A DEVELOPMENTAL STUDY OF SEVEN INTRODUCED TROPICAL GRASSES, WITH SPECIAL REFERENCE TO SEED VIABILITY AND STORAGE TESTS UNDER TRINIDAD CONDITIONS.

by

P.W.A. Davies, B.Sc. Agric. (Natal)

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INTRODUCTION

This project was carried out as one of the several stages in the grassland research programme of the Imperial College of Tropical Agriculture, and in part fulfillment of the requirements for the Diploma in Tropical Agriculture.

The various stages of the programme consist firstly, of studying both selected indigenous and imported grasses, although usually the latter. Observations are taken from small trial plots in order to determine their seasonality, rate and form of growth, their flowering habits, seeding ability and fertility. At the same time, in the case of imported grasses, a study is made of the available literature from their sources of origin and other countries where they have been grown with success. This is in order to ascertain the conditions best favouring their growth and utilisation and to obtain information regarding establishment and cultural and managerial problems already encountered elsewhere. These initial trials are carried out for nearly a year, covering both the wet and the dry seasons or as much of them as is possible, taking into account the fact that most of the work is done by temporary post-graduate students in the absence of a full time Pasture Research Officer. It is to this initial stage of the work that this project belongs.

The second stage of the programme consists of selecting the most promising species, varieties, or strains, from the previous year's small plot trials and bulking them up in larger plots in order to supply enough planting material for a large scale experiment in the third year. It must be remembered that the importation of grasses from overseas is a difficult procedure especially if viable seed is not obtainable and planting material has to be imported instead; hence the necessity for at least one bulking year.

In the third stage these selected grasses are laid down in a large scale replicated trial, to determine their
productivity in terms of yield of dry matter per acre and total nutrients per acre under differing intensities of cutting. At the same time the persistence under weed encroachment, the ground cover, the ability to stand up to the various cutting treatments and the ease of eradication is noted. During this third stage which must, because of seasonal differences, be carried out for more than one year, palatability and digestibility trials are undertaken in co-operation with the Animal-husbandry department on different classes of animal.

The final stage of the programme is the laying down of trial pastures using promising grasses of previous trials, to begin with as pure stands, but later when each grass' resistance to grazing at different intensities is known, in various combinations and mixtures.

In this project it is not proposed to discuss the potential value of grass in its various forms in Trinidad as this has been ably done by such workers as Paterson (1937 and 1941), Howes and Campbell (1953), Mulholland (1953) and Evans (1954).

The great expense of the present system of soilage is obvious as is the expense of carting out the manure associated with it. It is of interest however that in the temperate regions of the United States of America, there is a movement away from the utilisation of grass by grazing toward mechanical soilage. It is claimed that the reduced spoilage and selective grazing make it economical. It must be remembered however that this system together with the mechanical soilage done in Hawaii is only suitable for fully mechanical farms and is out of the question for a peasant population, such as that in Trinidad, lacking in capital. Thus in the grassland research programme emphasis is at the moment being laid more on the grazing grasses than soilage and silage grasses.

This project is divided into two main sections. Firstly an investigation of the vegetative characteristics of the
selected grasses which includes a botanical description with drawings of each one, an account of the rate, form and seasonality of growth, flowering frequency and a short review of literature. Observations for this section were taken from small plots, made into raised beds 3' x 9' on the St. Augustine sandy loam type of soil of the old farm. The second main section is based on work done in connection with seed viability and storage tests.

The epikalesa have one terminal fertile flower with a male flower below it. It belongs to the tribe Paniocae which is the largest tribe of grasses with 1,300-1,400 species, mostly tropical or sub-tropical, with a few temperate species (Bever 1924). There are nine species of the genus known in India and Tropical America, while A. crispipes comes from Jamaica and is known in South Africa (Botha 1940).

Origin and Ecology:

This grass was introduced to the Imperial College as rooted planting material from the Research Agricultural Office at Lilongwe, Nyasaland in April 1954. It is a grass with a wide distribution in tropical and sub-tropical Africa, being indigenous to the Moordrift area in the Northern Transvaal and having been found near Aldoret in Kenya, Mzimkhulu, Southern Umdoni, Rebec Natal, in the swashes of the Kwanza River Angola, in the Yezi district of Tanganyika, and has been collected from the Lebogga area near Kamba at an altitude of over 1,000' and a rainfall of 40'-60'. It is unsuitable for the more arid regions of Tanganyika (van Rensburg 1940, Botha 1940).

