	200	5.6 (0.056)	3.3 (0.033)	1.1 (0.011)	

4.1.5.2 Effect of interaction of different coconut milk levels and yam sections on cumulative percentage sprouting.

Table 6 shows the interaction of coconut milk concentration and Yam sections on cumulative percentage sprouting, 4-10 weeks after nursing.

With the exception of week four, when coconut milk and Distilled water treated head sections did not show significant difference ($P<0.05$) in sprouting, coconut milk treated head section sprouted significantly better than the Distilled Water treated sections in the rest of the weeks. In week ten, coconut milk treated minisetts showed 66 % improvement in sprouting over the control treatment.

The interaction on the middle section was not significant up to 10 WAN ($P<0.05$). For the tail section, interaction became significant ($P<0.05$) from 8 WAN upwards. In the tenth

week, the minisetts treated with coconut milk recorded 41 % more sprouting than those under the control treatment.

Table 6. The effect of interaction of different levels of coconut milk and sections of yam on cumulative sprouting, 4-10 WAN in Experiment 1.

Week	Concentration	% Sprouting Section. Head	Middle	Tail	LSD (0.05)
4	0 (control)	4.4 (0.045)	0 (0)	0(0)	**3.7 (0.038)**
	C. Milk	1.1 (0.011)	0 (0)	0(0)	
6	0 (control)	6.7 (0.067)	7.8 (0	1.1 (0.011)	**9.3 (0.096)**
	C. Milk	30.0 (0.310)	10.0 (0.102)	6.7 (0.067)	
8	0 (control)	44.4 (0.466)	44.4 (0.481)	32.2 (0.330)	**16.8 (0.197)**
	C. Milk	62.2 (0.689)	40.0 (0.429)	55.6 (0.601)	
10	0 (control)	62.2 (0.628)	68.2 (0.686)	51.1 (0.560)	**19.5 (0.299)**
	C. Milk	81.1 (1.077)	72.6 (0.842)	72.2 (0.834)	

4.1.5.3 Effect of interaction of different ethrel levels and yam sections on cumulative percentage sprouting.

Table 7 shows the interaction of different levels of ethrel and yam sections on cumulative percentage sprouting, 4-10 weeks after nursing.

The interaction was significant in the sixth and tenth weeks after nursing. In the sixth week, the 100 ppm and 1000 ppm treatments produced significantly ($P<0.05$) more sprouting than 500 ppm and the control treatments in the head section. In the tenth week, the 100 ppm and 500 ppm treatments induced more sprouting in the head section than the control treatment. The sprouting induced by the 1000 ppm treatment was not different from that under the control treatment.

Minisetts from the middle section did not show significant interaction ($P<0.05$) with the different ethrel levels. The tail section, on the other hand, showed significant interaction with ethrel at week eight and ten. In week eight, 500 ppm produced significantly higher percentage sprouting than the other levels and the control treatment. However, in week ten, 100 and 500 ppm induced significantly more sprouting than 1000 ppm and the

control treatment. No difference in sprouting was found between 1000 ppm and the control treatment.

Table 7. The effect of interaction of different levels of ethrel and yam sections on cumulative percentage sprouting, 4-10 WAN in Experiment 1

% Sprouting					
Week	Concentration (ppm)	Section			LSD(0.05)
		Head	Middle	Tail.	
4	0	1.1 (0.11)	0 (0)	0(0)	**3.9 (0.039)**
	100	4.4 (0.045)	0 (0)	0 (0)	
	500	4.4 (0.045)	0 (0.045)	0 (0)	
	1000	77.8 (1.063)	60.0 (0.714)	70.0 (0.799)	
6	0	1.1 (0.11)	0 (0)	0(0)	**13.4 (0.145)**
	100	26.7 (0.285)	14.4 (0.149)	11.1 (0.112)	
	500	16.7 (0.172)	12.2 (0.124)	13.3 (0.139)	
	1000	27.8 (0.297)	12.2 (0.124)	2.2 (0.022)	
8	0	44.4 (0.466)	44.4 (0.481)	32.2 (0.330)	**15.0 (0.211)**
	100	53.3 (0.603)	40.0 (0.478)	28.9 (0.298)	
	500	58.9 (0.737)	41.1 (0.445)	47.8 (0.516)	
	1000	46.7 (0.520)	37.8 (0.407)	27.8 (0.291)	
10	0	48.9 (0.516)	62.2 (0.705)	51.1 (0.547)	**17.3 (0.282)**
	100	67.8 (0.768)	54.4 (0.634)	61.1 (0.674)	
	500	77.8 (1.063)	60.0 (0.714)	70.0 (0.799)	
	1000	60.0 (0.684)	62.2 (0.599)	51.1 (0.557)	

4.1.6 Effect of growth regulators on adventitious root formed in yam varieties.

Figures 4 a, b and c show the cumulative number of adventitious roots produced due to (a) NAA, (b) Coconut milk and (c) Ethrel in the yam varieties between 4-10 weeks after nursing.

4.1.6.1 Effect of NAA on adventitious roots formed in yam varieties

Significantly different ($P<0.05$) number of adventitious roots were formed on yam varieties from week four to ten (Figure 4 a). In week four, all the varieties produced significantly different number of adventitious roots. Dakpaan produced the highest number of adventitious roots followed by Labreko. After the sixth week, Labreko and

Pona did not show any significant difference in adventitious root production but they recorded significantly fewer numbers of adventitious roots than Dakpaan.

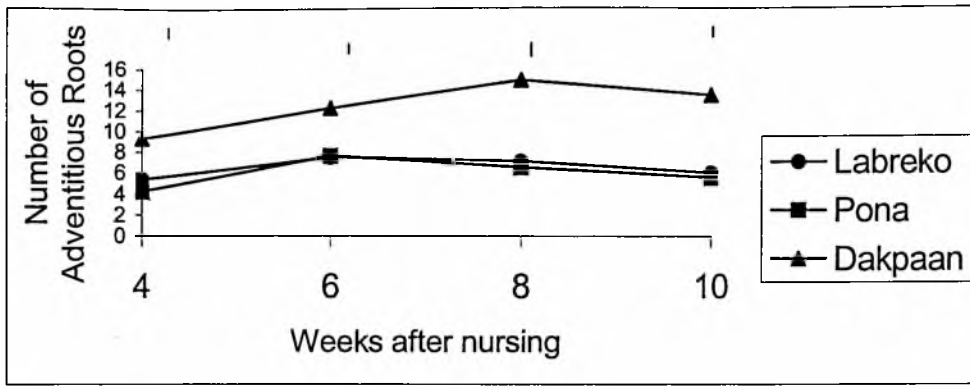
4.1.6.2 Effect of coconut milk on adventitious roots formed in yam varieties.

Apart from week eight when Dakpaan produced significantly ($P<0.05$) more adventitious roots than Labreko and Pona, the varieties did not show significant differences in adventitious root formation in the other weeks (Figure 4 b).

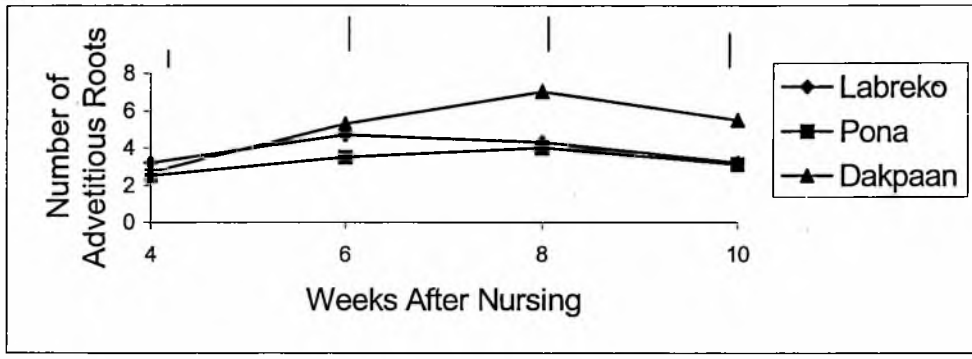
4.1.6.3 Effect of ethrel on adventitious roots formed in yam varieties.

Ethrel induced significantly different ($P<0.05$) number of adventitious roots in the three varieties throughout the nursing period (Figure 4 c). In week four, both Dakpaan and Pona produced more adventitious roots than Labreko. However, in week six Pona and Labreko produced similar numbers of adventitious roots.

(a)



(b)



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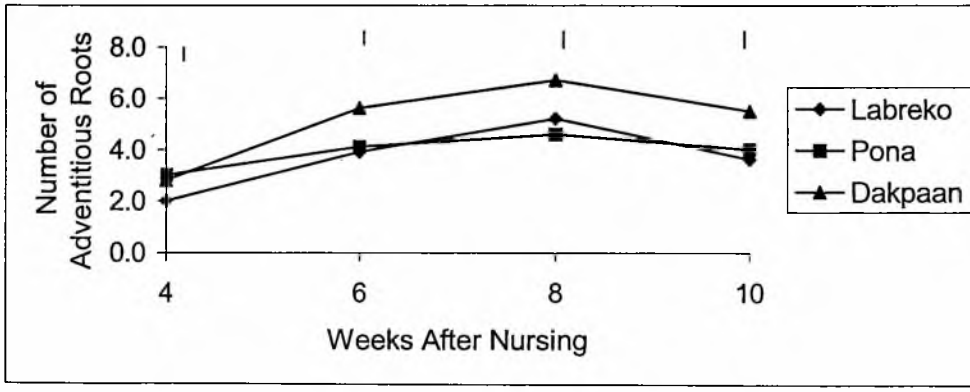


Figures 4 a, b and c. Cumulative number of adventitious root formed in yam varieties due to (a) NAA, (b) Coconut milk and (c) Ethrel, 4-10 weeks after nursing.

In week eight,the number of adventitious roots produced by ethrel-treated Dakpaan was not significantly different from that produced by Labreko but it was different from that observed in Pona. Differences in sprouting between Labreko and Pona were not significant. In week ten, sprouting in Labreko again was not significantly different from Pona but both produced less adventitious roots than Dakpaan.

In general, adventitious root formation increased from week four to eight and declined thereafter.

4.1.7 Effect of growth regulator levels on adventitious root formation.

Figures 5 a, b and c show the cumulative number of adventitious root formed in yam minisetts due to (a) NAA, (b) Coconut milk and (c) Ethrel levels, 4-10 weeks after nursing.

4.1.7.1 Effect of NAA levels on adventitious root formation.

The levels of NAA applied produced significant ($P<0.05$) differences in the number of adventitious roots produced by the minisetts (Figure 5 a). The control treatment recorded the least number of adventitious roots throughout the period. The number of adventitious roots increased with increasing concentration of NAA. The formation of adventitious roots increased up to the eighth week before it declined.

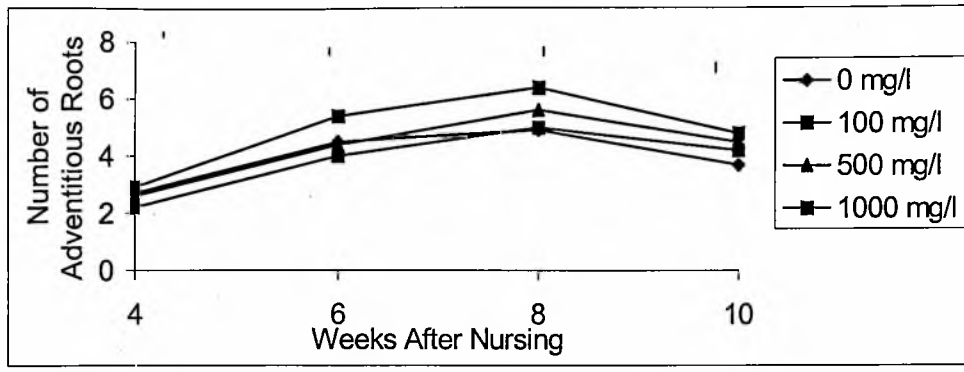
4.1.7.2. Effect of coconut milk levels on adventitious root formation.

Coconut milk did not show any significant difference in sprouting from the control treatment except the tenth week when coconut milk induced significantly more adventitious roots than the control treatment (Figure 5 b).

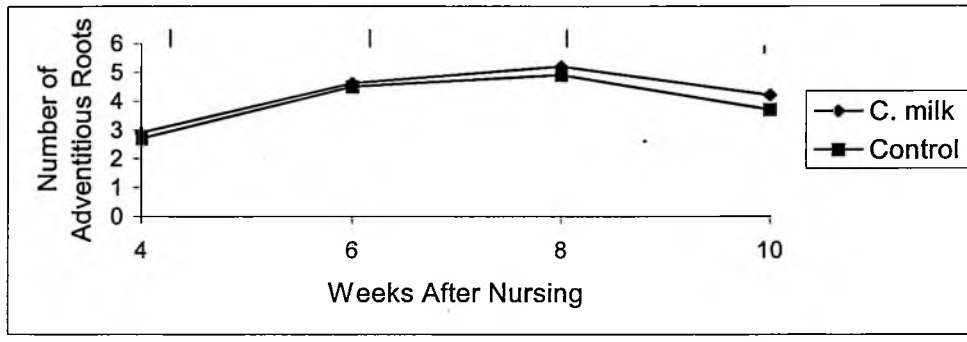
4.1.7.3 Effect of ethrel levels on adventitious root formed in yam minisetts.

