Mission Report
Pachyfhizus project
Depaftement of Botany
FBC / CERAAS

CENTRE D'ETUDES REGIONAL

POUR L'AMELIORATION

DE L'ADAPTATION A

LA SECHERESSE.

13th April - 12th May 1997

Ebenezer J. D. Belford
Departement of Botany
Fourah Bay College
University of Sierra Leone
Freetown, Sierra Leone

ISRA • CNRA
B.P. 53 BAMBEY SENEGAL
TEL. (221) 73.61.97 • 73.60.50
FAX (221) 73.61.97 • 73.6052

Mission Report
Pachyrhizusproject
Departement of Botany
FBC / CERAAS

13th April - 12th May 1997

Ebenezer J. D. Belford
Departement of Botany
Fourah Bay College
University of Sierra Leone
Freetown, Sierra Leone

TABLE OF CONTENTS

Acknowledgement

All praise and thanks to God who has made it possible for me to accomplish this mission. I greatly appreciate the kind auspices of Dr. Harold Roy-Macauley, Director of CERAAS, who has fascilited this visit and enabled me, in all respects, to have a pleasant stay at CERAAS.

I would also like, on behalf of The Department of Botany, Fourah Bay College, University of Sierra Leone, to thank Dr. Daniel Annerose (former Director of CERAAS) who with Dr. Harold Roy-Macauley initiated the link programme between The Department of Botany and CERAAS, which incorporates the ***Pachyrhizus*** research programme.

My heartly thanks and deep gratitude goes to the entire CERAAS team (scientific, technical and administrative support staff) and fellow visiting scientists, for their diligence and patience excercised during my stay. Special thanks goes to Dr, Macsumba Diouf, Dr. Benoît Sarr, Mr. Omar Diouf and Mr David Boggio, for the many useful information they were able to pass on to me and their excellent cooperation in seeing that my goals were achieved. The intellectual atmosphere of CERAAS is keen, warm and challenging. It is a model of the multidisciplinary centres Africa needs in tackling her developmental goals especially as far as agriculture is concerned.

Much thanks and appreciation goes to Prof. N.H.A. Cole, Head of The Department of' Botany, for kindly offering me the opportunity to work on the ***Pachyrhizus*** project and also to Dr. A.B. Karim for his supervision and support during the first phase of the research work.
"Merci à tous'.

INTRODUCTION

One of CERAAS's mandates accorded to it by member countries of the Conference of Heads of Agricultural Research in West and Central Africa (CORAF) and the Interstate Committee for Fighting against Drought in the Sahel (CILSS) is tu contribute to the development of the research capacities of research institutions of these countries, especially in the area of improvement of plant adaptation to drought.

The cooperation between the Department of Botany, Fourah Bay College, University of Sierra Leone and the Regional Centre for Studies on the Improvement of Plant Adaptation to Drought (CERAAS) Senegal, is an example of the efforts deployed by CERAAS to respect its mandate. This cooperation initiated by Dr Harold Roy-. Macauley, a member of staff of the Department of Batany and Dr Daniel Annerose, then Director of CERAAS incorporates two aspects :

- the rationalisation of the use of human ressources in the sub-region, with the detachment of Dr Harold Roy-Macauley to CERAAS as regional expert under CORAF in 1995, to help re-inforce the expertise that is being developed by CERAAS in the area of biochemistry of plant adaptation to drought,
- the development of the research capacity of member countries of CORAF and CILSS, by the joint *Pachyrhizus* project between The Department of Botany and CERAAS.

Dr Harold Roy Macauley has now risen to the position of Director of CERAAS with the departure of Dr Daniel Annerose who has been recalled to his institution of origin, CIRAD, to take up a higher position of Delegate to Africa and countries of the Indain Ocean.

CERAAS's main objective is to improve the adaptation of cultivated species to drought by varietal creation. One of its specific objectives is to introduce crops of economic value in the Sahel with the aim of improving the biodiversity in this zone. Pachyrhizus or yam bean is a legurninous tuber crop with excellent multipurpose qualities and uses. The tubers have a high nutritional value for human consumption, the leaves could be used as fodder for cattle feed, the pods, due to the presence of rotenone, could be used as an insecticide and it is a nitrogen fixing leguminous plant capable of improving soil fertility and adapting to different ecological zones.

CERAAS has therefore associated to its numerous research activities, work on *Pachyrhizus* with the aim of introducing this crop in the Sahelian region. Their approach to research work conducted on this crop is that of a multidisciplinary one rnvolving agronomical and physiological aspects. Important results from research conducted at CERAAS have shown the potential of this crop to adapt to conditions in the Sahelian zone. Though high tuber yields have been obtained, research on the physiology of this crop in the arid zone is still in progress with the aim of improving adaptation of this crop to drought.

An alternative crop for the farming community in Sierra Leone, where the need for ntroducing, developing and promoting new multipurpose crops of potential economic mportance should be welcomed. This would help alleviate the apparent food shortages. The research experience on *Pachyrhizus* at CERAAS has stimulated the dea of introducing this crop in Sierra Leone. The development of a joint research project on *Pachyrhizus* in Sierra Leone will facilitate its implementation, The project will serve not only to facilitate the introduction of this crop into Sierra Leone but wili

also result in a Masters thesis entitled 'Evaluation of the Tuber Production Potential of the Yam Bean (*Pachyrhizus erosus* (L) Urban) in Sierra Leone'.

This mission to CERAAS is the first of two visits programmed, to acquire the expertise needed in carrying out research on this crop. The objectives of this one month training programme are :

- to perform statistical analysis on the first set of data collected from the preliminary research work done on 15 varieties of Pachyrhizus in Sierra Leone during 1996,
- to acquire techniques and methods used in the study for improving the production of this crop in Sierra Leone,
- to review research work conducted on *Pachyrhizus* at CERAAS,
- to formulate the protocol for the next set of experiments to be conducted this year

I arrived in Dakar, Senegal on the 13th April, 1997 and proceeded to Bambey, where CERAAS is located, 120 km from Dakar. On my arrival I was first of all received by the Director, Dr Harold Roy-Macauley and then officially introduced to members of staff of CERAAS on the 1414197.

PLAN OF ACTIVITIES REALISED

A plan of the activities to be realised during my one month stay at CERAAS was elaborated as follows :

Week 1(14/4/97 - 20/4/97) : Data processing and analysis of preliminary research work done on Pachyrhizus in Sierra Leone during 1996.

Week 2 (21/4/97 - 27/4/97) :Techniques and methods use in the measurement of soil-plant water relations.

Week 3 (28/4/97 - 04/5/97) : Documentation, bibliography and literature review.

Week 4 (05/5/97 - 11/5/97) : Formulation of the experimental protocol for the second phase of the research and writing up of mission report.

DATA PROCESSING AND ANALYSIS

The success of an experiment depends on a well organised experimental design, the correct choice of data processing and analysis methods and the proper interpretation of results. The objective of this activity was geared towards the effective use of various computer analytical software in data processing and analysis.

The work was supervised by David Boggio, Biometrician/Statistician at CERAAS. The importance of experimental designs and methods related to biometry was discussed. A review of the experimental design used and the results obtained from the preliminary research was made. The choice of statistical analysis that should be applied was based on this review.

To begin with, an introductory session on the use of various statistical, tabloid, and word processing software (MSTAT 4.0, SAS 6.11, EXCEL 5.0 and WORD 6.0) was realised.