A station was established in the early 1930's at the Natalflora Grass Breeding Station near Pretoria from the Moordrift area, and disseminated a few years later to stations in the Eastern Transvaal and along the Natal north coast at altitudes of 1,000'-3,000' and 25'-30' rainfall, becoming very popular in the rain belt where there are short dry seasons. It then became
SECTION 1

ACROCERAS MACRUM STAPF.

Common names: - Nylgras (South Africa), Swamp Ryegrass (Northern Rhodesia).

Taxonomy: -

Acroceras macrum Stapf belongs to the family Gramineae and the sub family Panicoideae which is characterised by the spikelets falling entire from their pedicels singly or in groups. The spikelets have one terminal fertile floret with a male floret below it. It belongs to the tribe Paniceae which is the largest tribe of grasses with 1,300-1,400 species, mostly tropical or sub-tropical, with a few temperate species (Bews 1929). There are nine species of the genus known in India and Tropical America, while A. oryzooides comes from Jamaica and is known in South Africa (Botha 1948).

Origin and Ecology: -

This grass was introduced to the Imperial College as rooted planting material from the Research Agricultural Office at Lilongwe, Nyasaland in April 1954. It is a grass with a wide distribution in Tropical and Sub-tropical Africa, being indigenous to the Moordrift area in the Northern Transvaal and having been found near Eldoret in Kenya, Brokenhill Northern Rhodesia, Berea Natal, in the marshes of the Kunene River Angola, in the Tringa district of Tanganyika, and has been collected from the Lihogosa swamp near Njombe at an altitude of over 5,000' and a rainfall of 40"-55". It is unsuitable for the more arid regions of Tanganyika (van Rensburg 1948, Botha 1948).

A. macrum was established in the early 1930's at the Rietondale Grass Breeding Station near Pretoria from the Moordrift area, and disseminated a few years later to Athole in the Eastern Transvaal and along the Natal north coast at Altitudes of 1,000'-4,000' and 35"-60" rainfall, becoming very popular in the mist belt where there is a short dry season. It then became
popular in many areas in Africa as a vlei grass, as for example in the Sandvleis of Mashonaland where it grows in several inches of water during the wet season and longer (Fatray 1947).

*A. macrum* is essentially a high rainfall grass, the minimum rainfall being given as 30" under South African conditions (Botha 1948). It is quickly killed by drought and is very susceptible to frost damage having been killed out in Basutoland (Basutoland 1946). In Trinidad the fact that the grass was growing virtually at sea level appeared to make little difference.

Morphological description:

*A. macrum* is a perennial producing stoloniferous rhizomes. It has fine, slender non woody stems growing to a height of 2'-6" to 3' and stolons spreading from 1-2ft from the original plant. The leaf sheath clasps the internode loosely for half its length and may have a purplish tinge at the base. Auricles are absent and the ligule is reduced to a small fringe of very fine hairs. The leaf blade is lanceolate to linear, very finely pubescent 5"-6" long and 3/4" at the base. The inflorescence is a non-sphacelate panicle with a well developed long axis having spike-like branches. These are evenly covered with spikelets in a single row, in clusters of two, one sessile and one shortly pediculate. The lower most branches of the panicle are over 2/5 the length of the axis. The spikelets are green, awnless, oblong, and contain two florets, a terminal fertile floret and a lower male floret. The lower glume is well developed and hairless as are the lemmas. The lemma of the upper fertile floret has a curled and laterally compressed tip. The stigma is feathery, bilobed, and purple, while the anthers are large and protrude well on long filaments.

Growth and Development:

*A. macrum* was planted out in early November 1954 approaching the end of the wet season. Because of the absence of viable seed, stem cuttings 6" long were taken from an adjoin-
ACROGIRAS MACRUM.

Av. height of plant in inches.

Av. number of tillers per plant.

Av. number of leaves per plant.

Av. number of panicles per plot.
ing plot and planted out four to a hole at a spacing of 1' x 1'.

These cuttings all took extremely well, bud growth being intravaginal and extremely vigorous. It was noted however, that about 15% of the plants began to flower almost immediately, in spite of having no vegetative growth, and tillered poorly later in the season. This was possibly due to the fact that at the time the cuttings were taken the adjoining plot was flowering profusely and consequently some of the cuttings may have been from flowering culms. Care should thus be taken when planting on a large scale, to take planting material when the majority of plants are still in a vigorous vegetative phase. Otherwise although the cuttings will "take", subsequent growth will be slow and tillering weak.

Once the cuttings had taken they were thinned out to one per hole and the number of tillers, leaves and flowers produced was noted together with the total height of the plant, the results being presented in graphical form (Fig. 1).