Ethrel levels induced significantly ($P<0.05$) different number of adventitious roots in the minisetts from weeks four to eight (Figure 5 c). During that period, 1000 ppm induced significantly higher number of adventitious root than the other levels. In the tenth week, there was no significant difference between the number of adventitious roots produced by the different ethrel levels. They all produced significantly higher numbers of adventitious roots than the minisetts under the control treatment.

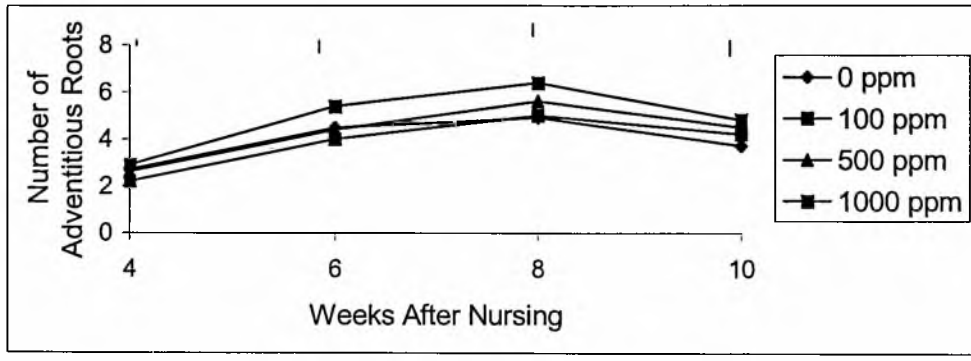
(a)



(b)



(c)



Figures 5 a, b and c. Cumulative number of adventitious root formed in yam minisetts due to (a) NAA, (b) Coconut milk and (c) Ethrel levels, 4-10 weeks after nursing.

4.1.8 Effect of Growth regulators on adventitious root formed in yam sections.

Figures 6 a, b and c show the cumulative number of adventitious root formed in yam sections due to (a) NAA, (b) Coconut milk and (c) Ethrel, 4-10 weeks after nursing.

4.1.8.1 Effect of NAA on adventitious roots formed in yam sections.

Minisetts from the head section developed significantly more adventitious roots than those from the middle and tail sections from the fourth to eighth weeks after nursing (Figure 6 a). The middle and tail sections did not show significant difference between them. In the tenth week, adventitious root formation became uniform in all the sections.

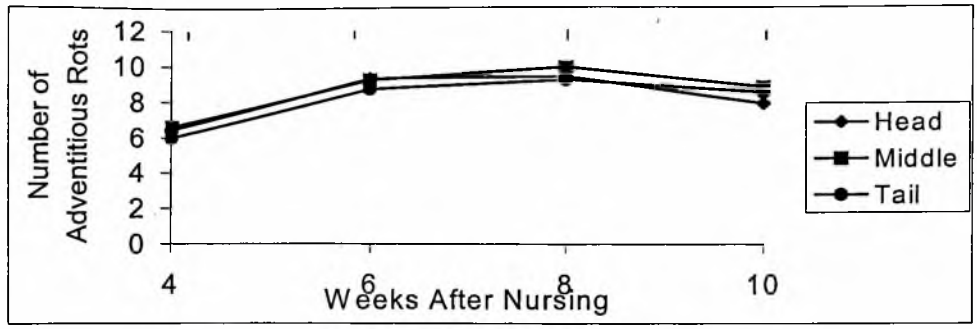
4.1.8.2. Effect of coconut milk on adventitious roots formed in yam sections

Coconut milk did not cause any significant difference ($P<0.05$) in formation of adventitious roots in the different yam sections during the ten weeks period (Figure 6b).

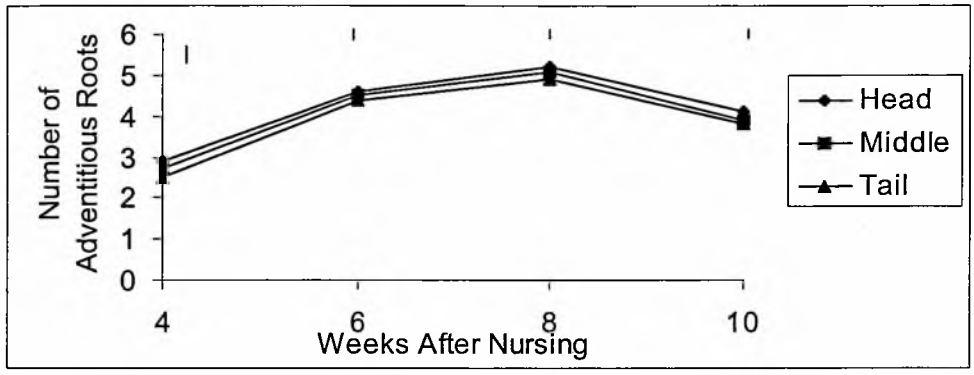
4.1.8.3. Effect of ethrel on adventitious roots formed in yam sections

The different sections treated with ethrel produced significantly different ($P<0.05$) number of adventitious roots in all the weeks except week six (Figure 6 c). In weeks four, eight and ten, the head section produced more adventitious roots than the middle and tail sections. Between the middle and tail sections no significant difference was observed in adventitious root formation.

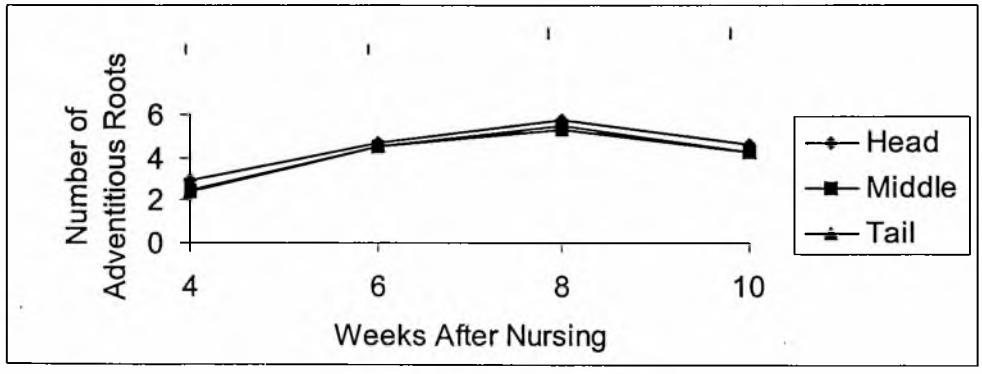
(a)



(b)



(c)



Figures 6 a, b and c. Cumulative number of adventitious root formed in yam sections due to (a) NAA, (b) Coconut milk and (c) Ethrel, 4-10 weeks after nursing.

4.2 Results of Experiment 2: The effect of ethrel and coconut milk on sprouting of three white yam varieties.

4.2.1. Effect of growth regulators on cumulative percentage sprouting of yam varieties

Figures 7 a and b show the cumulative percentage sprouting of yam varieties due to (a) Ethrel and (b) Coconut milk, 4-6 WAN.

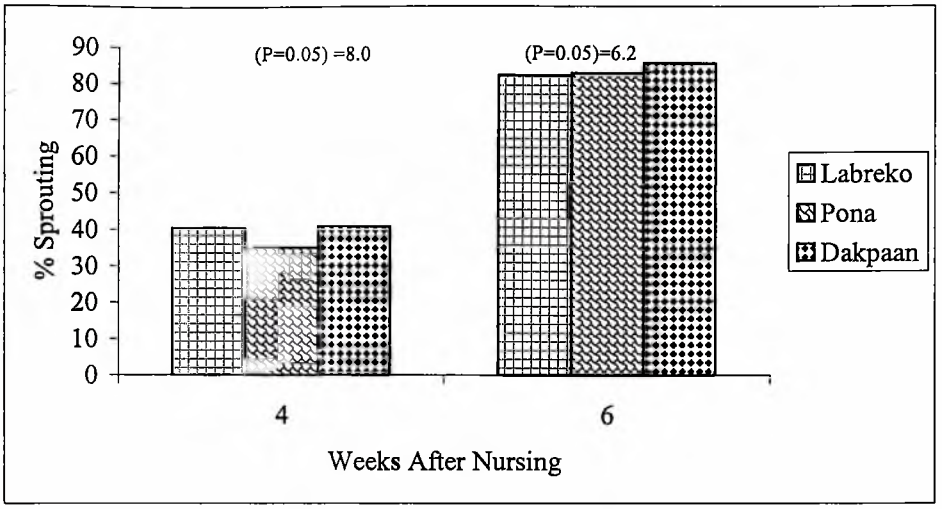
4.2.1.1 Effect of ethrel on cumulative percentage sprouting of yam varieties

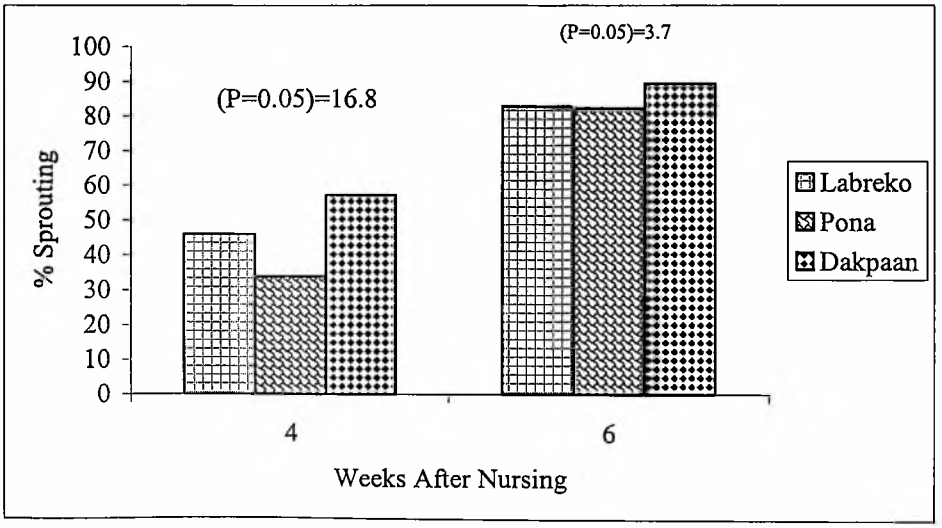
The varieties treated with ethrel did not show any significant differences ($P<0.05$) in percentage sprouting in weeks four and six (Figure 7 a). The increase in sprouting from weeks four to six was more than 100 %.

4.2.1.2 Effect of coconut milk on cumulative percentage sprouting of yam varieties

Coconut milk-treated Dakpaan minisetts sprouted significantly ($P<0.05$) more than Labreko and Pona minisetts that received a similar treatment in weeks four and six. Labreko and Pona did not show significant differences in percentage sprouting (Figure 7 b).

(a)





Figures 7 a and b. Cumulative percentage sprouting of yam varieties due to (a) Ethrel and (b) Coconut milk from 4-6 WAN in Experiment 2.

4.2.2 Effect of growth regulator levels on cumulative percentage sprouting

Figures 8 a and b show the cumulative percentage sprouting of yam minisetts due to levels of (a) Ethrel and (b) Coconut milk 4-6 WAN.

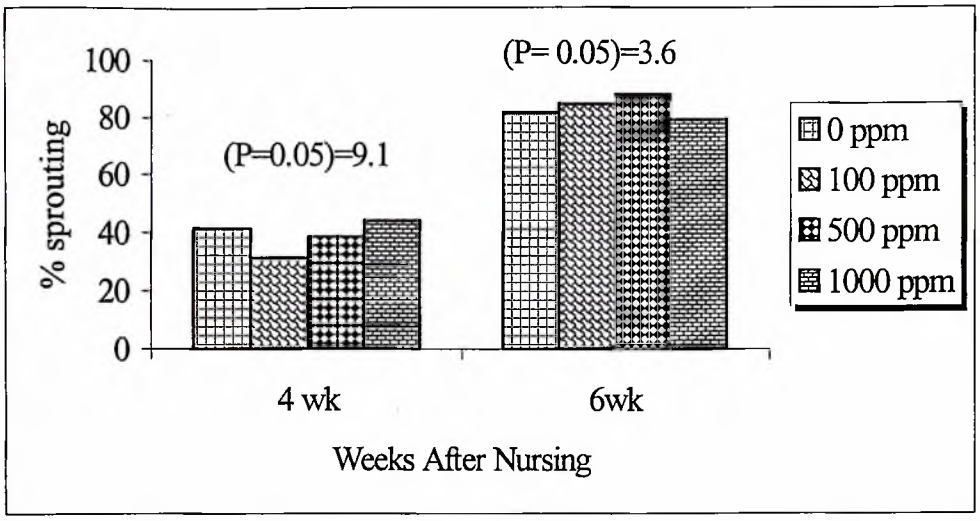
4.2.2.1 Effect of ethrel levels on cumulative percentage sprouting.

Different ethrel levels were significantly different ($P<0.05$) in the promotion of sprouting in both weeks four and six (Figure 8 a). In week four, 500,1000 ppm and the control treatments did not show significant differences among them, however 1000 ppm induced significantly more sprouting than 100 ppm. In week six, 1000 ppm significantly suppressed sprouting by 3 %. The 500 ppm treatment that was not significantly different from 100 ppm in week four significantly improved sprouting by 8 % over the control treatment in week six. The 100 ppm treatment also recorded 4 % improvement over the control treatment although this was not significant.