MSTAT 4.0 : is used for statistical analysis. This package consists of a main program and a series of subprograms that aid in designing experiments, data transformation and analysis.

SAS 6.11 : (Statistical Analysis Software) this program is also used for statistical and correlation analysis. It is quite sophisticated and requires basic skills in programming. Further training on this program is recommended.

EXCEL 5.0 : is used for data input, data transformation, and drawing of graphs.

WORD 6.0 : is used to edit data in text format, arrange them into tables and for report writing.

MSTAT 4.0 was used to analyse the data from the preliminary research work. Results were assessed using the analysis of variance (ANOVA) and the Duncan's multiple range test.

TECHNIQUES AND METHODS USE IN THE MEASUREMENT OF SOIL-PLANT WATER RELATIONS

For proper crop management strategies and for obtaining greater productivity a knowledge of the physiological processes operating in a crop is essential. The airn of this activity was to acquire the concepts, techniques and methods used in the measurement of soil-plant water relations. This programme was supervised by Drs. Macoumba Diouf (Ecophysiologist) and Benoît Sarr (Bioclimatologist). The practical aspects of this activity was realised in the field on ongoing experiments.

The following parameters were studied :

Soil Water Status

Three types of techniques were demonstrated :

- Gravimetry,
- Neutron probe (Troxler 4300),
- Thermocouples psychrometers (PCT-55 chamber) which is coupled to a psychrometer-microvoltmeter PR-55 for obtaining readings.

Gravimetry

This is a quantitative method used to measure the amount of water in the soil. It is the ratio of the difference between the fresh weight and dry weight of the soil expressed as a percentage of the dry weight. As the unit of water should be volumetric, the value obtained is multiplied by the soil density and expressed in $g.cm^{-3}$.

Neutron probe

It is used to measure soil moisture content. It operates on the principle of neutron moderation. Neutrons released from the radioactive source (probe) are slowed down by hydrogen atoms of water molecules. The more humid the soil is the greater the amount of hydrogen atoms and the more neutrons are slowed down. The values obtained are converted to soil water content values by using the equation obtained from a standard calibration curve generated from a plot of gravimetric soil water content against neutron probe measurements for both dry and humid soil at field

capacity. The advantage with this method is that the water content at a particular point in the field and at various depths, could be measured over a period of time.

Thermocouple psychrometer

It is used to measure water potential. The water content of the sample is allowed to equilibrate with that of the air vapour. This period is called the equilibrium time and depends therefore on the water status of the sample. The greater the amount of water in the sample the longer the equilibrium time. After equilibrium has been achieved, the thermocouple is cooled below the dew point by means of the Peltier Effect, resulting in condensation of the air vapour to form a film of water upon the junction surface. The energy used to evaporate the water condensed on the junction surface, recorded in microvolts on the micovoltimeter, corresponds to the water potential of the air vapour and consequently that of the sample. The reading in microvolts is then converted to bars or MPa.

Plant Water Status

Five different techniques are used in CERAAS as follows :

- Relative water content
- Pressure bomb (PWSC model 3005)
- Hydraulic press (Campbell J14)
- Thermocouples psychrometers (C-30, C-52, L-51 and PST-55 chambers)
- Vapour pressure osmometer (Wescor 5500)

Relative water content (R WC)

It is a quantitative mothod. The initial fresh weight (FW) and the water content of the leaf at turgidity (TW) are compared on a percentage basis. The type of leaf tissue and the sampling time are equally important in obtaining reliable results. At CERAAS measurements are usually performed on the third leaf of the plant counting from the summit of the main branch because it is well developed, physiologically functionai and has not yet started to senesce. The fresh weight is immedately recorded after ihe leaf sample is obtained. The leaf sample is then left to float on water to bring to full turgid weight for about 3-4 hours, depending on the plant material. The same leaf sample is allowed to dry in an oven at 85°C for 24 hours and the dry weight (DW) is measured.The RWC can then be calculated using the formula :

$$RWC = [(FW-DW) / (TW-DW)] \times 100$$

Pressure bomb or pressure chamber

It is used to measure total leaf water potential. The leaf petiole is quickly cut with a sharp scalpel and placed in a pressure chamber with the cut end of the petiole or stem just protruding from the chamber through a rubber gland which is used to seal the chamber. The pressure in the chamber is gradually increased by compressed air, nitrogen or another inert gas from a cylinder, until the sap just returns to the severed ends of the xylem vessels. This pressure required to push the sap to the severed end of the petiole corresponds to the water potential of the leaf, expressed in bars or MPa.

The Hydraulic press or leaf press

It is a modification of the pressure chamber technique. A leaf or disc is placed in a chamber in which the pressure is provided by a hydraulic pump. The pump presses the leaf between a flexible membrane and the transparent plastic lid of the chamber. The pressure required to induce a colour change in the leaf and to express water from the cut petiole or cut edge of the disc is taken as an index of the leaf water potential, expressed in pound square inch (psi).

Thermocouples psychrometers

Various chambers could be used (C-30, C-52, L-51 and PST-55 chambers). The principle has been exposed above.

The Vapour pressure osmometer

It is used to measure osmotic potential. Before measurements are made, the turgor pressure must be reduced to zero, usually by killing the tissue by freezing. The sample is sealed in a syringe and allowed to freeze at a temperature of -80°C and then thawed for 60 minutes to break down the membranes. The sap is squeezed out by the use of the syfinge on to a filter papef disc in the sample holder of the osmometer chamber and measurements of osmotic potential taken after equilibration. It is expressed in MPa.

Gaseous Exchange

Three types of techniques were demonstrated :

- Steady state porometer (LICOR, LI-1600)
- Leaf chamber analysis system (ADC, LCA-3)
- Infrared thermometer (Telatemp, AG42)

Steady state porometer

It is used to measure stomatal conductance, leaf transpiration, leaf temperature, relative humidity and photosynthetic active radiation (PAR). It measures water loss from a leaf placed in a cuvette by measuring the flow rate of dry air necessary ta maintain a constant relative humiclity inside the cuvette. The ambient relative humidity is used as a null point, and dry air is injected into the cuvette at a rate which is just sufficient to balance the transpirational water flux out of the leaf.

Leaf chamber analysis system

This system operates in a similar manner to the steady state porometer and measures the same types of parameters. The advantage with this system is that it also measures the photosynthetic rate of leaves by an infrared gas analyser (CO_2/H_2O) and therefore gives a valuable picture of the state of the plant.

Infrared thermometer

It is use to measure canopy or foliage temperature. It gives the difference between canopy and air temperature. These measurements are incorporated into crop wates stress indices that have been related to soil water availability and leaf water potential.

Growth Measurements

Three types of techniques are used in CERAAS as follows :

- Area meter (Delta-T MK2)
- Leaf Area Meter (LAI-2000)
- Sunfleck Ceptometer

The Area Meter

It is used for measuring leaf area and root length. This is a destructive method as both leaves and roots must be harvested in order to obtain measurements. Since most agromorphological measurements are coupled with physiological ones which are non-destructive, CERAAS is now using a portable Area Meter model LI-3000.

The Leaf Area Meter

It is used to measure leaf area index and other canopy structure attributes from radiation measurements made with a 'fish-eye' optical sensor. The measurements made above the canopy are to deterrnine canopy light interception at 5 angles, from which LAI is computed using a model of radiative transfer in vegetative canopies.

The Sunfleck Ceptometer

It is also used to measure leaf area index. It emits radiations that goes through the canopy of the crop. The amount of radiation that goes through depends on the cover and level of the crop. The rate of growth of different plots can be compared using this index,

The Department of Botany, FBC stands to benefit from CERAAS's existing research infrastructure and equipment for research work.