Developmental studies with this grass corresponded more to those done on seedling plants as only one stem cutting of 3 or 4 nodes constituted a single "plant". Whereas with the grasses propagated by root cuttings it was difficult to establish from how many "plants" the tillers and leaves were produced.

Periodic flooding during the wet season had no adverse affects on the grass and growth during the wet season was very rapid. During the dry season although the soil at times dried out thoroughly the grass continued to grow slowly. These dry periods, as can be seen from the rainfall figures (Appendix ) were never very long.

Flowering was somewhat abnormal because of the planting material used, some 15% flowering only two to three weeks after planting. Normal plants tillered rapidly until the beginning of February and by this time the plot was in full flower. Flowering was continuous throughout the growing season with a lull at the end of February and beginning of March, thereafter
flower production continued until May. It is felt however, that this continual flowering could have been quite easily prevented by cutting back and encouraging vegetative growth, but since this was a developmental study the plants were left and watched. It should be noted that this grass remains green and succulent, without becoming fibrous, throughout the dry season in spite of the growth rate slowing down.

Economic uses and yields:

*A. macrum* is a grass whose value as a fodder and pasture has been known for the past twenty years in South Africa, and whose value is being rapidly appreciated all over the higher rainfall areas of Africa to-day. Various ecotypes exist believed to be functions of the habitat, and both upright and prostrate types are available, being suited to hay or silage production and grazing respectively (Botha 1948). It is a grass that forms a good cover quickly, and has been used for some years in preference to Setarias, in rotation with wattles, in the mist belt areas of South Africa, as it prevents the accumulated organic matter washing away (Botha 1953).

Having very fine stems it is a useful grass for hay and silage making as it dries out and cures rapidly. For silage it should be cut just as it begins to flower and 2% molasses should be added. Being a fine grass it is not necessary to chaff it in order to get consolidation (Henning 1949).

For Trinidad conditions there are as yet no yield or nutritive value figures. Yields of 5 tons per acre per annum, with a grazed aftermath for three seasons, have been recorded in the Eastern Transvaal with no fertiliser (Botha 1953). Yields of 10-15 tons per acre have been claimed from two cuts per season in wetter areas (Henning 1949).

No chemical analyses are available but it is claimed to be a grass of high nutritive value. During an experiment in South Africa, Hereford cross steers fed nothing but *A. macrum* hay,
bonemeal and salt during the winter period, gained an average of 206 and 195 lbs. in 119 days, surpassing daily weight increases expected by Morrison for lucerne (Botha 1948, Herb. Abstr. 1948). Large increases in beef yields have been reported from Southern Rhodesia when *A. macrum* was used in a mixture with *Paspalum dilatatum* and *P. urvillei* on wet vleiland. (Pasture Research Committee 1944). Experiments are being conducted at the Athole Experimental Station in South Africa to establish the fertiliser requirements under those conditions (Davel 1949). In Trinidad good response was observed when pen manure was applied to a section of the observation plots.

Because it is a mat forming grass with spreading stoloniferous rhizomes it has been found difficult to eradicate in South Africa and Tanganyika (Botha 1948, van Rensburg 1948 and Gildenhuys 1950). Consequently it is not advisable to plant it as a temporary ley, but rather as a permanent pasture. It is advisable to plough it out every 4-6 years to regenerate it as it becomes rather root bound and matted (Pienaar 1947, Botha 1948).

**Propagation and Seed setting ability:**

Most of the indigenous mat forming grasses of Africa including *A. macrum* are notably more sterile than the indigenous bunch type grasses. The trend of natural selection seems to have been away from high seed set towards higher vegetative vigour. Under Trinidad conditions *A. macrum* flowers profusely and appears to produce viable pollon and ovules, but no seed is ever set. Many spikelets were examined and no fertilised ovules could be found. Both the stigmas and anthers protrude well from the floret and the anthers appear to dehisce satisfactorily but two to seven days after this the whole spikelet turns brown and falls from the axis. As an observational experiment, a number of panicles were sprayed with a solution containing 0.0005% alphaphenanthrene acetic acid, with the idea of preventing abscission, but no conclusive results were obtained and certainly no seed
was formed. Milbrath and Hartman in 1940 were successful in preventing abscission in Holly using the same solution, as was Warne in 1947 working with garden lupins. The solution at 10 ppm has also been used with success on citrus by Cole and Heeley in 1947.

In South Africa *A. macrum* has been known to produce a very small quantity of seed and workers at the Prinshof Grass Breeding Station have obtained interesting variations of the grass from seed. (Botha 1948), Laubsher (1949) intimates that seed is produced in South Africa when he says that *A. macrum* is difficult to establish from seed in South Africa, partly due to the soil drying out too quickly, and to the small size of the seed which cannot be buried too deep.