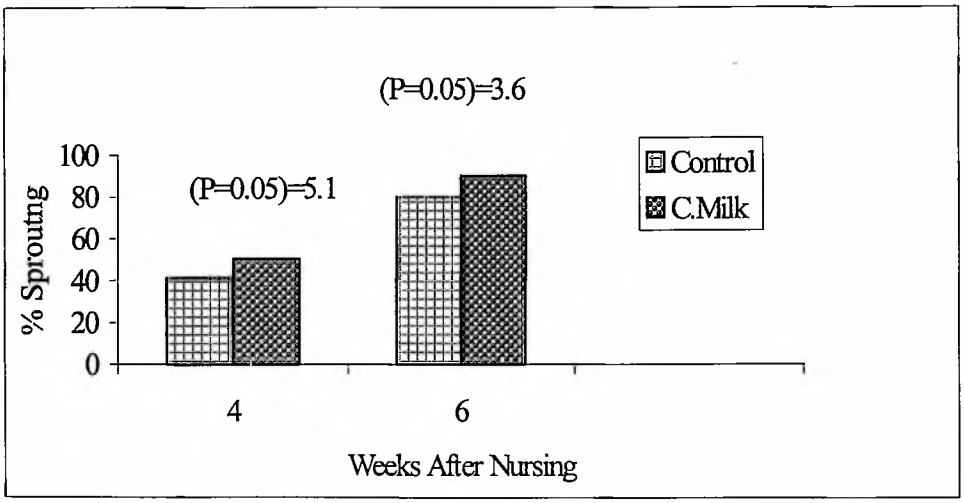
4.2.2.2 Effect of coconut milk levels on cumulative percentage sprouting.

Coconut milk significantly ($P<0.05$) improved sprouting in the minisetts over the control treatment in both weeks four and six (Figure 8 b). The improvement in weeks four and six were 23 % and 13 % respectively.

(a)



(b)



Figures 8 a and b. Cumulative percentage sprouting of yam minisetts due to levels of (a) Ethrel and (b) Coconut milk, 4-6 WAN in Experiment 2

4.2.3. Effect of growth regulators on cumulative percentage sprouting of yam sections.

Figures 9 a and b show the cumulative percentage sprouting of yam sections due to (a) Ethrel and (b) Coconut milk, 4-6 WAN.

4.2.3.1 Effect of ethrel on cumulative percentage sprouting of yam sections.

Sprouting in the sections was not even (Figure 9 a). There were significant differences ($P<0.05$) in both weeks four and six. Sprouting decreased distally.

4.2.3.2 Effect of coconut milk on cumulative percentage sprouting of yam sections.

Sprouting in the sections treated with coconut milk was not even (Figure 9 b). In the fourth week, sprouting was not significantly different ($P< 0.05$) in the middle and tail sections but both significantly sprouted less than the minisetts from the head. In the sixth week, the head and middle recorded statistically similar percentage of sprouting, which was 12 % and 6 % higher than the tail respectively.

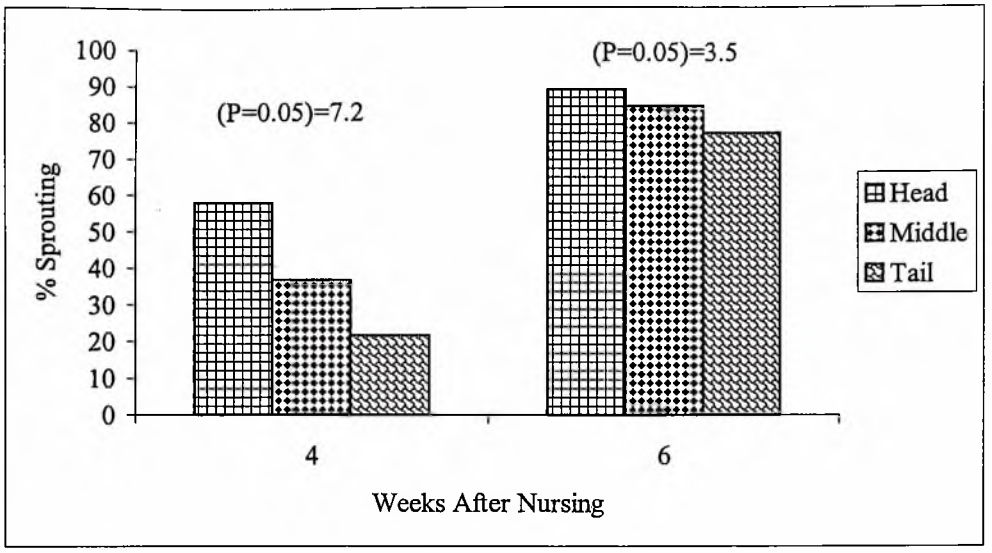
4.2.3.3 Average effect of growth regulators on cumulative percentage sprouting.

In both weeks four and six, coconut milk performed better than ethrel and the control (Table 8). In week four, there was no significant difference between ethrel and the control. However, in week six, ethrel induced significantly more sprouting than the control. The improvement of ethrel and the coconut milk over the control in week six were 7 % and 13 % respectively.

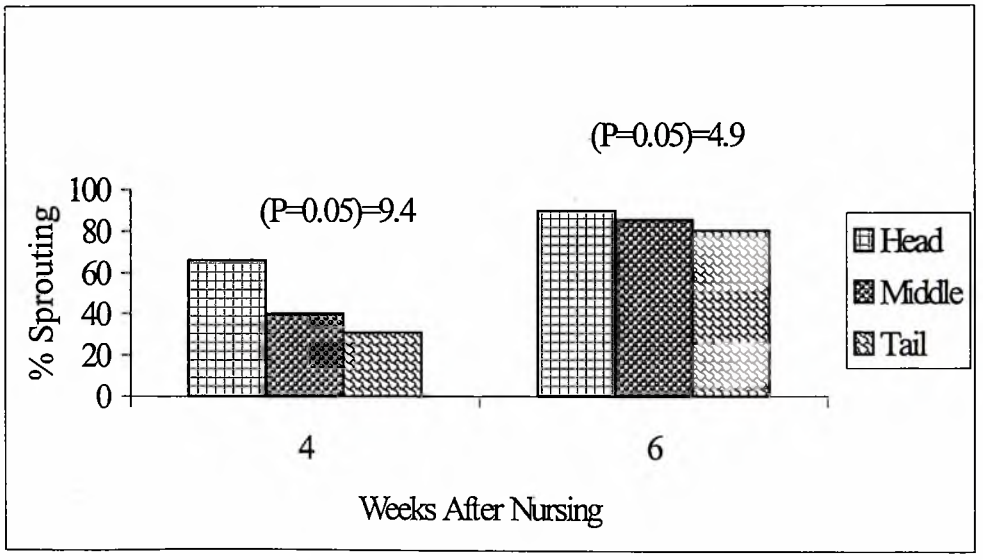
Table 8. Mean effect of growth regulators on cumulative percentage sprouting.

% Sprouting		
Growth regulators	4 Week	6 Week
Ethrel	37.9	84.9
Coconut milk	50.4	90.0
Control	41.1	79.6
LSD (0.05)	**8.3**	**2.8**

(a)



(b)



Figures 9 a and b. Cumulative percentage sprouting of yam sections due to (a) Ethrel and (b) Coconut milk from 4-6 WAN.

4.2.4 Effect of interaction of different levels of growth regulators and yam varieties on cumulative percentage sprouting

4.2.4.1 Effect of interaction of different levels of ethrel and yam varieties on cumulative percentage sprouting

Table 9 shows the interaction of different levels of ethrel and yam varieties on cumulative percentage sprouting, 4-6 weeks after nursing.

Labreko showed significant interaction ($P<0.05$) with ethrel levels in week four. However, in week six the effect of the interaction was not significant. In the fourth week, the control treatment was not significantly different from 500 and 1000 ppm but the three induced significantly more sprouts than 100 ppm.

Table 9. The effect of interaction of different levels of ethrel and yam varieties on cumulative sprouting, 4-6 WAN in Experiment 2.

	% Sprouting				
Week	Concentration (ppm)	Variety			LSD(0.05)
		Labreko	Pona	Dakpaan	
4	0	40.0 (0.430)	32.2 (0.320)	51.1 (0.570)	14.7 (0.179)
	100	26.7 (0.278)	26.7 (0.278)	40.0 (0.426)	
	500	40.0 (0.420)	35.6 (0.367)	40.0 (0.426)	
	1000	54.4 (0.609)	45.6 (0.484)	32.2 (0.340)	
6	0	78.9 (0.919)	75.6 (0.869)	83.3 (1.000)	7.1 (0.157)
	100	84.4 (1.013)	82.2 0.979)	78.9 (0.959)	
	500	80.0 (0.941)	83.3 (0.996)	91.1 (1.256)	
	1000	85.6 (1.103)	90.0 (1.177)	88.9 (1.156)	

The fourth week pattern observed in Labreko minisetts treated with ethrel was also observed in the Pona minisetts. However, in week six, Pona and ethrel levels showed significant interaction ($P<0.05$). Sprouting increased with increasing concentration though between 100 and 500 ppm and also 100 and 0 ppm (control) there were no significant differences. The 500 ppm and 1000 ppm treatments recorded 10 % and 19 % improvement respectively over the control treatment.

In the case of Dakpaan, significant interaction (P<0.05) was observed between the variety and the levels of ethrel in both weeks four and six. In week four, the control treatment, 100 ppm and 500 ppm produced statistically similar percentage sprouting, and this was significantly more than that produced by 1000 ppm.

In the sixth week, the difference in sprouting between 1000 and 500 ppm was not significant so also were the differences between 1000 ppm and the control and 100 ppm and the control. 500 ppm recorded a significant 9 % sprouting improvement over the control.

4.2.4.2 Effect of interaction of different levels of coconut milk and yam varieties on cumulative percentage sprouting

Table 10 shows the interaction of coconut milk concentrations and Yam varieties on cumulative percentage sprouting, 4-6 weeks after nursing.

The interaction between coconut milk and the yam varieties in week four was not significant (P<0.05) but was significant in the sixth week. In week six, coconut milk treated Labreko, Pona and Dakpaan minisetts significantly produced (10, 18 and 12 % respectively) improvement in sprouting over the control treated varieties.

Table 10. The effect of interaction of different levels of coconut milk and yam varieties on cumulative sprouting, 4-6 WAN in Experiment 2.

% Sprouting					
Week	Concentration	Variety			**LSD (0.05)**
		Labreko	Pona	Dakpaan	
4	0	40.0 (0.430)	32.2 (0.342)	51.1 (0.570)	**16.5 (0.654)**
	C. milk	52.2 (0.572)	35.6 (0.366)	63.3 (0.748)	
6	0	78.9 (0.919)	75.6 (0.869)	84.4 (1.017)	**5.0 (0.141)**
	C. milk	86.7 (1.084)	88.9 (1.156)	94.4 (1.349)	

4.2.5 Effect of interaction of different levels of growth regulator and yam sections on cumulative percentage sprouting.

4.2.5.1 Effect of interaction of different levels of ethrel and yam sections on cumulative percentage sprouting.

Table 11 shows the interaction of ethrel levels and Yam sections on cumulative percentage sprouting, 4-6 weeks after nursing.

The head section and the levels of ethrel showed significant interaction effect ($P<0.05$) in weeks four and six. The control treatment was higher and significantly different from 100 and 500 ppm but not 1000 ppm treatment in week four. The differences in sprouting among ethrel levels were not significant. In the sixth week, 1000 ppm induced 12 % more sprouting than the control treatment, which was significant. The 100 and 500 ppm levels induced 7 and 8 % improvement respectively over the control treatment; although these values were not statistically significant

Table 11. The effect of interaction of different levels of ethrel and sections of yam on cumulative sprouting, 4-6 WAN in Experiment 2.

	% Sprouting				
Week	Concentration (ppm)	Sections Head	Middle	Tail	LSD(0.05)
4	0	68.9 (0.781)	33.3 (0.347)	21.1 (0.214)	14.5 (0.173)
	100	50.0 (0.539)	30.0 (0.309)	13.3 (0.134)	
	500	52.2 (0.558)	41.1 (0.427)	22.2 (0.229)	
	1000	60.9 (0.667)	42.2 (0.456)	30.0 (0.311)	
6	0	83.3 (0.991)	80.0 (0.948)	74.4 (0.850)	6.7 (0.151)
	100	88.9 (1.127)	81.1 (0.958)	75.6 (0.867)	
	500	90.0 (1.206)	85. 6 (1.072)	78.9 (0.915)	
	1000	93.3 (1.270)	91.1 (1.227)	80.0 (0.939)	

The middle section and the ethrel levels showed significant interaction ($P<0.05$) in the sixth week. The pattern was not different from that observed in the head section. 1000 ppm recorded 14 % improvement over the control.

The tail section showed significant interaction (P<0.05) with the ethrel levels in week four. 1000, 500 ppm and the control treatment were not significantly different. Similarly, 100 ppm, 500 ppm and the control treatments were not significantly different. The 1000 ppm concentration of ethrel recorded 8 % more sprouting than the control; although this was not statistically significant.

4.2.5.2 Effect of interaction of different levels of coconut milk and yam sections on cumulative percentage sprouting in Experiment 2.

Table 12 shows the interaction of coconut milk and yam sections on cumulative percentage sprouting, 4-6 weeks after nursing.

The sections and coconut milk interaction were significant (P<0.05) in both weeks four and six with the exception of the head section in week four. In the sixth week, the head, middle and tail sections treated with coconut milk recorded 15, 13, and 12 % more sprouting than their counterparts treated with Distilled water (control).

Table 12. The effect of interaction of different levels of coconut milk and sections of yam on cumulative sprouting, from 4-6 WAN in Experiment 2.