DOCUMENTATION

Review of work done on *Pachyrhizus erosus* at CERAAS

The aim of this activity was to review the work done on *Pachyrhizus*. I had a detailed discussion with Mr. Omar Diouf the soientist responsible for the yam bean project at CERAAS, on the cultivation of the crop in Senegal, during which he mentioned some important points.

He expressed concern on the need to increase the dry matter content of the tubers. It was observed that the high percentage of water in the tubers reduced the cooking quality. The farmers therefore expressed the need to reduce the water content of the tubers. The tubers were thus left in the field for a longer period after the rains. This effort did not bring satisfactory results as the size of the tubers increased due to an increase in fibre content which also reduced cooking quality.

Though water requirement studies have not yet been conducted, it has however been estimated from the trials conducted so far at CERAAS that this crop needs about about 600mm of water, well distributed in 4 months, for obtaining good yields. The crop exhibits good growth plasticity to complete the vegetative phase and goes into the generative phase at a time when there is still enough water for assimilate deposition into the sink. Sowing before May favours fodder production after which seed and tuber production is favoured with a corresponding floral pruning.

The Hydraulic press or leaf press

It is a modification of the pressure chamber technique. A leaf or disc is placed in a chamber in which the pressure is provided by a hydraulic pump. The pump presses the leaf between a flexible membrane and the transparent plastic lid of the chamber. The pressure required to induce a colour change in the leaf and to express watet from the cut petiole or cut edge of the disc is taken as an index of the leaf water potential, expressed in pound square inch (psi).

Thermocouples psychrometers

Various chambers could be used (C-30, C-52, L-51 and PST-55 chambers). The principle has been exposed above.

The Vapour pressure osmometer

It is used to measure osmotic potential. Before measurements are made, the turgor pressure must be reduced to zero, usually by killing the tissue by freezing. Ths sample is sealed in a syringe and allowed to freeze at a temperature of -80°C anc then thawed for 60 minutes to break down the membranes. The sap is squeezed out by the use of the syringe on to a filter paper disc in the sample holder of the osmometer chamber and measurements of osmotic potential taken after equilibration. It is expressed in MPa.

Gaseous Exchange

Three types of techniques were demonstrated :

- Steady state porometer (LICOR, LI-1600)
- Leaf chamber analysis system (ADC, LCA-3)
- Infrared thermometer (Telatemp, AG42)

Steady state porometer

It is used to measure stomatal conductance, leaf transpiration, leaf temperature, relative humidity and photosynthetic active radiation (PAR). It measures water loss from a leaf placed in a cuvette by rneasuring the flow rate of dry air necessary to maintain a constant relative humidity inside the cuvette. The ambient relative humidity is used as a null point, and dry air is injected into the cuvette at a rate which is just sufficient to balance the transpirational water flux out of the leaf.

Leaf chamber analysis system

This system operates in a similar manner to the steady state porometer and measures the same types of parameters. The advantage with this system is that it also measures the photosynthetic rate of leaves by an infrared gas analyser (CO_2/H_2O) and therefore gives a valuable picture of the state of the plant.

Infrared thermometer

It is use to measure canopy or foliage temperature. It gives the difference between canopy and air temperature. These measurements are incorporated into crop water stress indices that have been related to soil water availability and leaf water potential.

Growth Measurements

Three types of techniques are used in CERAAS as follows :

- Area meter (Delta-T MK2)
- Leaf Area Meter (LAI-2000)
- Sunfleck Ceptometer

The Area Meter

It is used for measuring leaf area and root length. This is a destructive method as both leaves and roots must be harvested in order to obtain measurements. Since rost agromorphological measurements are coupled with physiological ones which are non-destructive, CERAAS is now using a portable Area Meter model U-3000.

The Leaf Area Meter

It is used to measure leaf area index and other canopy structure attributes from radiation measurements made with a 'fish-eye' optical sensor. The measurements made above the canopy are to determine canopy light interception at 5 angles, from which LAI is computed using a model of radiative transfer in vegetative canopies.

The Sunfleck Ceptometer

It is also used to measure leaf area index. It emits radiations that goes through the canopy of the crop. The amount of radiation that goes through depends on the cover and level of the crop. The rate of growth of different plots can be compared using this index.

The Department of Botany, FBC stands to benefit from CERAAS's existing research infrastructure and equipment for research work.

DOCUMENTATION

Review of work done on ***Pachyrhizus erosus at CERAAS***

Phe aim of this activity was to review the work done on *Pachyrhizus.* I had a detailed discussion with Mr. Omar Diouf the scientist responsible for the yam bean project at CERAAS, on the cultivation of the crop in Senegal, during which he mentioned some important points.

He expressed concern on the need to increase the dry matter content of the tubers. It was observed that the high percentage of water in the tubers reduced the cooking quality. The farmers therefore expressed the need to reduce the water content of the lubers The tubers were thus left in the field for a longer period after the rains. This effort did not bring satisfactory results as the size of the tubers increased due to an increase in fibre content which also reduced cooking quality.

'Phough water requirement studies have not yet been conducted, it has however been estimated from the trials conducted so far at CERAAS that this crop needs about about 600mm of water, well distributed in 4 months, for obtaining good yields. The crop exhibits good growth plasticity to complete the vegetative phase and goes into the generative phase at a time when there is still enough water for assimilate deposition into the sink. Sowing before May favours fodder production after which seed and tuber production is favoured with a corresponding floral pruning.

Seeds must be stored under low humidity and low temperature conditions, preferably in a refrigerator. However, they should not be frozen. They should be exposed ta high temperature before planting.

The following references were consulted :

Annerose, D.J.M. and Diouf, O., 1994. Some aspects of response to drought in the genus ***Pachyrhizus*** Rich. ex DC Pp. 199-214 in Proceedings of the First International Symposium on Tuberous Legumes (M. Sorensen, ed.), Guadeloupe, FWI, April 21-24,1992. Jordbrugsforlaget, Copenhagen, Denmark.

Annerose, D.J.M. and Diouf, O., 1994. Studies on the adaptation to drought of ***Pachyrhizus spp.*** in semi-arid zones. Paper presented at the Tuber legumes workshop in Mexico, 1996.

Diouf, O., Roy-Macauley, H. and Annerose, D.J.M., 1995. Tuber-pod competitiort and drouhgt respone in Yam bean ***(Pachyrhizus spp.).*** In Proceedings of Interdrought 96. Montpellier.

Fukuda, S. and R.E. Paull. 1994. Yam bean (Pachyrhizus erosus (L.) Urban) production in Hawaii. Pp. 283-286 in Proceedings of the First International Symposium on Tuberous Legumes (M. Sorensen, ed.), Guadeloupe, FWI, April 21-24, 1 992. Jordbrugsforlaget, Copenhagen, Denmark.

Halafihi, M., M. Grum, 0. Stölen and M. Sorensen. 1994. Biological nitrogen fixation in Pachyrhizus Rich. ex DC. Pp. 215-226 in Proceedings of the First Internationar Symposium on Tuberous Legumes (M. Sorensen, ed.), Guadeloupe, FWI, April 21-24,1992. Jordbrugsforlaget, Copenhagen, Denmark.