The lack of seed production in the case of *A. macrum* is, however, not a serious disadvantage as vegetative propagation is extremely effective and not expensive. The standard method of propagation in South Africa where the grass is grown on a large scale, is to cut stolons into lengths of 1½" by passing them through an ordinary farm chaff-cutter. These cuttings can then be broadcast over a previously worked field andDisced in, with a final rolling for compaction. More satisfactory results have been obtained by ploughing in the setts. Labourers walk behind a two furrow plough and drop hand-fulls of roots every 18". There is no need for the sets to protrude above the soil, and four natives can easily keep pace with a two furrow plough. The field is ultimately harrowed to facilitate later mowing. Complete emergence takes several weeks and the first hay crop can be taken after five months. Planting dates will, of course, depend upon the presence of weeds and weather conditions. As a general rule 6 bags of cuttings will plant an acre. (Botha 1948).

During the course of this investigation an observational experiment was laid out to find the most satisfactory planting material. Cuttings having one, two and three nodes were planted both protruding and entirely below ground. It was found that in
all cases the cuttings struck but that the more nodes there were the better was the vigour of the plants. It made no difference being below the ground or protruding above it.

Recommendations:

A. macrum is a grass that shows much promise as a pasture and hay grass for Trinidad. It is adapted for growth in poorly drained areas and is expected to survive any normal dry season. Although it does not set seed, vegetative propagation is easy and economical. It would be interesting to start a trial plot on the Aripo or Piarco savannah areas which are notably poorly drained.

Planting should be done at the beginning of the wet season in Trinidad to give the grass a good start and enable a hay cutting to be taken in the first season. Planting in November does not allow sufficient development before growth slows down in the dry season.

A. macrum is undoubtedly a grass which warrants further research in such aspects as nutritive value and yielding ability under Trinidad conditions.

A. macrum is undoubtedly a grass which warrants further research in such aspects as nutritive value and yielding ability under Trinidad conditions.
ANDROPOGON GAYANUS Kunth.

Common names: - Gamba (Nigeria)

Taxonomy:

The genus Andropogon contains about 100 species mainly in the tropics of both hemispheres, with some 43 species in Tropical Africa. It belongs to the tribe Andropogoneae, the sub-family Panicoideae and the family Gramineae. Members of the tribe Andropogoneae are distinguished by their glumes being more or less rigid and the lower glumes are longer than the floret and enfold it.

Origin and Ecology.

Andropogon gayanus was introduced to the College in March 1953 from the Goldcoast in the form of seeds. It is said to be a common grass from the Cape Verde Islands across Africa to the Sudan and Rhodesia, occurring as a major constituent of the high grass savannahs in the Moist Tropical Belt. The most notable fact about these savannahs is the influence of fire. During the dry season lightning and also humans cause fires which burn the then tall, coarse, mature grasses down to the ground. A new flush of grass then appears with the first rains. A. gayanus is thus a grass that has developed under conditions of a fire sub-climax.

A. gayanus appears to be well adapted to Trinidad conditions, growing well during the wet season and not showing adverse effects from temporary poor drainage. Adapted for the severe drought conditions in parts of Africa it stands up well to the dry season in Trinidad.

Morphological description:

A. gayanus is a typical tall bunch grass growing up to 10-15 ft. in height when in flower, with very little lateral spread. The stems are many jointed, the nodes being swollen.
At maturity axillary growth may occur from these nodes. When young, the stems are densely covered with soft hairs and may be swollen and purple at the base.

The leaf sheaths clasp the stem loosely and are round with no keel. Both leaf sheath and leaf blades are covered with short white hairs. Auricles occur in the form of small brown pigmented projections and the ligule is a dense fringe of white hairs. The leaf blade is lax with a prominent midrib. The leaves are \( \frac{3}{8} - \frac{5}{8} \) inches wide and up to 18 inches long being very soft to the touch when young.

The inflorescence is a panicle up to 12 inches long with numerous branched, spikelike racematus branches. The spikelets are borne in a single row in pairs. One is sessile and fertile and bears an awn \( \frac{5}{8} \) inch long and the other has a short pedicel and is sterile. The spikelets are subtended by a dense involucre of white hairs giving the whole inflorescence a hairy appearance.

Growth and Development.

*Agavamus* was planted out from seed in beds on the "Old Farm" in November 1954. Presumably it was because of poor seed (germination 4%) that the first plot sown was a complete failure. Another plot was sown during the second week of January with freshly harvested seed (germination 14%). With frequent waterings of the seed bed a good stand was eventually obtained by the middle of February. Unfortunately when the original plot was sown a vegetatively propagated plot was not planted, as in the case of the other grasses, because of limited planting material. "Developmental studies" thus had to be, due to necessity, on this late sown sample. Results are of limited value, as this grass would normally complete most of its growth during the wet season, reaching maturity in January to February. The results are included however for the sake of completeness.