		% sprouting			
		Section			LSD (0.05)
Week	Concentration	Head	Middle	Tail	
4	0 (control)	68.9 (0.781)	33.3 (0.347)	21.1 (0.214)	11.6 (0.161)
	Milk	63.3 (0.755)	46.7 (0.499)	41.1 (0.431)	
6	0	83.3 (0.991)	80.0 (0.948)	75.6 (0.867)	6.4 (0.149)
	Milk	95.6 (1.371)	90.0 (1.202)	84.4 (1.013)	

4.2.6 Effect of Growth regulators on adventitious root formation in yam varieties.

Figures 10 a and b show the cumulative numbers of adventitious roots produced due to (a) Ethrel, and (b) Coconut milk in yam varieties 4-6 WAN

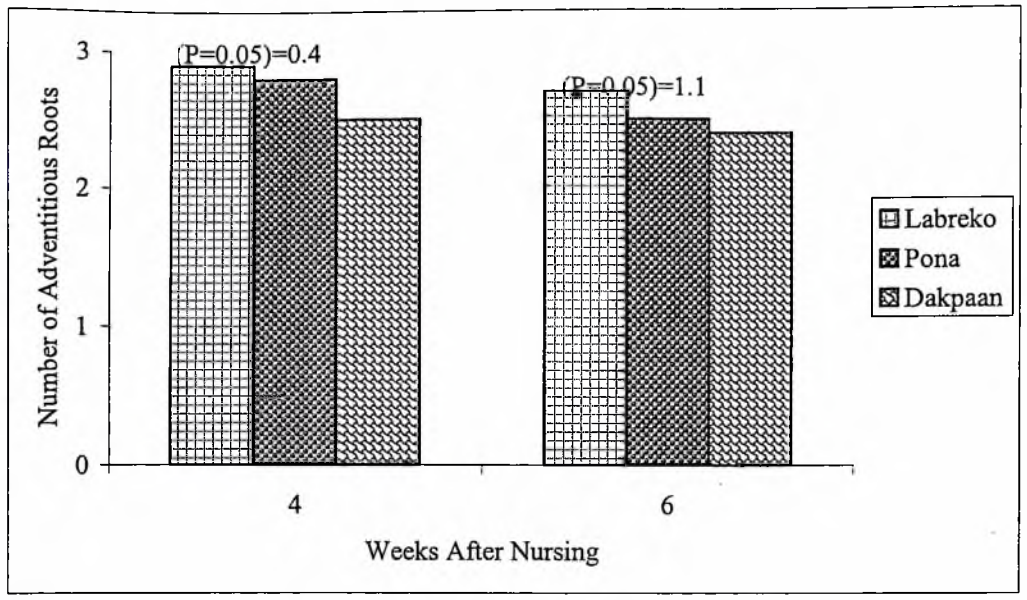
4.2.6.1 Effect of ethrel on formation of adventitious roots in yam varieties.

The varieties did not show any significant difference ($P<0.05$) in adventitious root formation in both weeks four and six. (Figure 10 a).

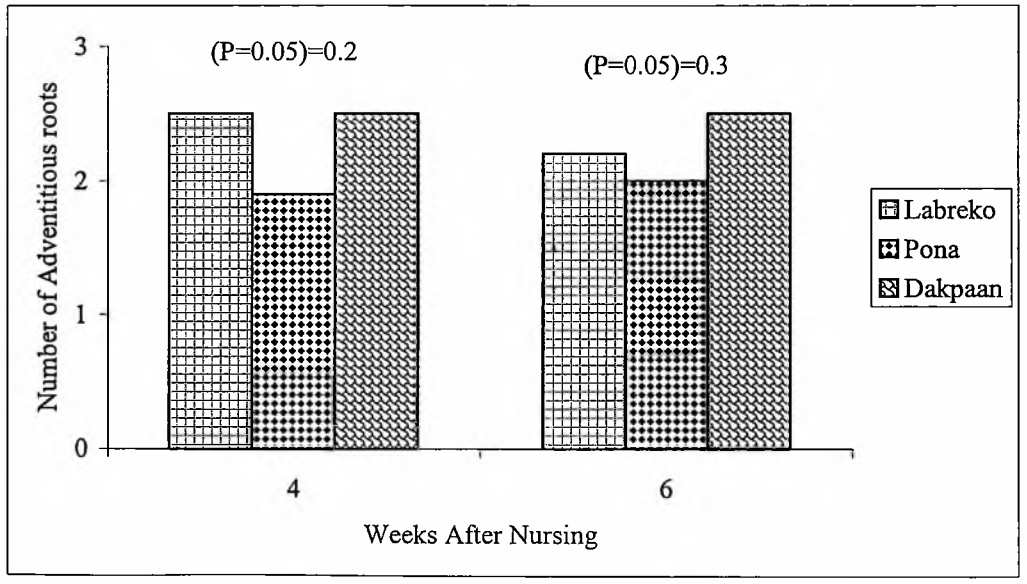
4.2.6.2 Effect of coconut milk on formation of adventitious roots in yam varieties.

The varieties recorded significantly different ($P<0.05$) number of adventitious roots during the study (Figure 10 b). In week four, the Labreko and Dakpaan minisetts significantly developed more adventitious roots than Pona. In the sixth week, Labreko and Pona did not show significant differences between them but they produced less adventitious roots than Dakpaan.

(a)



(b)



Figures 10 a and b. Cumulative mean number of adventitious roots per minisett formed in yam varieties due to (a) Ethrel, and (b) Coconut milk, 4-6 WAN.

4.2.7 Effect of Growth regulator levels on formation of adventitious roots in minisetts of different yam varieties

Figures 11 a and b show the cumulative number of adventitious roots formed due to levels of (a) Ethrel and (b) Coconut milk, 4-6 weeks after nursing.

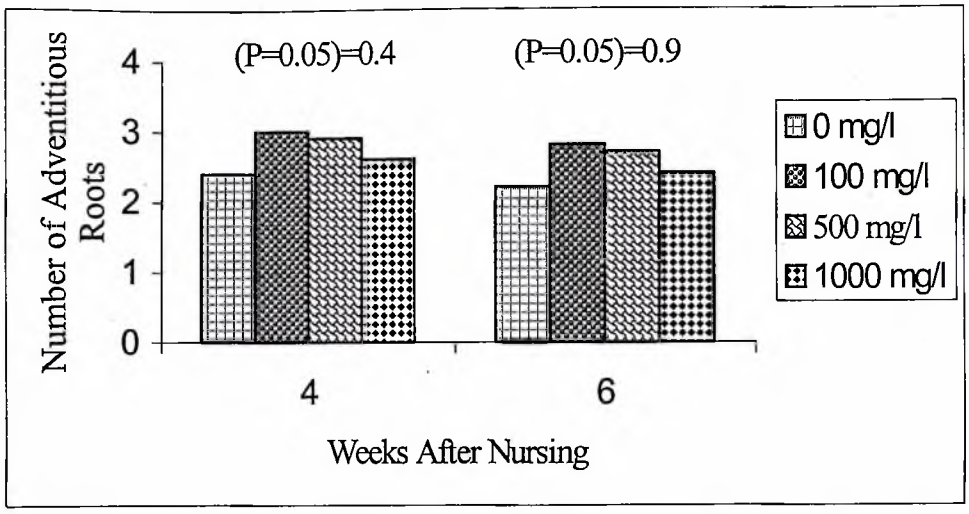
4.2.7.1 Effect of Growth regulator levels on formation of adventitious roots in minisetts of different yam varieties

Minisetts treated with different levels of ethrel did not show significant differences ($P<0.05$) in the formation of adventitious roots in week four (Figure 11 a). However, they produced significantly more adventitious roots than the control treatment. In the sixth week, the differences between ethrel levels and the control treatment were not statistically significant ($P<0.05$).

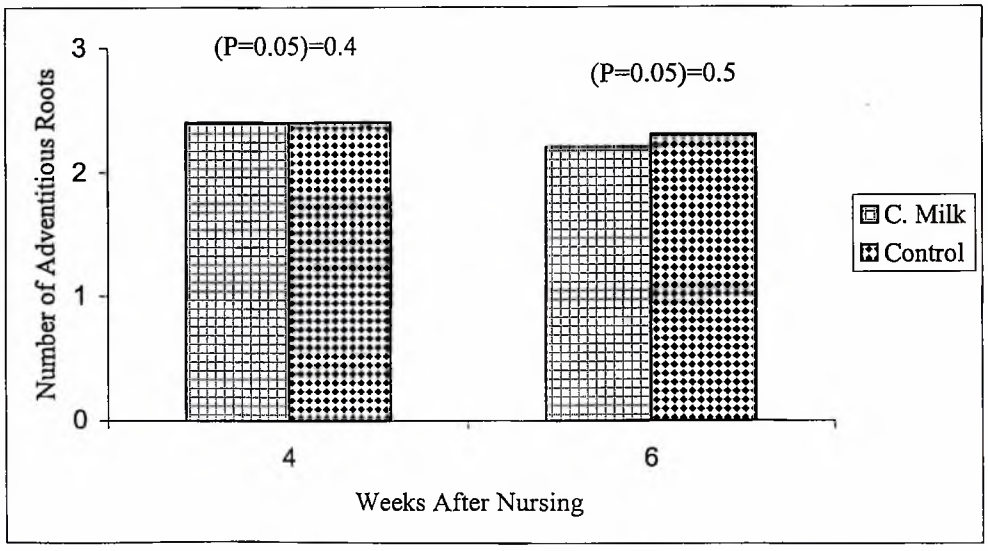
4.2.7.2 Effect of coconut milk levels on formation of adventitious roots in minisetts of different yam varieties.

The difference in adventitious roots formed by minisetts treated with coconut milk and the distilled water was not significant ($P<0.05$) during the study (Figure 11 b).

(a)

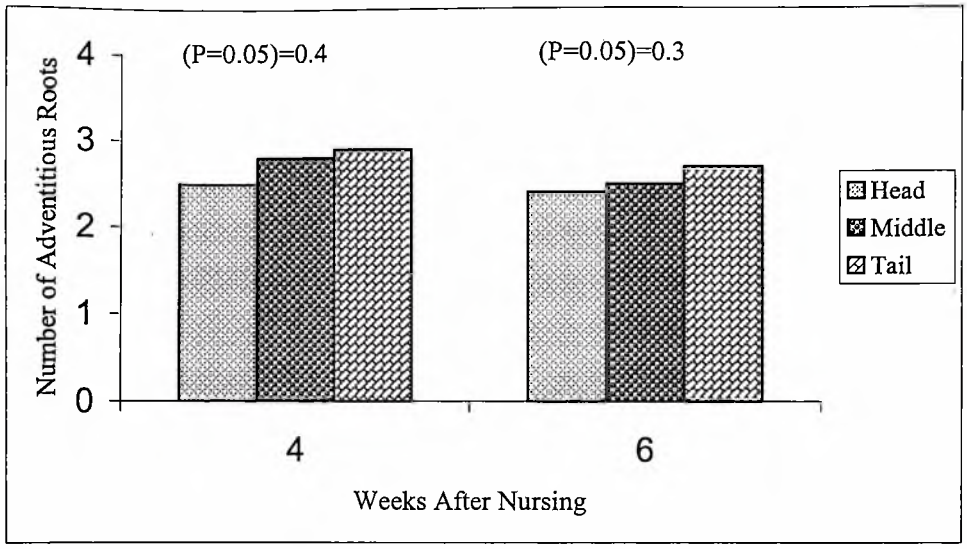


(b)

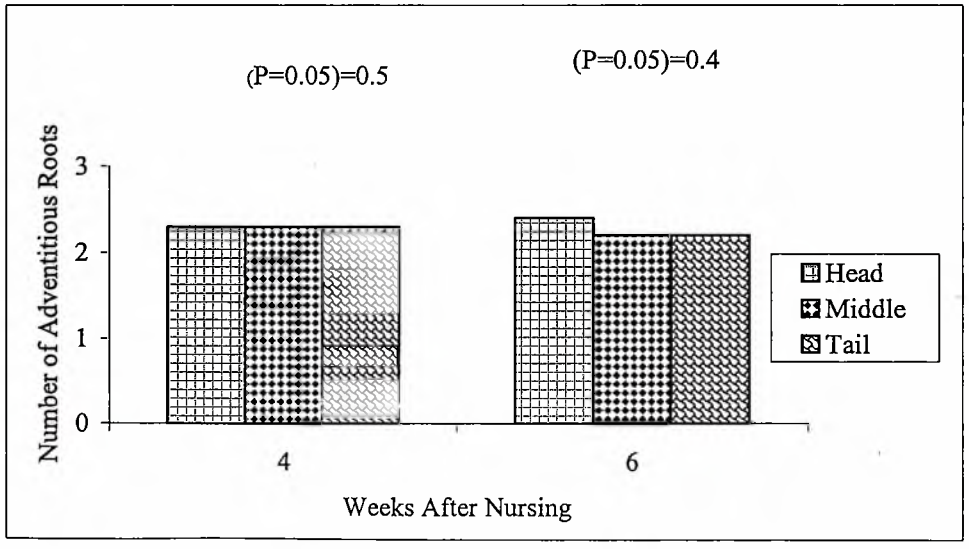


Figures 11 a and b. Cumulative mean number of adventitious roots per miniset formed in yam minisetts due to levels of (a) Ethrel and (b) Coconut milk, 4-6 WAN.

(a)



(b)



Figures 12 a and b. Cumulative mean number of adventitious roots per minisett formed in yam sections due to (a) Ethrel and (b) Coconut milk, 4-6 WAN.