Hartmann, R.W. 1994. Performance of interspecific hybrid yam bean progeny (Pachyrhizus erosus x ahipa) in Hawaii. Pp. 321-328 in Proceedings of the First International Symposium on Tuberous Legumes (M. Sorensen, ed.), Guadeloupe, FWI, April 21-24, 1992. Jordbrugsforlaget, Copenhagen, Denmark.

Kjaer, S. and M. Sorensen. 1994. Symbiotic nitrogen fixation in Pachyrhirus anipa (Wedd.) Parodi. Pp 227-236 in Proceedings of the First International Symposium on Tuberous Legumes (M. Sorensen, ed.), Guadeloupe, FWI, April 21-24, 1992. Jordbrugsforlaget, Copenhagen, Denmark.

Ratanadilok, N. and S. Thanisawanyangkura. 1994. Yam bean (Pachyrhizus erosus (L.) Urban) status and its cultivation in Thailand. Pp. 305-314 in Proceedings of the First International Symposium on Tuberous Legumes; Guadeloupe, FWI, 21-24 April 1992. (M. Sorensen, ed.) Jordbrugsforlaget, Kobenhavn.

Sirju-Charran, G., A. Edwards-Henry, C.R. McDavid, N. Lackhan and A. Maxwell. 1994 Research initiatives at the Univ. West Indies towards the identification of parameters for a Pachyrhizus Rich. ex DC. crop ideotype. Pp. 249-256 in Proceedings of the First International Symposium on Tuberous Legumes; Guadeloupe, FWI, 21-24 April 1992. (M. Sorensen, ed.) Jordbrugsforlaget, Kobenhavn.

Sorensen, M. 1988. A taxonomic revision of the genus ***Pachyrhizus*** (Fabaceae-Phaseoleae). - Nord. J. Bot. 8(2):167-l 92. Copenhagen.

Sorensen, M. 1994. Review of the yam bean project 1982-92. Pp. 47-54 in Proceedings of the First International Symposium on Tuberous Legumes;

Guadeloupe, FWI, 21-24 April 1992. (M. Sorensen, ed.) Jordbrugsforlaget, Kobenhavn.

Sorensen, M. 1996. Yam bean (*Pachyrhizus* DC.). Promoting the conservatuon and use of underutilized and neglected crops. 2. Institute of Plant Genetics and Crop Plant Research, Gatersleben / International Plant Genetic Resources Institute, Rome.

Stolen, O. 1994. Introduction, Improvement and Marketing of New Crops. Pp. 37-46 in Proceedings of the First International Symposium on Tuberous Legumes; Guadeloupe, FWI, 21-24 April 1992. Jordbrugsforlaget, Copenhagen, Denmark.

ANALYSIS AND INTERPRETATION OF RESULTS OF PRELIMINARY TRIALS CONDUCTED IN SIERRA LEONE

Botanical and Morphological Description of P. *erosus*

The plant is a herbaceous climbing or trailing vine. The stem, leaves and pods have strigose hairs. The stem is spirally striated. The outline of the leaflets varied from dentate to palmate. Flowers exhibit a racemate inflorescence. Pods are oblong, acuminate and slightly to deeply contracted between seeds. Seeds are square to rounded, and colour ranges from olive-green to brown or reddish brown (Sorensen, 1988). The tubers have a light to dark brown surface and a white succulent, fleshy interior. They are broader than long with some plants producing more than one tuber.

During the trials in Sierra Leone, flowering started for most of the varieties studied in late April and early May, with the exception of EC 114 and EC 117 which did not flower until June. By late July all the plants had obtained 50% flowering. Flowerrng continued profusely until harvest. The different dates of flowering observed between these varieties tell us that some of them are photoperiodic. Stolen (1994) pointed out that a specific daylength is required by each crop for proper growth and development. According to Sorensen (996) day length sensitivity in *P. erosus* has been studied by several scientists and it is a generally held view that yam beans are short-day plants.

Analysis and Interpretation of results

The Analysis of variance test was used to assess the data for the responses of the varieties to yield and the evaluation of all possible pairs of treatment means by the Duncan's Multiple Range test and Student-Newman-Keuls test ($P < 0.05$).

Germination Trials

No significant differences were observed between light and dark and darnp and flooded treatments as far as % germination for the varieties studied is concerned. However, significant difference in % germination was observed between varietics. There were also no significant interaction between varieties and treatments [Table 1).

Under light and dark conditions, the percentage germination of EC 538, EC 503, EC 219, EC 550, EC 114, EC 003, EC 525 and EW229 were not significantly different and ranged between 92 to 100%. The % germination of these varieties was significantly higher than that of EC 509 at 58%. EC 117 showed the lowest germination of 43% (Table 2) (Fig.I). Under damp and flooded conditions EC 525 separated from the first group with a lower germination percentage of 82, significantly different from that of EC 509 and EC 117 which showed the same % germination of 53. (Table 3).

No significant differences were observed between the light and dark treatment as far as the number of days it took the seeds to reach maximum germination is concerned. Also, no significant differences between the varieties were observed. However, srgnificant differences between the damp and flooded treatment (Fig.2) and also between the varieties were recorded for this parameter (Table 1). The time to reach maximum germination was hampered by excess humidity (Table 4). EC 509 and

EC525 show no difference in the number of days to reach maximum germination whether in damp or flooded conditions (Fig.3).

Field Trials

Yield performance between the 15 varieties of *P. erosus* was evaluated.Significant variations between the varieties were observed for all the measured characters (tuber fresh weight, leaf and vine weight, flower fresh weight and pod fresh weight) including the percentage germination at 7 and 21days after sowing (Table 5). There is a block effect observed only for tuber fresh weight (Table 5).

Fresh tuber yield ranges from 10190 Kg/ha recorded for EC 219 and EC 509, to 22870 Kg/ha for EC 201 (Table 6). Taking into consideration that these figures were obtained without any application of fertilizer or reproductive pruning and when compared with figures from Thailand with yields of 18,000 - 24,000 Kg/ha (Ratanadilok and Thanisawanyangkura, 1994), the production potential of the yam bean in Sierra Leone is quite promising.

The three best tuber yielding varieties are EC 201, EC 550 and EC 114, with yields of 22870, 18520 and 17320 kg/ha respectively.

The capacity of EC 201 to produce tubers when compared to that of pod production is very high (Tables 7). The low SNK ranking when tuber and pod production are compared shows that EC 550 is also a good pod producer (Table 7). It can be selected for both tuber and pod production (Fig 4) Eigenvector 2. Only EC '114 showed substantially good yields in both vegetative (leaf & Vine weight) and reproductive (flower and pod weight) matter (Tables 8,9 and 10). Field trials carried out in Senegal (Annerase and Diouf, 1996) have showed that this variety is better than the others in terms of tuber yield. Though EC 117 may not be a high yielding cultivar for tuber production, the yields for LVW, FFW, and PFW are potentially good. Figure 4, confirms the capacity of EC 114 and EC 117 to show better performance in yields for all the characters studied. The competiton between pod and tuber formation might have suppressed tuber production. The tuber yielding potentials of these varieties could therefore be increased if they are subjected to reproductive and or vegetative pruning.

EC 120 proved to be the highest yielding cultivar in vegetative growth (leaf & vine weight) (Table 8). Its performance in terms of tuber and pod production are very poor. It would be a good variety for fodder production.

Despite the fact that EW 229 achieved 100% field germination after 21 days (Table 12), its yield performance for all the measured characters were on the average. The reason for this has been pointed out by Sorensen (1996). Wild genotypes generally have smaller and often elongated ancl irregular shaped tuberous roots. All the other remaining varieties (EC 104, EC 209, EC 041, EW 229, EC 538, EC 503, EC 033, EC 525, EC 120, EC 509 and EC 219) have very low potentials as far as tuber yield is concerned and thus may not be recommended for tuber production.

Percentage field germination (Table 11) showed that 50% germination was achieved after 7 days in all the varieties except EC 509 which had 41 .1%. Percentage germination and survival rate increased from 7 days to 21days in all the varieties (Table 12). On the 21day percentage germination varied from 81.13% to 100%. Only EC 509 and EC 041 had % germinations lower than 90%.

Practical Problems Encountered

The first problem encountered was the inter-twinning of plants within and between beds when the vegetative growth became abundant. For further experiments on field trials the spacing within and between beds would be increased and the trailing vines properly monitored.

High humidity and excess water as a result of the heavy rainfall caused rapid deterioration of pods, seeds and tubers. As a result of these problems encountered during the rainy season, it is recommended that planting should be done during or at the end of the rainy season, for harvesting to take place during the dry season.

CONCLUSION

This study carried out to evaluate the tuber production potentials of 15 varieties of *Pachyrhizus erosus* represents the first of such studies in Sierra Leone.

The existence of some diversity between the varieties for tuber production has been demonstrated and it seems that certain varieties have greater potential for increased tuber

production. Selection of the most outstanding varieties for further crop development has therefore been made along these lines.

The results show that EC 201 is a better variety for tuber yield. EC 550, EC 114 and EC 117 showed very good potentials for pod production added to their tuber yielding potentials.

Reproductive pruning is recognized to enhance tuber production on the basis of campetition between tuber and pod. As has been demonstrated in numerous field trials, the effect of the operation depends on the cultivar, the season used (whether long or short day) and the climate (Sorensen, 1996). In order for us to realise the maximum potential of this crop in tuber production in Sierra Leone the influence of reproductive pruning on tuber yield should be investigated. The four varieties have been selected to investigate whether the absence of pod production would increased tuber yield.

Results from both laboratory trials and field germinations tells us that the germination potential and survival rate of the yam bean are quite good under different external conditions as long as the seeds are viable.

Though, the climatic requirements of P. erosus in Sierra Leone have not been critically studied, it is obvious that moisture affected the developmental stages or cycle of the crop. For further studies harvesting of the crop will be done during the dry season.

Tables and figures

Table 1 : summary of Analysis of Variance for Percentage Germination and Nurnber of days to reach maximum germination for 10 varieties of *Pachyrhizus erosus*

		% Germination	N° of days to maximum germination
Source	df	F Value	F Value
Variety	9	35.13***	0.71^{ns}
Light/Darkness	1	0.22^{ns}	0.92^{ns}
Var*LD	9	0.11^{ns}	0.52^{ns}
Error	40		
C V		9.41%	87.33%
Variety	9	37.71***	2.35*
Damp/Flooded	1	1.13^{ns}	155.87***
Var*DF	9	0.08^{ns}	3.14**
Error	40		
C V.		8.43%	31.29%

(ns not significant ; * : significant at 5% ; ** : significant at 1% ; *** : significant at 0.1%)

Table 2 : Percentage Germination under conditions of Light/Darkness for 10 varities of *P.* erosus. Duncan's Multiple Range Test

Variety	%GERMI	Ranked Order
EC 538	100.0	A
EW 229	100.0	A
EC 503	100.0	A
EC 219	98.33	A
EC 550	96.67	A
EC 114	95.00	A
EC 033	95.00	A
EC 525	91.67	A
EC 509	58.33	B
EC 117	43.33	C

Means followed by the same letter are not significantly different at the 5% level.

Table 3 : Percentage germination under Damp & Flooded conditions for 10 variety of *P. erosus.* Duncan's Multiple Range Test

Variety	% Germi.	Ranked Order
EC 538	100.0	A
EW 229	100.0	A
EC 503	98.33	A
EC 114	95.00	A
EC 033	95.00	A
EC 219	95.00	A
EC 550	95.00	A
EC 525	81.67	B
EC 509	53.33	C
EC 117	53.33	C

Means followed by the same letter are not significantly different at the 5% level.

Fig. 1 : variety effect on percentage germination under conditions of light and darkness