4.3 Results of Experiment 3: The effect of ethrel and coconut milk on sprouting of Labreko and Pona.

4.3.1 The influence of different growth regulators on minisetts of different yam varieties.

Coconut milk induced significantly ($P<0.05$) more sprouting than ethrel and distilled water (control) (Table 13). Ethrel and the control treatment did not show significant differences in sprouting.

The difference in sprouting percentage between Pona and Labreko was not significant ($P<0.05$) (Table 13.)

Sprouting was uniform among the sections (Table 13).

Table 13. Effect of growth regulators on sprouting of yam varieties and sections

Growth regulator	Percentage sprouting	Yam variety	Percentage sprouting	Yam section	Percentage sprouting
Ethrel	81.2	Labreko	75.6	Head	79.3
Coconut milk	86.9	Pona	87.5	Middle	82.4
Distilled water	76.7			Tail	82.9
LSD (0.05)	**4.8**	**LSD (0.05)**	**10.9**	**LSD (0.05)**	**4.2**

4.3.2 Interaction of growth regulators and yam varieties on percentage sprouting.

The interaction of Pona and the growth regulators were significant ($P<0.05$). Coconut milk and ethrel induced statistically similar percentage sprouting (Table 14). Coconut milk recorded 7 % improvement over the sprouting recorded by the control treatment. The difference between ethrel and the control treatment was not significant. Coconut milk

and ethrel- treated Labreko recorded 21 and 8 % improvement over labreko minisetts treated with distilled water.

Table 14. Interaction of growth regulators and yam varieties on sprouting.

	% sprouting		
Variety	Coconut milk	Ethrel	Water
Pona	90.4	87.8	84.4
Labreko	83.3	74.4	68.9
LSD (0.05)	**4.8**		

4.3.2.1 Interaction of growth regulators and yam sections on sprouting.

In minisetts treated with coconut milk, the middle sections sprouted significantly ($P<0.05$) more than the head (Table 15). The difference between the head and the tail sections was not statistically significant so also was the difference between the middle and the tail.

In the case of sections treated with ethrel, the head and middle sections did not show any significant difference but the two sprouted more than the tail. The opposite was true for the tail sections treated with distilled water. The tail sprouted better than the middle and the head. The head and tail did not show any significant difference.

Table 15. Interaction effect of growth regulators and yam sections on sprouting.

	% sprouting		
Yam section	Coconut milk	Ethrel	Water
Head	82.2	85.0	70.6
Middle	90.0	83.3	73.9
Tail	88.3	75.0	85.6
LSD (0.05)	**5.8**		

4.3.3 Effect of Growth regulators on percentage non-sprouting of minisetts of yam varieties.

Percentage non-sprouting was significantly higher in ethrel and Distilled water treated minisetts than those treated with coconut milk (Table 16). The differences between ethrel and the Distilled water were not significant.

Labreko recorded significantly ($P<0.05$) higher percentage non-sprouting than Pona (Table 16).

Minisetts that did not sprout were significantly less for the head and tail sections than the middle section (Table 16). The head and the tail sections recorded statistically the same percentage of non-sprouting minisetts.

Table 16. Percentage non-sprouting in growth regulator-treated minisetts, yam varieties and yam sections.

Growth regulator	Percentage Non-sprouting	Yam variety	Percentage Non-sprouting	Yam section	Percentage Non-sprouting
Ethrel	12.4	Labreko	17.0	Head	10.9
Coconut milk	9.4	Pona	7.3	Middle	14.8
Distilled water	14.2			Tail	10.8
LSD (0.05)	2.4	**LSD (0.05)**	**6.1**	**LSD (0.05)**	**3.2**

4.3.4. Effect of Growth regulators on percentage rotten yam minisetts.

Coconut milk-treated minisetts recorded significantly lower percentage rotting than those treated with distilled water although distilled water was not significantly different from ethrel. Coconut milk was also not different from ethrel (Table 17).

The difference in percentage rotten minisetts between Labreko and Pona was not significant ($P<0.05$) (Table 17).

The distal and proximal ends of the tubers recorded more percentage rot than the middle. The head recorded more rotten minisetts than the tail (Table 17).

Table 17. Percentage rotting of growth regulator-treated minisetts, yam varieties and yam sections.

Growth regulator	Percentage rotting	Yam variety	Percentage rotten	Yam section	Percentage rotting
Ethrel	6.4	Labreko	7.4	Head	9.8
Coconut milk	3.7	Pona	5.2	Middle	2.8
Distilled water	9.1			Tail	6.3
LSD (0.05)	**4.4**	**LSD (0.05)**	**6.6**	**LSD (0.05)**	**2.8**

4.4 Results of Experiment 4: The effect of type of growth regulator and development stage of sprouted minisett (at transplanting) on field performance of three white yam varieties.

Table 18. Effect of stage of development of sprouted yam minisett on numbers of nodes and leaves, vine height, average tuber weight and percentage survival in Experiment 4.

Stage and (vine length)	Node Number	Leaf Number	Vine Height (cm)	Av. Tuber weight (kg)	% Survival
1 (<2.0 cm)	14.8 (3.9)	30.4 (5.43)	55.7	0.356	77.2 (1.07)
2 (2.1-4.0 cm)	28.7 (3.87)	56.3 (5.42)	77.4	0.550	80.4 (1.08)
3 (>4.1 cm)	27.3 (4.07)	54.1 (5.68)	81.4	0.354	69.8 (1.08)
LSD (0.05)	1.1 (0.34)	2.7 (0.59)	4.2	0.08	8.1 (0.13)

4.4.1 Effect of stage of development of sprouted yam minisett on vegetative growth, average tuber weight and plant survival at harvest.

Stages 2 and 3 minisetts performed better than Stage1 in numbers of nodes and leaves, and vine height (Table 18). Apart from number of nodes in which Stage 2 produced significantly ($P<0.05$) more than the Stage 3, the Stages 2 and 3 were not significantly different ($P<0.05$) in number of leaves and vine height.

Stage 2 sprouted minisetts yielded significantly ($P<0.05$) better than those of Stages 1 and 3; there was no significant difference in tuber yield between the two stages (Table 18).

Stages 1 and 2 sprouted minisetts significantly survived ($P<0.05$) better than those of Stage 3 (Table 18).

4.4.2 Vegetative growth, average tuber weight and plant survival at harvest of yam varieties.

Vegetative growth of Dakpaan yam variety in terms of number of nodes and leaves, and vine height was significantly better than in Labreko and Pona (Table 19). The difference in vegetative growth between Labreko and Pona was not significant ($P<0.05$).

Table 19. Response of yam varieties to numbers of nodes and leaves, vine height, average tuber weight and percentage survival in Experiment 4.

Variety	Node Number	Leaf Number	Vine Height (cm)	Av. Tuber weight (kg)	% Survival
Labreko	22.5 (4.7)	44.9 (6.6)	69.6	0.371	79.4 (1.00)
Pona	22.3 (4.6)	43.7 (6.5)	68.6	0.350	68.8 (0.80)
Dakpaan	26.1 (5.1)	52.1 (7.2)	76.3	0.513	79.4 (1.02)
LSD (0.05)	1.4 (0.16)	2.5 (0.19)	2.8	0.040	9.5 (0.20)

Tuber yield in Dakpaan yam variety was significantly higher than in Labreko and Pona (Table 19). The difference in yield between Labreko and Pona was not significant. Plates 6, 7 and 8 show harvested yam setts of the three varieties.

Labreko and Dakpaan survived significantly ($P<0.05$) better than Pona. Labreko and Dakpaan did not show significant differences in percentage survival (Table 19).

4.4.3 Effect of growth regulators on vegetative growth, average tuber weight and plant survival at harvest.

The growth regulators, ethrel and coconut milk did not show significant differences ($P<0.05$) from the control (distilled water) in number of nodes they induced (Table 20). Coconut milk induced significantly ($P<0.05$) more leaves than ethrel and the control. The difference between ethrel and the control was not significant.

Coconut milk significantly enhanced vine growth more than ethrel and the control. Vine growth in the control was in turn better than ethrel.

Table 20. Effect of plant growth regulators on numbers of nodes and leaves, vine height, average tuber weight and percentage survival in Experiment 4.

Growth regulator	Node Number	Leaf Number	Vine Height (cm)	Av. Tuber weight (kg)	% Survival
Ethrel	23.5 (4.7)	46.9 (6.8)	70.1	0.401	73.5 (0.88)
Coconut milk	24.2 (4.8)	48.0 (6.9)	73.9	0.440	77.8 (0.94)
Control	23.2 (4.7)	45.8 (6.7)	71.8	0.391	76.2 (0.99)
LSD (0.05)	NS	2.0 (0.17)	2.0	0.030	NS

Application of Coconut milk significantly ($P<0.05$) improved tuber weight compared to ethrel and the distilled water (Table 20). However, ethrel and the control were not significantly different in their effect on tuber weight.

There was no significant effect of treatment with different growth regulators on survival of yam plant when compared with the control ($P<0.05$) (Table 20).

Plate 6. Labreko harvested yam setts

Plate 7. Pona harvested yam setts.

Plate 8. Dakpaan harvested yam setts

4.5 Results of Experiment 5: The effect of ethrel and coconut milk on field performance of Labreko, Pona and Dakpaan sprouted minisetts.

4.5.1 Vegetative growth, average tuber weight and plant survival at harvest of yam varieties.

There were no significant differences ($P<0.05$) in the percentage survival of the different yam varieties. The numbers of nodes and leaves developed in the different varieties were also not significantly different. However, vine growth in Dakpaan was significantly higher than that of Labreko and Pona (Table 21).

Average tuber weight was significantly ($P<0.05$) higher in Dakpaan than in Labreko and Pona; which had similar tuber weight (Table 21).

Table 21 shows that differences in percentage survival were not significant ($P<0.05$).

Table 21. Response of yam varieties to numbers of nodes and leaves, vine height, average tuber weight and percentage survival in Experiment 5.

Variety	Node Number	Leaf Number	Vine Height (cm)	Av. Tuber weight (kg)	% Survival
Labreko	15.3 (3.91)	29.5 (5.43)	54.7	0.233	87.2 (1.07)
Pona	15.0 (3.87)	29.4 (5.42)	55.2	0.203	87.9 (1.08)
Dakpaan	16.6 (4.07)	32.5 (5.68)	63.5	0.326	87.8 (1.08)
LSD (0.05)	NS	NS	2.2	0.049	NS

4.5.2 Effect of growth regulators on vegetative growth, average tuber weight and plant survival at harvest.

The growth regulators did not significantly ($P<0.05$) affect nodes and leaves numbers, and vine height. Plant survival and average plant weight were also not affected by the growth regulators (Table 22).

Table 22. Effect of plant growth regulators on numbers of nodes and leaves, vine height, average tuber weight (yield) and percentage survival in Experiment 5.

Growth regulator	Node Numbers	Leaf Numbers	Vine Height (cm)	Av. Tuber weight (kg)	% Survival
Ethrel	15.6 (3.95)	30.4 (5.51)	57.3	0.251	87.5 (1.07)
Coconut milk	15.7 (3.95)	30.3 (5.50)	56.7	0.254	87.9 (1.08)
LSD (0.05)	**NS)**	**NS**	**NS**	**NS**	**NS**

4.5.3 The effect of varying concentrations of growth regulators on numbers of nodes and leaves, vine height, average tuber weight and percentage survival of yam minisetts

The numbers of nodes and leaves, vine height, average tuber weight and percentage survival were not affected by the concentration levels of the growth regulators (Table 23).

Table 23. Effect of levels of ethrel and coconut milk on numbers of nodes and leaves, vine height, average tuber weight (yield) and percentage survival in Experiment 5.

Ethrel Concentration (ppm)	Node Numbers	Leaf Numbers	Vine Height (cm)	Av. Tuber weight (kg)	% Survival
0	15.3 (3.91)	29.5(5.46)	58.6	0.251	86.5(1.05)
100	16.2 (4.03)	31.4(5.59)	58.1	0.252	89.1(1.11)
500	15.3 (3.91)	29.8(5.45)	56.7	0.526	87.6(1.07)
1000	15.7 (3.96)	30.6(5.52)	57.8	0.260	87.6(1.07)
Coconut milk	16.0 (3.99)	30.9(5.56)	58.4	0.256	89.4(1.11)
LSD (0.05)	NS)	NS	NS	NS	NS

4.6 Results of Experiment 6: The effect of ethrel and coconut milk on the field performance of Labreko and Pona.

4.6.1 Vegetative growth, average tuber weight and plant survival at harvest of yam varieties.

The numbers of nodes and leaves, vine height, average tuber weight and percentage plant survival in Labreko and Pona yam varieties were not significant ($P<0.05$) (Table 24).

Table 24. Numbers of nodes and leaves, vine height, average tuber weight and percentage survival of Labreko and Pona in Experiment 6.

Variety	Node Numbers	Leaf Numbers	Vine Height (cm)	Av. Tuber weight (kg)	% Survival
Labreko	14.4 (3.79)	28.1 (5.25)	53.9	0.236	81.6 (0.96)
Pona	14.2 (3.77)	28.4 (5.32)	53.2	0.227	81.4 (0.95)
LSD (0.05)	NS	NS	NS	NS	NS

4.6.2 Effect of growth regulators on vegetative growth, average tuber weight and plant survival at harvest.

The numbers of nodes and leaves, vine height, average tuber weight and percentage plant survival were not affected by the growth regulators (Table 25).

Table 25. Effect of plant growth regulators on numbers of nodes and leaves, vine height, average tuber weight (yield) and percentage survival in Experiment 6.