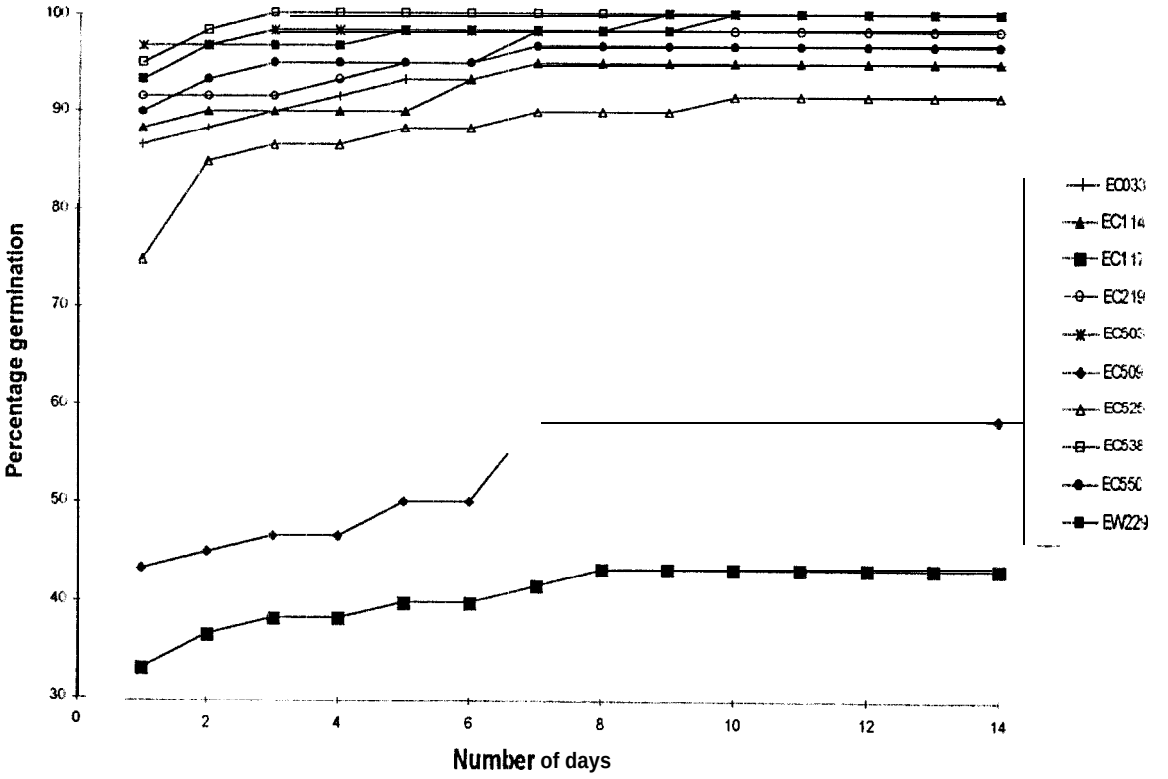


Fig.2 : damp and flooded conditions effect on percentage germination

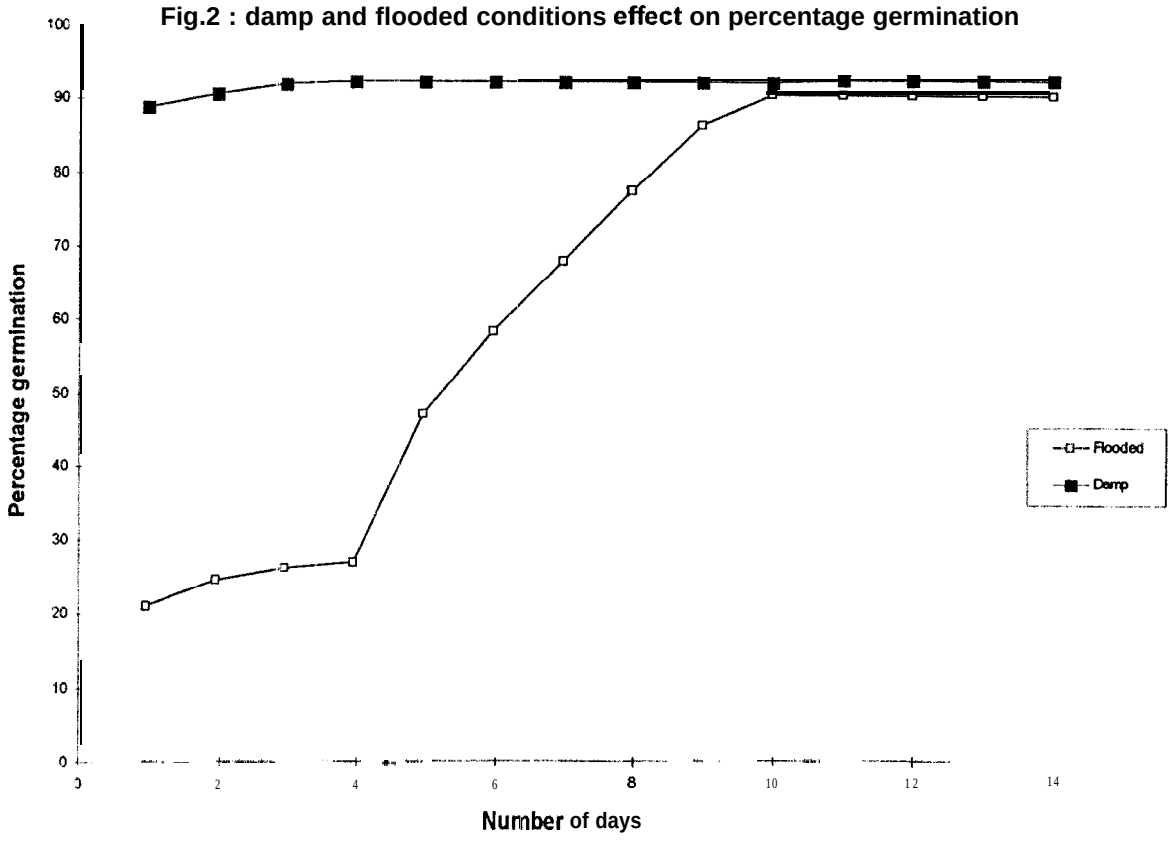


Table 4 : Interaction between Damp and Flooded conditions and Variety for the Number of days to reach maximum germination. Duncan's Multiple Range Test

Variety	Treatment	N° of days	Ranked Order
EC 033	Flooded	10.00	A
EC 114	Flooded	10.00	A
EW 229	Flooded	9.67	A
EC 219	Flooded	9.00	AB
EC 550	Flooded	9.00	AB
EC 509	Flooded	9.00	AB
EC 503	Flooded	8.67	ABC
EC 538	Flooded	7.67	ABC
EC 117	Flooded	7.67	ABC
EC 525	Flooded	7.33	ABC
EC 509	Damp	7.33	ABC
EC 525	Damp	5.67	BC
EC 550	Damp	5.33	C
EC 117	Damp	1.67	D
EC 503	Damp	1.67	D
EC 033	Damp	1.67	D
EC 114	Damp	1.67	D
EC 538	Damp	1.33	D
EC 219	Damp	1.33	D
EW 229	Damp	1.33	D

Means followed by the same letter are not significantly different at the 5% level.

Fig. 3 : Damp and flooded effect on varieties EC 509 and EC 525

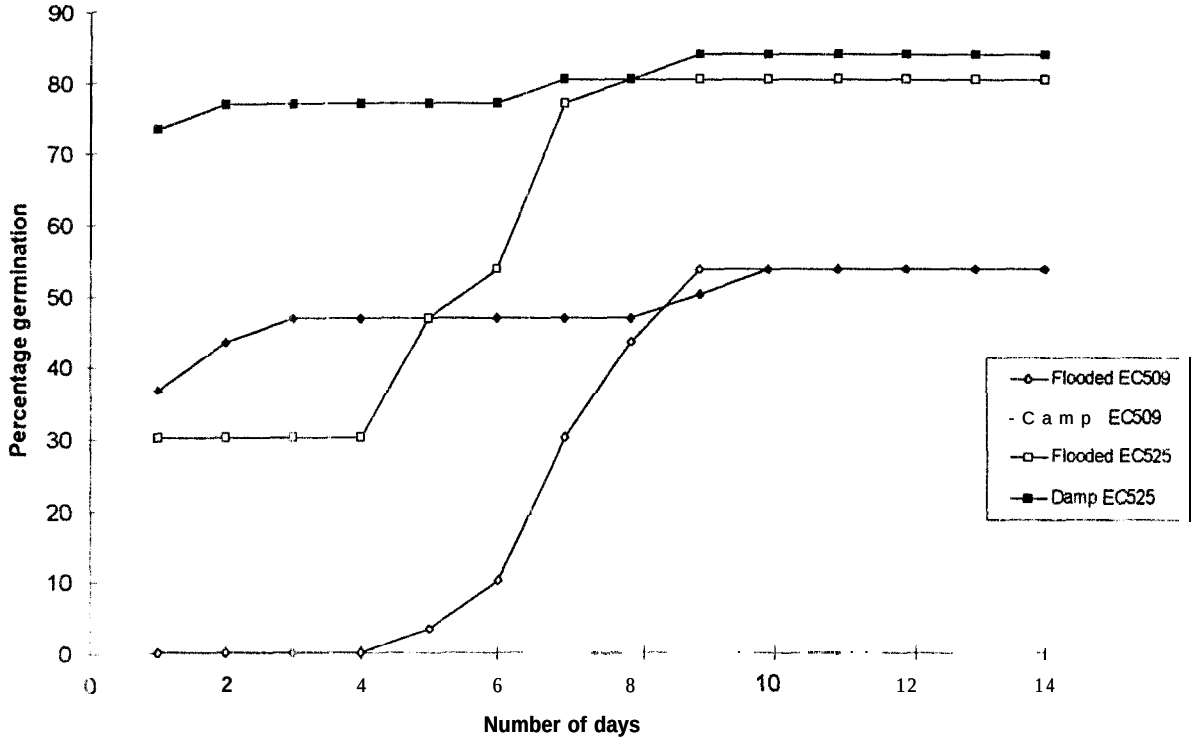


Table 5 : summary of Analysis of Variance for TFW, LVW, FFW, PFW and Percentage germination at 7 and 21 days for 15 varieties of *Pachyrhizus erosus*.

Source	df	F Value					
		TFW	LVW	FFW	PFW	% Germi. 7days	% Germi. 21 days
Replication	2	7.75**	1.90 ns	0.88 ns	1.37 ns	0.26 ns	0.36 ns
Variety	14	44.59***	359.44***	25.28***	42.42***	22.51***	10.93***
Error	28						
CV		6.70%	4.35%	24.50%	16.22%	7.15%	3.00%

(ns : not significant ; * : significant at 5% ; ** : significant at 1% ; *** : significant at 0.1%)

Note: TFW is Tuber Fresh Weight, LVW is Leaf & Vine Weight
FFW is Flower Fresh Weight, PFW is Pod Fresh Weight

Table 6 : Tuber Fresh Wt. Kg/ha . Duncan's Test

Variety	TFW	Ranked Order
EC 201	22870	A
EC 550	18520	B
EC 114	17320	BC
EC 104	16670	C
EC 209	16670	C
EC 041	16480	C
EW 229	14820	D
EC 117	14540	D
EC 538	12690	E
EC 503	12040	EF
EC 033	11390	EFG
EC 525	10830	FG
EC 120	10460	FG
EC 509	10190	G
EC 219	10190	G

Means followed by the same letter are not significantly different at the 5% level.

Table 7 : Student-Newman-.Keuls test for Tuber Fresh Weight / Pod Fresh Weight

Variety	Mean	SNK ranking *
EC 209	20.706	A
EC 120	14.154	B
EC 104	9.087	C
EC 201	5.787	D
EW 229	5.385	D
EC 503	2.630	E
EC 538	2.323	E
EC 114	1.929	E
EC 041	1.802	E
EC 033	1.737	E
EC 117	1.503	E
EC 550	1.439	E
EC 219	1.378	E
EC 509	1.231	E
EC 525	0.941	E

(* Means with the same letter are not significantly different)

Table 8 : Leaf & Vine Wt. Kg/ha. Duncan's Test

Variety	LVW	Ranked Order
EC 120	50000	A
EC 117	46300	B
EC 509	43520	C
EC 114	42590	CD
EC 104	40740	D
EW 229	35190	E
EC 033	32410	F
EC 041	26850	G
EC 209	25930	GH
EC 550	24540	H
EC 219	24070	H
EC 525	18520	I
EC 503	10190	J
EC 538	10190	J
EC 201	6481	K

Means followed by the same letter are not significantly different at the 5% level.

Table 9 . Flower Fresh Wt. Kg/ha. Duncan's Test

Variety	FFW	Ranked Order
EC 117	1251	A
EC 114	1067	B
EC 509	581.3	C
EC 550	427.7	CD
EC 120	422.3	CD
EC 104	418.7	CDE
EC 033	392.7	CDE
EW 229	375.0	DE
EC 041	345.3	DE
EC 219	333.3	DE
EC 209	279.7	DEF
EC 503	237.0	DEF
EC 525	222.3	DEF
EC 538	210.3	EF
EC 201	84.33	F

Means followed by the same letter are not significantly different at the 5% level.

Table 10 : Pod Fresh Wt. Kg/ha. Duncan's Test

Variety	PFW	Ranked Order
EC 550	12960	A
EC 525	12040	A
EC 117	9907	B
EC 041	9259	BC
EC 114	8981	BC
EC 509	8333	BCD
'EC 219	7407	CD
EC 033	6759	DE
EC 538	5556	EF
EC 503	4630	F
EC 201	3982	FG
EW 229	2778	GH
EC 104	1851	HI
EC 209	833.3	I
EC 120	740.7	I

Means followed by the same letter are not significantly ciifferent at the 5% level.

Table 11 : Percentage Germination 7 days. Duncan's Test

Variety	% Germi	Ranked Order
EW 229	93.33	A
EC 503	91.10	AB
EC 114	90.00	ABC
EC 538	90.00	ABC
EC 550	87.77	ABC
EC 104	83.33	ABCD
EC 525	81.13	BCD
EC 219	81.10	BCD
EC 033	80.00	CD
EC 041	73.33	DE
EC 117	67.77	EF
EC 201	63.33	FG
EC 209	63.33	FG
EC 120	57.77	G
EC 509	41.10	H

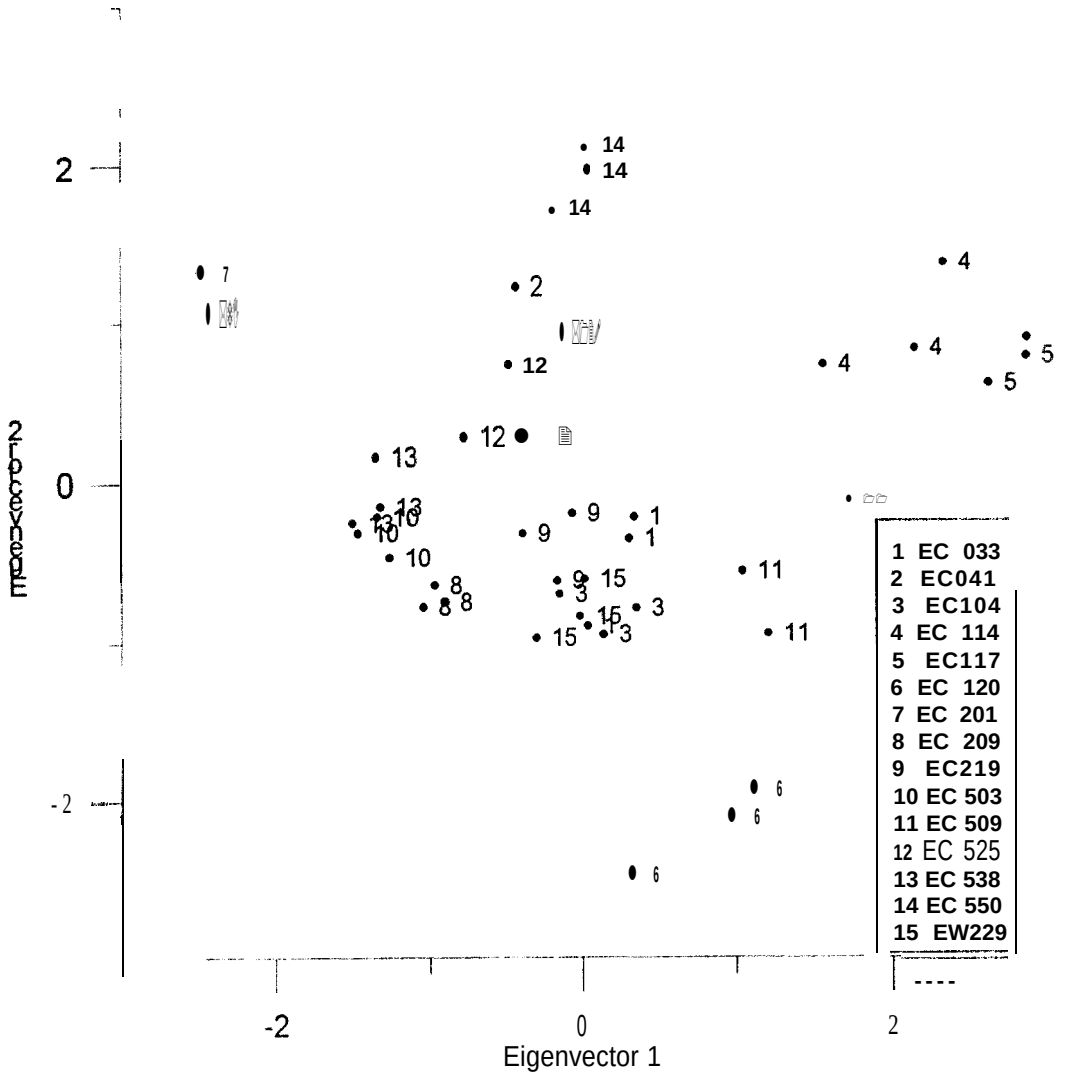
Means followed by the same letter are not significantly different at the 5% level.