Growth regulators	Node Numbers	Leaf Numbers	Vine Height (cm)	Av. Tuber weight (kg)	% Survival
Ethrel	14.1 (3.75)	27.4 (5.17)	53.8	0.230	81.3 (0.95)
Coconut milk	14.4 (3.79)	28.5 (5.34)	53.4	0.227	81.6 (0.96)
Control	14.2 (3.77)	28.7 (5.35)	53.4	0.222	81.6 (0.96)
LSD (0.05)	NS	NS	NS	NS	NS

4.6.3 Influence of yam sections on vegetative growth, average tuber weight and plant survival at harvest.

The numbers of nodes and leaves, vine height, average tuber weight and percentage survival were not influenced by yam sections (Table 26).

Table 26. Numbers of nodes and leaves, vine height, average tuber weight and percentage survival for minisetts produced in the different tuber sections in Experiment 6.

Section	Node Numbers	Leaf Numbers	Vine Height (cm)	Av. Tuber weight (kg)	% Survival
Head	14.4 (3.79)	27.1 (5.13)	53.3	0.221	80.8 (0.94)
Middle	14.3 (3.77)	28.9 (5.37)	52.7	0.231	82.6 (0.97)
Tail	14.0 (3.78)	28.7 (5.36)	53.6	0.227	81.1 (0.95)
LSD (0.05)	NS	NS	NS	NS	NS

CHAPTER FIVE

5.0 DISCUSSION

5.1 Sprouting in minisetts of yam varieties.

In order to ensure sprouting of yam minisetts, Otoo et al. (1985) recommended that the mother seed yams used should have been in storage for 2-3 months to overcome tuber dormancy, which is indicated by the observation of sprouts at the head-ends of the tubers. The tubers used for the Experiment 1 had been in storage for three months with sprouts at the head-ends. Tubers used for Experiments 2 and 3 had been in storage for 6 months. Tubers used in Experiments 1 and 2 were yams that were pricked or milked in October while those of Experiment 3 were yams that were full season grown and harvested in December.

Six weeks after nursing in Experiment 1, the highest percentage sprouting observed among the varieties treated with ethrel were 18.9 and 16.4 for Pona and Labreko respectively. Dakpaan, which was used as control because the farmer from whom the tubers were bought testified that he had used yam minisett technique to multiply his stock, failed to sprout well. When the sprouting process was observed beyond the recommended time of 4-6 weeks, the percentage sprouting recorded was about 50 % in the eighth week after nursing. By the tenth week, sprouting had improved to about 69 % for Pona and Labreko and about 57 % for Dakpaan.

In Experiment 2, the sprouting observed in the fourth week was about 40 %. This doubled to about 80 % in the sixth week. Dakpaan was at par with Labreko and Pona in

Experiment 2. Sprouting observed in the sixth week of Experiment 3 was 76 % for Labreko and 88 % for Pona, which was not different from the results of Experiment 2

From the results of Experiments 1-3, it was observed that if Experiment 1 had been terminated at the recommended time, it would have been concluded that the varieties do not respond well to sprouting although indications of breakage of tuber dormancy was seen before the start of the experiment. When the sprouting process was extended to week ten, appreciable percentage sprouting was recorded. When pricked and full season grown tubers that had been in storage for 6 months were used, about 80 % sprouting was recorded by the varieties by the sixth week. It appears the minisett sprouting problem is not with the varieties or the yam type (i.e. pricked or full season grown) but with the level of breakage of tuber dormancy. The mere presence of sprouts at the head-ends is not an indication that the tuber will sprout well. The dormancy ought to be well released, more than 3 months in storage, in this case 6 months, before some minisetts of varieties such as Pona, Labreko and Dakpaan can respond to sprouting. A similar observation was made by Amoako (unpublished) with respect to Pona and Punjo minisetts.

5.2 Effect of growth regulators on sprouting.

NAA suppressed sprouting in Experiment 1. This was in contrast to the findings of Ndzana *et al.* (1992) in which NAA induced 5.3 % more sprouting than the control (water). This contrast might be due to varietal differences as some varieties sprout more profusely than others. Coconut milk performed better than the other growth regulators in the three experiments. In the beginning, ethrel and the control were not significantly different but in Experiments 2 and 3 ethrel performed better than the control. The enhancement of sprouting by coconut milk more than the other growth regulators may be

due to the presence of cytokinins, auxins and other growth promoting substances in the milk although these were not investigated in this study. Moore *et al.* (1995) reported that cytokinins stimulate cellular division and its effect depends on the presence of auxins. The finding of Gregory (1968) supports the performance of ethrel. He observed that Ethephon (ethrel) breaks dormancy and enhances sprouting in yam tubers.

5.3 Effect of growth regulator levels on sprouting

The levels of NAA tested suppressed sprouting. This may reflect the finding of Nyamekye (1999) that the higher the concentration of NAA the less the sprouting of split corms of plantain.

100 and 500 ppm of ethrel application performed better than 1000 ppm and the control. The 500 ppm treatment was the best level in both Experiments 1 and 2. 1000 ppm of ethrel in the sixth week of Experiment 2 caused 3 % suppression of sprouting.

5.4 Sprouting of minisetts from different yam sections

In Experiments 1 and 3, sprouting was even among the yam sections. However, in Experiment 2, the head section sprouted more than the middle and the tail; the middle and tail did not show significant difference in sprouting. This observation agrees with the findings of Miege (1957), Coursey (1967) and Onwueme (1973) that the rate of sprouting of the head section is higher than the middle and tail and no differences exist between the middle and the tail sections. Campbell et al., (1962a) have suggested that dormancy is associated with low levels of glutathione in the tuber, and that the glutathione level is high when the dormancy level is low. Sprouting initiation of minisetts from *D. alata* and *D. cayenensis* correlated well with increased glutathione levels (Wellington and Ahmad, 1993). Looking at the pattern of sprouting in the three experiments, it may be speculated

that at the time of harvest the glutathione level in the tubers may probably be uniformly low across the length of the tuber. With time its level increases proximally until later it becomes high and even along the length of the tuber. Probably a low and uniform glutathione level in the initial stage might have caused equal but low percentage sprouting in all sections although this speculation is subject to proper investigation. The increase in the level of glutathione level proximally might be the reason why sprouting increased proximally in Experiment 2. It may also be speculated that a high and even glutathione level in the third experiment might be responsible for the high and even sprouting of the sections.

5.5 Average performance of the growth regulators on sprouting.

In Experiment 1, coconut milk performed better than ethrel and the control. The difference between ethrel and the control was not significant. NAA suppressed sprouting. The improvement of coconut milk over the control was 30 % at the termination of the experiment. The superior performance of coconut milk was again observed in Experiment 2. In that experiment, ethrel performed better than the control. The improvement of coconut milk over the control dropped from 30 % in Experiment 1 to 13 % in Experiment 2 while that of ethrel fell from 8 % to 7 %. In Experiment 3, coconut milk was better than ethrel and the control while the difference between ethrel and the control was insignificant. This may suggest that as dormancy becomes sufficiently broken the influence of the growth regulators become less important probably because other relevant factors needed endogenously for the breaking of dormancy in yams may already be present at their optimum concentrations

5.6 Interaction of growth regulator levels and yam varieties on sprouting.

The levels of NAA showed significant negative interaction with the yam varieties in terms of sprouting.

Coconut milk did not show significant interaction with Labreko and Dakpaan but exhibited interaction effect on sprouting with Pona. Coconut milk-treated Pona minisetts sprouted significantly better than those given the control treatment. The ethrel levels that induced superior sprouting among the varieties were 500 and 1000 ppm.

5.7 Interaction of growth regulator levels and yam sections on sprouting.

Suppression of sprouting by NAA concentration levels in the head, middle and tail sections were in the range of 41-89 %, 63-95 % and 44-98 % respectively. This contrasted the observation of Ndzana *et al.* (1992) in which 100 and 300 mg/l of NAA increased sprouting in the head by 49 % and 30.6 % respectively. They also reported that 300 and 500 mg/l induced 6.7 and 13.9 % improvement of sprouting in the middle section. For the bottom section, a slight improvement was noted at 100 mg/l (2.4 %), then a high rate at 500 mg/l (12.2 %).

Minisetts from the head and tail sections interacted significantly with coconut milk in Experiment 1 but in Experiment 2 all the sections showed significant interaction effect. In week ten, the head and the tail sections treated with coconut milk in Experiment 1 recorded 66 %and 41 % more sprouting than the control. At the termination of Experiment 2, the head, middle and tail sections treated with coconut milk recorded 15,13 and 12 % more sprouting than the control treated minisetts. This is in accord with the results obtained by Ndzana *et al.* (1992) when benzyl aminopurine-treated yam head section recorded 65.6 % more sprouting than the control while the counterpart tail section recorded 18.4 % more sprouting. The coconut milk-treated middle section was not significantly different from the control in Experiment 1 but was different in Experiment 2. At 300 and 500 mg/l of BAP, Ndzana *et al.* (1992) found sprouting rate in the middle section lower than the control.

In Experiment 1, the head section showed interaction with ethrel concentrations in the sixth and tenth weeks. Lower concentration levels were required to induce more sprouting in the head section. The same pattern was observed in the tail section. The middle section did not show interaction effect with ethrel. In the second experiment, higher concentrations of the ethrel were required to induce more sprouting in the sections. The average performance of the growth regulators revealed that as release from dormancy progresses the influence of the growth regulators become less important probably because other relevant factors needed endogenously for the breaking of dormancy in yams may already be present at their optimum concentrations. Therefore higher concentrations of ethrel had to be applied to get significant improvement in sprouting.

5.8 Effect of growth regulators on adventitious root formation in yam varieties.

In most cases the three varieties did not show significant differences in the early part of each experiment. However, at or towards the end of the experiments, Dakpaan produced more adventitious roots than Labreko and Pona. The latter two varieties in most cases did not show any significant difference between them. Dansi *et al.* (1998) classified Pona and Labreko under the same varietal group. It is not surprising that in most cases the two did not behave differently. NAA induced more adventitious roots than ethrel and coconut milk. Geneve and Heuser (1982) have reported the promotion of adventitious roots by NAA. In mung bean stem cutting experiment, Geneve and Heuser (1982) found NAA and 2,4-D the most effective auxins in adventitious root promotion.

5.9 Effect of levels of growth regulators on adventitious root formation.

As the concentration of NAA increased, the number of adventitious roots formed increased. In Experiment 1, the same pattern was observed with ethrel- treated minisetts except on the last week when no difference existed between the levels. In the second experiment however, the differences that were observed among the different ethrel levels in the fourth and sixth weeks were not significant. The intensity of adventitious roots production declined in the Experiment 2. Apart from week ten in Experiment 1 when coconut milk induced more adventitious roots than the control, the effect of coconut milk was generally not different from that of the control in the induction of adventitious roots. Nyamekye (1999) observed that as the concentration of NAA increased the number of adventitious roots formed in plantain split-corm also increased.

In most cases, the growth regulators caused more adventitious roots in the head section than the middle and tail sections. Ndzana *et al.* (1992) attributed the higher activity of the head region to the sensitivity of the growth centres to applied chemicals.

5.10 Contribution of rotten and non-sprouting to percentage sprouting of yam minisetts.

The low sprouting performance of Labreko as compared to Pona was mainly due to high percentage of non-sprouting minisetts since percentage rotting among the two varieties was similar

Though the middle section recorded significantly higher number of non-sprouted minisetts than the rest, non- sprouting minisetts alone did not influence the percentage sprouting of the sections. Percentage rotten minisetts greatly contributed to the numerically low percentage sprouting of the head section. The ends of the tubers

experienced more rots than the middle section. A study by Ametepe (unpublished) revealed that the head and the tail sections of some varieties of *Dioscorea rotundata* experienced more rotting than the middle section. These two sections are proned to injuries during harvesting and storage thereby creating points of entry for rot causing pathogens.

5.11 Stages of development of sprouted minisetts.

Stages 2 and 3 sprouted minisetts performed better than those of stage 1 in vegetative growth. This was not surprising because Stage 1 minisetts took longer time to emerge from the soil although they were transplanted one and two weeks respectively before Stages 2 and 3 sprouted minisetts were sent to the field.

Though Stage 3 sprouted minisetts performed well in vegetative growth, their percentage survival was lower than that of Stages 1 and 2. Gyansah-Ameyaw (1987) working with TDR 131 white yam variety, found that, the leafy shoot stage of sprouted minisetts (corresponding to Stage 3) recorded more leaf number 10 WAN but significantly lower percentage survival at harvest than that of non-green emerged shoot (0.5-1.5 cm long) and green pin leafless shoot (3.0-3.5 cm long) corresponding to Stages 1 and 2 respectively. Leafy shoots normally die back soon after they have been transplanted. This is to due to the fact that leafy vines develop extensive root system that is damaged during the transplanting process. The scorching of the leaves by the sun aggravates this situation.

Both stages 2 and 3 sprouted minisetts were able to transform their superior vegetative growth to tuber yield. Gyansah- Ameyaw (1987) however, did not recognise any difference in yield among the sprouting stages.

Dakpaan yam variety produced significantly higher tuber yield than Labreko and Pona. This may be accounted for by the superior vegetative growth of Dakpaan as compared with vegetative growth of Labreko and Pona. In Experiment 5, the same yield pattern was observed although vegetative growth differences were not significant among the varieties. Varietal difference may account for the yield differences that were observed. Amoako (unpublished) observed that Punjo white yam variety yielded more than Pona white yam variety.

Labreko and Dakpaan survived better on the field than Pona in Experiment 4. However, in Experiments 5 and 6, the more than 80 % survival of Pona made its survival similar to Labreko and Dakpaan. Mensah (2002) noticed that the percentage field survival of Pona and Asana were not statistically different but the level of survival was low for both varieties. Probably when field moisture content is sufficient and the sprouted materials are handled carefully a substantial percentage survival of the transplanted materials will be obtained.

Coconut milk induced higher vegetative growth than ethrel and the control and this corresponded with the average tuber weight. Ethrel-treated minisetts were not different from the control in vegetative growth. Study by Onwueme (1974) showed that kinetin and coconut milk induced more leaf growth than the control in white yam. Higher leaf growth correlates well with photosynthetic yield.

The growth regulators did not influence survival of sprouted minisetts on the field.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS.

6.1 Conclusions

6.1.1 Effect of growth regulators on sprouting.

NAA suppressed sprouting while coconut milk and ethrel improved sprouting. The improvement in sprouting over the control due to coconut milk treatment was between 13-30 % while that of ethrel was 7-8 %.

6.1.2 Sprouting of yam minisetts.

It was observed that the mere presence of sprouts at the ends of tuber is not an indication that the minisetts of the tuber will sprout well. Dormancy ought to be sufficiently released (through storage for more than 3 months after harvesting) before varieties such as Pona, Labreko and Dakpaan could respond well to minisetting.

6.1.3 Sprouting of minisetts from yam sections.

When dormancy is sufficiently broken, minisetts from different sections of Labreko, Pona and Dakpan yam varieties sprout uniformly.

6.14 Interaction of growth regulator levels and yam varieties.

NAA levels suppressed sprouting in the varieties while higher concentrations of ethrel induced more sprouting. Coconut milk showed interaction effect with only Pona and its effect was better than the control.

6.1.5 Interaction effect of growth regulator levels and yam sections.

NAA levels used suppressed sprouting in yam sections. Percent sprouting of minisetts from the head, middle and tail sections were in the ranges of 41-89, 63-95 and 44 -98 respectively. Minisetts from the head, and tail sections interacted significantly with coconut milk levels or concentrations (Experiment 1).

Lowest concentration of ethrel (100 ppm) induced more sprouting in the head and tail sections (Experiment 1). As the dormancy becomes sufficiently broken, higher concentrations of ethrel were required to make a difference between the ethrel levels and the control. Ethrel is therefore necessary in the sprouting process when dormancy is not sufficiently broken. The active growing points (head and tail sections) require smaller concentrations of ethrel as compared to the middle section.

6.1.6 Adventitious roots development.

Higher concentrations of ethrel and NAA induced more adventitious roots. Coconut milk was not different from the control in adventitious root promotion.

6.1.7 Percentage rotten yam minisetts.

The ends of the tubers experienced more rots than the middle section.

6.1.8 Stage of development of sprouted minisetts.

Though sprouted leafy minisetts (stage 3) performed well in vegetative growth, their survival percentage was less than those of Stages 1 and 2. Stage 2 minisetts produced the highest tuber yield. Hence prospective minisetts should be transplanted to the field at the Stage 2.

6.1.9 Growth regulators

Coconut milk induced higher vegetative and tuber yield than ethrel and the control. Consequently this may be the choice treatment for promoting minisett sprouting.

6.2 Recommendations

1. Many scientists have expressed doubt about the true identity of yam tubers referred to as Pona and Labreko on the market. While great efforts were made to get Pona and Labreko yam varieties from farmer's farm in Northern region it is recommended that the findings should be confirmed using well authenticated Pona and Labreko varieties.

2. Pricked and full season grown yam tubers are equally good for minisetting. They should be used for minisetting 5-6 months after harvesting, when dormancy is sufficiently released in the mother yam.

3. Coconut milk showed superiority in inducing both sprouting and field experiments. It is recommended that it could be used in yam minisett sprouting. It can be obtained freely from market women who sell coconut.

References

Acquah, E T. and Evange, N.W. (1994). An economic examination of constraints and opportunities in yam production in Fako Division Cameroon In: Ofori, F and Khan, S (Eds.) Tropical root crops in a developing economy. Proceedings of the 9 th symposium of International Society for Tropical Economy Crops, 20-26 October, 1991, Accra.

Agarwal, D.K, Sharal-Tiwari and Tiward, S (1995). Effect of genotypes and nutrient media on immature embryo of wheat. India Journal of Genetics and Plant Breeding. 1995, 55: 50-57.

Ametepe, K (2002).Sources of Rot Causing Organisms in Yam. Master of Philosophy Thesis, Faculty of Agriculture,
University of Ghana, Legon. Unpublished.

Amoako, K (2002) Influence of Potassium nitrate, Indole butryric acid and Ethrel on sprouting and field performance of minisetts of Pona and Punjo varieties of *Dioscorea rotundata.* Master of Philosophy Thesis, Faculty of Agriculture, University of Ghana, Legon. Unpublished.

Anonymous (2000). Ghana Export Promotion Council (GEPC) Annual Report, pp. 26.

Anonymous (2000b). Statistics, Research and Information Department (SRID) Annual Report. Ministry of Food and Agriculture, Ghana, pp. 2.

Anonymous (1996). Feasibility studies to set up Root and Tuber Improvement Programme, IFAD document, pp.25.

Campbell, J.S., Chukueke, V.O., Teriba, R.A and Hia-shu, H.V.S. (1962a). Some physiological investigations into the white Lisbon yam (*D. alata*). The breakage of the rest period in tubers by chemical means. Empire Journal of Exper. Agric. 30,108-114.

Campbell, J.S., Chukueke, V.O., Teriba, R.A and Hia-shu, H.V.S.(1962b). Some physiological investigations into the white Lisbon yam (*D. alata*) in Trinidad. Empire. Journal of Exper. Agric. 30,232-238.

Coursey, D.G.(1967). Yams, an account of the nature, origins, cultivation and Utilisation. Longmans, London.

Dansi, K., Mignouna, H.D., Zoundjihekpon, J., Sagare, A. and Asiedu,R. (1998). Varietal identification key of the cultivated yams (*D. cayensis /D. rotundata* complex) of Benin Republic. Plant Genetic Resources Newsletter No.116, 18-25.

Gamborg, O.L and Phillips, G.C (1995). Media preparation and handling In Plant Cell Tissue and Organ culture. Springer-Verlag, Berlin, Germany.

Gebremeskel,T and Oyewole D.B. (1987). Yam production in Africa and the world trend of vital statistics 1965-1984. Socio-economic unit, IITA Ibadan, Nigeria.

Geneve, R.L and Heuser, C.W. (1982). The effect of IAA, IBA, NAA and 2,4-D on root promotion and ethylene evolution in *Vigna radiata* cuttings. Journal of America Society of Horticultural Science 107 (2): 202-205.

Gregory, L.E (1968). Effect of Ethephon on breaking of dormancy in yam tubers Journal of Agric. Univ. of Puerto Rico, 56: 46-56

Gupta, S., Sobti, S.N. and Atal, C.K. (1979). Tuber dormancy in *Dioscorea composita*: effect of growth regulators. Indian Journal of Experimental Biology 17, 612-614

Gyansa-Ameyaw, C.A. (1987). Microsett and slip propagation of *Dioscorea rotundata* seed yam. PhD Thesis, University of Ghana pp 100-110.

Lev, L.S. and Shrivel, A.C.(1998). A trend analysis of yam production (1961-1996) In: L'igname, plante seculaire et culture d'avenir. Actes du seminaire Internationa CIRAD-INRA-ORSTOM-CORAAF,3-6 Jun 1997, CIRAD, Paris, France.

Mamaril, J.C., Paner, E.T., Trinidad, L.C., Palacpac, E.S., Cruz A. dela (1988). Effect of coconut milk on seedling growth of *Centrosema pubescens* Philippine Journal of Crop Science. 1988,13:1,1-7; 12.

Martin, F.W. (1976). Tropical yams and their potential. Series part 3. United States Agricultural Department handbook number 495. Washington D.C. USA.

Mensah, C. (2002). The effect of some pytohormones on sprouting of Pona yam minisetts. Master of Science Thesis, School of Agriculture Univ. Cape Coast. Unpublished.

Miege, J. (1957). Influence de quelques caracteres des tubercules semences cultivee et le rendement des ignames cultivees, J. Agric. Trop. Bot. Appl.,4,315-342.

Moore, R., Clark, W.D and Stern, K.S. (1995). Botany. W. C. Brown communications, inc. Dubuque, USA.

Mozie, O.C. (1987). The effect of 2,4-D and other plant growth regulators on sprout formation in *D. rotundata* (white yam) in storage. Tropical Science 27, 229-232.

Ndzana,X., Wutoh, J.G. and Onokpise, O.U.(1992). Relative distribution of hormones in yam in relation to uniform sprouting in yam minisetts. Proceedings of the Fourth Triennial Symposium of International Society for Tropical Root Crops-Africa Branch held in Kinshasha pp285-290.

Nweke, F.I., Ugwu,B.O., Asadu, C.L.A. and Ay, P. (1991). Production cost of yam-based cropping system of South-eastern Nigeria. RCMP research monograph No.6. IITA, Ibadan, Nigeria.

Nweke, F.I. and Okonkwo, S.N.C. (1981). Length of tuber dormancy in yam. Nigeria Journal of Agriculture Science. 3,153-156

Nyamekye, S.K (1999) Effect of Auxin treatment on root induction, growth and development of plantain. Master of philosophy thesis, University of Ghana, Legon.

Okoli, O.O. and Akoroda, M.O. (1995). Production of seed tubers for production of food yams in Africa. Journal of Root and Tuber Crops.Vol.1 28, 101-107

Okoli, O.O. (1980). Dry matter accumulation and tuber sprouting in yams (*Dioscorea* sp.). Experimental Agriculture 16,161-167.

Onwueme, I.C. (1978). The Tropical Tuber Crops. The Pitman press, Bath, Britain.

Onwueme, I.C. (1976). Performance of yam (*Dioscorea* sp.) setts planted without water. Journal of Agricultural Science. Cambridge, 85, 413-415.

Onwueme, I.C. (1975a). Influence of storage time on earliness of sprouting and tubering in *Dioscorea rotundata* yams, Journal of Agricultural science. Cambridge, 84, 503-505.

Onwueme, I.C. (1975b). Temperature effects on yam sprouting. Proc. of Agriculture Society, Nigeria, 12,18.

Onwueme, I.C. (1974). Leaf area development in white yam as affected by Kinetin and coconut milk. Nigeria Journal of Agric. 11:17-22

Onwueme, I.C. (1973). The sprouting process in yam (*Dioscorea* sp.) tuber pieces, Journal of Agricultural Science. Cambridge, 81,375-379.

Osagie, A.U. (1985). Lipoxygenase from white yam (*Dioscorea rotundata*) tubers. Nigeria Journal of Biochemistry 2, 62-69.

Otoo, J.A., Osiru, D.S.O., Ng, S.Y. and Hahn, S.K.(1985). Improved technology for seed yam production, IITA, Ibadan.

Passam, H.C, Wickham, L.D. and Wilson, L.A. (1982). Comparative observation on the polarity of sprouting of bulbils of *D. bulbifera* and *D. alata*. Analytical Botany 49, 359-366.

Purseglove, J.W. (1969). Tropical crops: dicotyledons. Longman Group Ltd., London, U.K.

Tetteh, J.P. and Saakwa, C (1991). Prospects and constraints to yam production in Ghana In: Tropical Root Crops in a Developing Economy. (Eds.) Ofori F and Hahn S.K. Proceedings of the 9th symposium of International Society for Tropical Economy Crops, 20-26 October 1991, Accra. pp 335.

Tiki, M. (1988). Analyse de l'effet des substances de croissance sur la dormance et la germination de semenceaux d'igname: cas de *Dioscorea rotundata* Poir.Dschang University Centre, Cameroon.