Table 12 : Percentage Germination 21 days. Duncan's Test

Variety	% Germi	Ranked Order
EW 229	100.0	A
EC 219	98.90	A
EC 120	97.80	AB
EC 114	97.80	AB
EC 201	97.80	AB
EC 104	96.70	ABC
EC 209	96.67	ABC
EC 550	96.67	ABC
EC 538	96.67	ABC
EC 033	93.33	BCD
EC 503	93.33	BCD
EC 525	92.20	CD
EC 117	90.00	D
EC 509	84.43	E
EC 041	81.13	E

Means followed by the sarne letter are not significantly different at the 5% level.

Fig. 4 Principal Components Analysis:
representation of varieties in the 2 main eigenvectors plane



Eigenvectors		
Variable	Eigenvector 1	Eigenvector 2
Tuber fresh weight	-0.1841	0.5575
Leaf and vine weight	0.6566	-0.3395
Flower fresh weight	0.6883	0.2110
Pod fresh weight	0.2475	0.7277

Eigenvalues			
Component	Eigenvalue	Proportion	Cumulative
Eigenvector 1	1.7465	0.4366	0.4366
Eigenvector 2	1.0766	0.2691	0.7058

REFERENCES

Annerose and Diouf, 1994. Studies on the adaptation to drought of Pachyrhizus spp. in semi-arid zones. Paper presented at the Tuber legumes workshop in Mexico, 1996.

Ratanadilok, N. and S. Thanisawanyangkura. 1994. Yam bean (Pachyrhizus erosus (L.) Urban) status and its cultivation in Thailand. Pp. 305314 in Proceedings of the First International Symposium on Tuberous Legumes; Guadeloupe, FWI, 21-24 April 1992. (M. Sorensen, ed.) Jordbrugsforlaget, Kobenhavn.

Sorensen, M. 1996. Yam bean (*Pachyrhizus* DC.). Promoting the conservatuon and use of underutilized and neglected crops. 2. Institute of Plant Genetics and Crop Plant Research, Gatersleben / International Plant Genetic Resources Institute, Rome.

Sorensen, M. -1988 A taxonomic revision of the genus *Pachyrhizus* (Fabaceae - Phaseoleae). - Nord. J. Bot. 8/ 167-192. Copenhagen.

Stolen, 0. 1994. Introduction, Improvement and Marketing of New Crops. Pp. 37-46 in Proceedings of the First International Symposium on Tuberous Legumes: Guadeloupe, FWI, 21-24 April 1992. Jordbrugsforlaget, Copenhagen, Denmark.

EXPERIMENTAL PROTOCOL FOR SECOND PHASE EXPERIMENTS IN SIERRA LEONE

Title: The influence of reproductive pruning on tuber yield of four varieties of *Pachyrhizus* erosus at three different locations.

Sites: Multilocational; with diverse ecologies and edaphic features.

- Site 1: Botany Department Experimental Gardens, Fourah Bay college.
- Site 2: Lungi Agricultural Station, Lungi
- Site 3: Ogoo Farm

Key words: *Pachyrhizus* erosus, reproductive pruning, yield.

Objective: To test the effect of reproductive pruning on tuber yield of four outstanding varieties of *Pachyrhizus erosus* in three experimental sites.

Cultivation: Cultivation will take place on the three located sites during the rains at a period when harvesting will coincide with the beginning of the dry season

- Seeds will be treat.ment with a fungicide before sowing.
- Sowing: 2 to 3 seeds per hole at a depth of not below 2cm, after watering the plots to field capacity the day before.
- Thinning of the plants to one per hole 3 weeks after sowing.
- Erection of pickets if vegetative growth is abundant.
- Treatment of plants with insecticide if and when necessary,,
- Reproductive prunings would be applied twice, after 50% flowering.

Varieties: *Pachyrhizus erosus;* EC 201, EC 550, EC 114, and EC 117.

Studïed factors: Two factors:-

- Variety: four varieties (EC 201, EC 550, EC 114, and EC 117).
- Reproductive pruning : - with reproductive pruning
  - without reproductive pruning.
- 4 x 2 = 8 Treatments

Experimental design: It is a randomised complete block (RCB) involving 8 treatments replicated 3 times.

The bed size will be 2.4m x 1.8m consisting of 6 columns x 6 rows, with seeds sown at 30cm between rows and 40cm between columns. Sampling area will be 1 .92m^2, comprising the four inner columns of 16 plants. The distance between beds will be 1m. The data will be assessed by an analysis of variance and means calculated using a Duncan's test ($P < 0.05$).

Amount of seeds required for each variety:-

- 6 columns x 6 rows = **36** holes per bed
- 2 seeds per hole = **72** seeds per bed
- with reproductive pruning = 3 replicates

- without reproductive pruning = 3 replicates
- number of experimental sites = 3

Total N° of seeds required per variety = 72 x 6 replicates x 3 sites = 1296 seeds

Observations and measurements:

- Measurement of soil NPK content and pH before sowing and after harvest
- Date of 50% emergence / germination.
- Date of 50% flowering.
- Date of 50% tuber initiation.
- Harvest at the end of fifth month.

Expected results: Increase in tuber yield by reproductive pruning. Effect of varieties, sites or interaction between varieties and sites. Acceptance by the faming community.Fodder for cattle feed.

Experimental Layout -

- 4 varieties
- 2 reproductive prunings:- with reproductive pruning (WRP)
  - without reproductive pruning (WOP)
- 3 replicates

SITE 1

	1	2	3	4	5	6	7	8
Rep 1	EC114 WRP	EC201 WOP	EC550 WOP	EC114 WOP	EC201 WRP	EC550 WRP	EC117 WOP	EC117 WRP
Rep 2	EC201 WRP	EC117 WRP	EC550 WRP	EX201 WOP	EC114 WRP	EC117 WOP	EC114 WOP	EC550 WOP
Rep 3	EC117 WRP	EC201 WOP	EC550 WOP	EICI 17 WOP	EC201 WRP	EC550 WRP	EC114 WOP	EC114 WRP

SITE 2

	1	2	3	4	5	6		7	
Rep 1	EC201 WRP	EC117 WRP	EC114 WRP	EC117 WOP	EC550 WRP	EC1	1 WOP	4 WOP	EC550201 WOP
Rep 2	EC117 WOP	EC550 WOP	EC201 WRP	EC117 WRP	EC114 WOP		EC550 WRP	EC201 WOP	EC114 WRP
Rep 3	EC114 WRP	EC117 WRP	EC117 WOP	EC550 WRP	EC201 WOP		EC550 WOP	EC114 WOP	EC201 WRP

SITE 3

	1	2	3	4	5	6	7	8
Rep 1	EC114 WOP	EC550 WOP	EC117 WRP	EC550 WRP	EC117 WOP	EC20 1 WRP	EC201 WOP	EC114 WRP
Rep 2	EC117 WRP	EC201 WOP	EC550 WRP	EC117 WOP	EC114 WOP	EC201 WRP	EC114 WRP	EC550 WOP
Rep 3	EC201 WRP	EC114 WOP	EC201 WOP	EC550 WRP	EC117 WRP	EC114 WRP	EC117 WOP	EC550 WOP