Wellington, M. A and Ahmad, M..H (1993). Gluthathione and beta-amylase, peroxidase and o-diphenolase activities during sprouting of minisett of yam *(D. sp)*.Journal of Science of Food and Agriculture. 1993,62:3,225-228

Appendix i

Analysis of Variance of percentage sprouting due NAA in Experiment 1					
	Mean Square for % sprouting 4-10 WAN				
Source of variation	d.f	4 wk	6 wk	8 wk	10 wk
Reps	2	28.70	100.93	100.00	136.1
Variety	2	14.81	212.04*	2158.30*	3633.3*
Error (a)	4	6.48	16.20	29.2	111.1
Concentration	3	20.68	304.63	8189.8*	15440.00*
Variety*Concentration	6	27.16	137.96	416.40*	1321.0*
Error (b)	18	13.89	103.70	117.0	210.8
Section	2	45.37*	178.70*	469.4*	11.1
Variety *Section	4	14.81	18.98	269.4	106.9
Concentration*Section	6	20.68	75.00*	131.2	191.4
Variety*Conc.*Section	12	27.16	59.72	296.0*	237.2
Error (c)	48	13.89	26.39	106.5	128.2

Appendix ii

ANOVA of percentage sprouting due coconut milk in Experiment 1					
Mean Square for % sprouting 4-10 WAN					
Source of variation	d.f.	4 wk	6 wk	8 wk	10 wk
Reps	2	12.96	96.30	335.20	568.5
Variety	2	24.07	401.85	1135.20	540.7
Error (a)	4	15.74	249.07	351.90	90.7
Concentration	1	16.67	1451.85*	2016.70	4816.7*
Variety*Concentration	2	38.89	135.19	405.60	288.9
Error (b)	6	14.81	146.30	431.50	720.4
Section	2	46.30	968.52*	646.30	51.9
Variety *Section	4	24.07	329.63*	804.60	1249.10*
Concentration*Section	2	16.67	579.63*	972.20	955.60*
Variety*Conc.*Section	4	38.89	112.96	469.4	152.8
Error (c)	24	14.81	55.56	222.2	188.00

Appendix iii

Analysis of Variance of percentage sprouting due ethrel in Experiment 1					
	Mean Square for % sprouting 4-10 WAN				
Source of variation	d.f	4 wk	6 wk	8 wk	10 wk
Reps	2	14.81	34.3.	36.1	38.3
Variety	2	59.26*	2706.5*	12786.1*	3623.3*
Error (a)	4	0.93	103.7	222.2	55.1
Concentration	3	11.11	741.7	702.2	1409.9
Variety*Concentration	6	14.81	199.1	709.6	518.2
Error (b)	18	19.14	270.7	229.3	491.4
Section	2	145.37*	1434.3*	2533.3*	428.7
Variety *Section	4	39.81	1041.2*	1369.4*	832.9*
Concentration*Section	6	8.33	275.0	264.2	494.1
Variety*Conc.*Section	12	12.04	178.2	463.3	448.3
Error (c)	48	15.74	164.8	266.2	258.3

Appendix iv

Analysis of Variance of mean effects of growth regulators on percentage sprouting in Experiment 1					
	Mean Square for % sprouting 4-10 WAN				
Source of variation	d.f	4 wk	6 wk	8 wk	10 wk
Reps	2	29.17	179.6	176.4	478.2
Variety	2	59.72	2517.1	11393.1	8758.8
Error (a)	4	11.81	32.4	42.4	103.9
Growth regulators (GR)	3	15.64	2817.3	24171.2	42344.9
Variety*GR	6	41.41	507.9	1921.7	570.9
Error (b)	18	13.07	187.2	245.9	430.8
Section	2	234.72	2200.5	2654.2	936.6
Variety *Section	4	46.53	744.9	774.3	810.2
GR*Section	6	11.47	365.3	566.7	384.5
Variety*GR.*Section	12	36.55	316.5	611.9	503.2
Error (c)	156	18.04	121.3	223.6	294.3

Appendix v

ANOVA of number of adventitious roots due NAA inExperiment 1					
	Mean Square for adventitious number, 4-10 WAN				
Source of variation	d.f	4 wk	6 wk	8 wk	10 wk
Reps	2	0.35	1.07	6.61	5.09
Variety	2	250.05*	265.73*	798.56*	714.11*
Error (a)	4	1.27	3.30	7.32	0.92
Concentration	3	266.55*	381.38*	383.07*	341.23*
Variety*Concentration	6	32.62*	31.21*	59.70*	48.19*
Error (b)	18	2.03	3.13	4.60	3.92
Section	2	2.89*	3.54*	4.91*	6.91*
Variety *Section	4	1.79*	0.40	1.44	4.78*
Concentration*Section	6	1.65*	0.48	0.53	1.60
Variety*Conc.*Section	12	1.49*	0.76*	0.72	1.06
Error (c)	48	0.21	0.37	0.57	1.74

Appendix vi

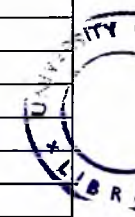
ANOVA of number of adventitious roots due coconut milk in Experiment 1					
	Mean Square for adventitious number, 4-10 WAN				
Source of variation	d.f	4 wk	6 wk	8 wk	10 wk
Reps	2	0.29	1.60	5.65	5.10
Variety	2	2.34	15.53	50.26	32.76
Error (a)	4	1.13	4.82	7.45	6.94
Concentration	1	0.43	0.03	0.81	3.18*
Variety*Concentration	2	0.57	1.49	1.26	2.76*
Error (b)	6	0.60	1.91	2.92	0.33
Section	2	0.16	0.27	0.33	0.31
Variety *Section	4	0.17	0.13	0.12	0.71
Concentration*Section	2	0.01	0.06	0.54	1.42
Variety*Conc.*Section	4	0.13	0.55*	0.34	1.63*
Error (c)	24	0.08	0.09	0.27	0.57

Appendix vii

ANOVA of number of adventitious roots due ethrel in Experiment 1					
Mean Square for adventitious number, 4-10 WAN					
Source of variation	d.f	4 wk	6 wk	8 wk	10 wk
Reps	2	1.84	8.89	3.72	4.35
Variety	2	10.02*	29.92	41.72	37.81*
Error (a)	4	0.87	4.91	9.09	3.95
Concentration	3	2.76*	9.47*	12.25*	6.48*
Variety*Concentration	6	2.73*	3.47	3.56*	2.42*
Error (b)	18	0.68	1.60	1.26	0.76
Section	2	2.54*	0.59*	1.50*	1.88*
Variety *Section	4	0.21	0.38*	0.24	0.29
Concentration*Section	6	0.17	0.07	0.33	1.14*
Variety*Conc.*Section	12	0.25	0.24*	0.25	0.98
Error (c)	48	0.11	0.12	0.26	0.40

Appendix viii

Analysis of Variance of percentage sprouting due ethrel in Experiment 2			
Mean Square for % sprouting, 4-6 WAN			
Source of variation	d.f	4 wk	6 wk
Reps	2	1223.1	62.04
Variety	2	373.10	114.81
Error (a)	4	148.10	89.81
Concentration	3	830.90*	396.30*
Variety*Concentration	6	718.80*	144.44*
Error (b)	18	253.40	38.58
Section	2	11848.1*	1248.15*
Variety *Section	4	406.5*	134.26
Concentration*Section	6	282.70	25.93
Variety*Conc.*Section	12	92.90	60.19
Error (c)	48	227.80	56.02



Appendix ix

Analysis of Variance of percentage sprouting due coconut milk in Experiment 2			
Mean Square for % sprouting, 4-6 WAN			
Source of variation	d.f	4 wk	6 wk
Reps	2	207.4	68.52
Variety	2	2451.9*	290.74*
Error (a)	4	329.6	15.74
Concentration	1	1157.4*	1451.85*
Variety*Concentration	2	118.5	35.19
Error (b)	6	59.3	29.63
Section	2	5957.4*	401.85*
Variety *Section	4	629.6*	149.07*
Concentration*Section	2	790.7*	12.96
Variety*Conc.*Section	4	101.9	4.63
Error (c)	24	188.0	50.93

Appendix x

Analysis of Variance of mean effects of growth regulators on percentage sprouting in Experiment 2			
Mean Square for % sprouting 4-6 WAN			
Source of variation	d.f	4 wk	6 wk
Reps	2	29.17	179.6
Variety	2	59.72	2517.1
Error (a)	4	11.81	32.4
Growth regulators (GR)	2	15.64	2817.3
Variety*GR	4	41.41	507.9
Error (b)	12	13.07	187.2
Section	2	234.72	2200.5
Variety *Section	4	46.53	744.9
GR*Section	4	11.47	365.3
Variety*GR.*Section	8	36.55	316.5
Error (c)	90	18.04	121.3

Appendix xi

ANOVA of number of adventitious roots due ethrel in Experiment 2			
Mean Square for adventitious number, 4-6 WAN			
Source of variation	d.f	4 wk	6 wk
Reps	2	0.28	2.08
Variety	2	1.65	0.81
Error (a)	4	0.31	2.75
Concentration	3	2.55*	1.89
Variety*Concentration	6	0.92	1.40
Error (b)	18	0.43	1.06
Section	2	2.20*	0.79
Variety *Section	4	3.36*	1.19*
Concentration*Section	6	1.14	0.36
Variety*Conc.*Section	12	0.76	0.67
Error (c)	48	0.60	0.36

Appendix xii

ANOVA of number of adventitious roots due to coconut milk in Exp. 2			
Mean Square for adventitious number, 4-6 WAN			
Source of variation	d.f	4 wk	6 wk
Reps	2	0.31	0.34
Variety	2	1.95*	1.03*
Error (a)	4	0.06	0.13
Concentration	1	0.16	0.01
Variety*Concentration	2	0.18	0.20
Error (b)	6	0.32	0.56
Section	2	0.002	0.25
Variety *Section	4	0.73	0.59
Concentration*Section	2	0.16	0.06
Variety*Conc.*Section	4	0.34	0.12
Error (c)	24	0.46	0.36

Appendix xiii

ANOVA of percentage sprouting, rotten and non- sprouting in Experiment 3				
Mean Square values, 6 WAN				
Source of variation	d.f	% sprouting	% rotten	% non-sprouting
Reps	2	34.77	22.22	1.44
Variety	1	1936.01*	66.67	1284.16*
Error (a)	2	87.86	32.09	27.37
Growth regulator (GR)	2	469.34*	148.76*	91.71*
Variety* G.R	2	87.86	11.73	60.08
Error (b)	8	39.09	33.33	40.64
Section	2	71.81	222.84*	95.27*
Variety *Section	2	339.71*	68.52*	205.14*
GR*Section	4	286.63*	86.42*	184.77*
Variety* G.R.* Section	4	71.19	37.65	56.99
Error (c)	24	37.86	16.46	21.40

Appendix xiv

Analysis of Variance of numbers of nodes and leaves, vine height, tuber weight and percentage survival in Experiment 4.						
Mean Square values						
Source of variation	d.f.	Number of nodes	Number of leaves	Vine height	Avg. tuber weight/ trt.	Percent survival
Reps	2	7.40 (0.127)	20.40 (0.197)	4.43	0.006	259.5 (0.006)
Stages	2	1581.48* (19.60)	5563.29* (34.489)	5162.40*	0.365*	796.2* (0.365)
Error (a)	4	2.13 (0.051)	13.20 (0.134)	30.32	0.011	115.9 (0.011)
Variety	2	127.11* (1.594)	552.04* (3.575)	470.13*	0.200*	1007.8* (0.200)
Stages *Variety	4	21.49 * (0.393)	103.52 (0.969)	141.17*	0.009	433.4 (0.009)
Error (b)	12	5.88 (0.071)	18.22 (0.113)	22.48	0.005	254.5 (0.005)
Growth regulators (GR)	2	6.86 (0.092)	34.14 (0.277)	46.30*	0.018*	123.5 (0.018)
Stages *GR	4	4.82 (0.062)	25.16 (0.210)	26.06	0.004	161.2 (0.004)
Variety* GR	4	2.31 (0.034)	10.37 (0.079)	8.18	0.001	157.5 (0.001)
Stages *Variety * GR	8	2.29 (0.035)	5.75 (0.51)	4.65	0.001	416.4 (0.001)
Error (c)	36	3.68 (0.043)	13.02 (0.093)	12.92	0.003	201.6 (0.003)

Appendix xv

Analysis of Variance of numbers of nodes and leaves, vine height, tuber weight and percentage survival in Experiment 5.

		Mean Square values				
Source of variation	d.f.	Number of nodes	Number of leaves	Vine height	Avg. tuber weight/ trt.	Percent survival
Reps	2	1.87 (0.030)	16.29 (0.138)	477	0.00035	27.80 (0.014)
Variety	2	13.21 (0.198)	54.72 (0.400)	435.92*	0.0732	2.81 (0.001)
Error (a)	4	8.08 (0.131)	48.31 (0.406)	5.644	0.0028	40.82 (0.019)
Growth regulators (GR)	1	0.03 (0.001)	0.001 (0)	21.51	0.0001	2.77 (0.001)
Variety*GR	2	1.25 (0.021)	3.23 (0.031)	4.79	0.00019	6.20 (0.002)
Error (b)	6	1.73 (0.028)	7.77 (0.066)	1.53	0.000357	5.99 (0.003)
Concentration (Conc.)	5	1.50 (0.024)	3.91 (0.322)	4.66	0.00012	16.59 (0.007)
Variety *Conc.	10	0.46 (0.008)	3.53 (0.030)	2.33	0.00031	11.90 (0.005)
Error (c)	21	1.31 (0.022)	5.29 (0.045)	3.30	0.00051	13.18 (0.006)

Analysis of Variance of numbers of nodes and leaves, vine height, tuber weight and percentage survival in Experiment 6.

		Mean Square values				
Source of variation	d.f.	Number of nodes	Number of leaves	Vine height	Avg. tuber weight/ trt.	Percent survival
Reps	2	0.98 (0.017)	8.33 (0.190)	7.416	0.00164	83.39 (0.023)
Variety	1	0.58 (0.010)	1.07 (0.071)	6.000	0.00002	0.46 (0.0002)
Error (a)	2	0.35 (0.006)	22.78 (0.370)	5.936	0.00100	4.24 (0.0012)
Growth regulators (GR)	2	0.20 (0.004)	8.03 (0.186)	1.194	0.00028	0.39 (0.0002)
Variety*GR	2	0.08 (0.001)	16.33 (0.293)	6.427	0.00074	6.02 (0.0019)
Error (b)	8	0.63 (0.011)	15.66 (0.279)	3.529	0.00112	10.37 (0.0031)
Section	2	0.07 (0.001)	17.73 (0.317)	0.659	0.00046	17.17 (0.0051)
Variety *Section	2	0.25 (0.004)	14.27 (0.268)	5.387	0.00015	16.46 (0.0052)
GR*Section	4	0.15 (0.003)	8.67 (0.196)	0.710	0.00044	5.47 (0.0013)
Variety* GR*Section	4	0.17 (0.003)	7.12 (0.174)	2.726	0.00056	3.60 (0.0012)
Error (c)	24	0.41 (0.007)	15.76 (0.286)	2.118	0.00050	18.02 (0.0054)