Germination of some seeds when tested on filter paper
Vegetative growth.

Root system.
ANDROPOGON GAYANUS

Av. height of plant.

Av. number of tillers per plant.

Av. number of seedlings per plot.
was extremely rapid, taking from only 2 days up to a week. On the sown plot however, inspite of frequent watering, germination took a month. This necessitated continuous weeding to prevent the grass becoming overgrown. From the end of February in spite of the dry weather growth was good and the plants tillered well and reached a height of 12-15 inches by the end of March. The results of measurements taken are presented in graphical form as with the other grasses (Fig. 2).

Economic uses and Yields.

*A. gayanus* is a grass capable of producing a large bulk of material when grown in the right season, but it must be used when young, as it becomes very stalky and fibrous when mature. Being a tufted grass it is not ideally suited as a pasture grass and gives a poor ground cover. When young, however, it produces a good flush of very palatable material.

It is a grass that has been tried out under West Australian conditions where it is said to grow well during the wet season and it has also been tried under irrigation. Its tufted habit of growth is however said to be a disadvantage (Australia 1952, West Australia 1947-49). It has also been imported to South Johnstone, Queensland, where it out-yields Quinea grass *Panicum maximum* in monthly cuttings.

Although it is a grass developed in a fire sub-climax, at Ilorin, Nigeria, in burning experiments, it has been killed out by too frequent burning. Less frequent burning tends to improve pastures by encouraging "Gamba" *A. gayanus* as its seed is resistant to fire. (Dueng-Huu-Thei 1946, Nigeria 1950).

It is a grass which stands up well to grazing and as a hay grass seems to be filling an urgent need in the Goldcoast (Goldcoast 1943).

Propagation and Seed setting ability.

Under Trinidad conditions *A. gayanus* flowers well and produces viable seed. The viability of the seed varies with the
date of collection and from sample to sample. This is mainly due to poor cleaning of the seed samples and the presence of large amounts of extraneous matter. This aspect of the work, namely the cleaning of Tropical grass seeds, is one deserving more research. In this project it has received little attention mainly due to the small samples of seed available.

From Southern Rhodesia is described a simple method of cleaning grass seed for mechanised planting. The seed is merely passed through a hammer-mill at a fixed number of revolutions and size of sieve. 2450 R.P.M. and a 4.75 m.m. sieve have worked well for Cenchrus ciliaris, Panicums and Urocloa species. For Chloris gayana it is advised that the sieve be reduced to 1.96 mm (Schwim 1952). Once sufficient stocks of seed become available it is hoped to try this system on A. gayanus as once the awns and the inflorescence have been broken up the seed will be easier to clean.

Recommendations.

As the main need in Trinidad is one of pasture grasses rather than soilage and hay grasses A. gayanus with its very tufted habit cannot be recommended.

Although it is one of the few grasses dealt with that sets viable seed in Trinidad, it takes a long time to germinate. It is thus thought that unless some pre-treatment of the seed to quicken germination is practised, seeded pastures of this species would fail due to weed domination.
Bothriochloa Pertusa A. Camus (= Amphilophis pertusa Stapf. = Andropogon pertusus (L.) Willd.).

Common names: Barbados Sour grass.

Taxonomy:

Bothriochloa pertusa belongs to the tribe Andropogoneae, the sub-family Panicoideae and the family Gramineae. The genus is characterised by the fact that spikelets are borne in pairs, one sessile and one pediculate. The lower spikelet is fertile and awned. This is an extremely well distributed grass throughout the tropics and consequently a large number of synonyms occur. Bothriochloa pertusa A. Camus is however the name adopted by the College on the advice of Kew Gardens.

Origin and Ecology.

B. pertusa was imported to the College in the form of seed from Barbados in February 1953. This is an Old World grass and has been introduced into the West Indies (Hitchcock 1917). It is found throughout Africa and India and is an important grass in the Northern plains of India. According to Bews, Amphilophis intermedia Stapf. is native to the West Indies "where it is known as Sour grass". There seems to be some confusion!

In Kenya B. pertusa appears to be wide spread from the coast into most parts of the midlands, and up to 6,000 ft. where it is often associated with Themeda triandra and grows well under dry conditions.

Morphological description.

B. pertusa is a tufted perennial sending out numerous stolons. The upright tillers are swollen at the base and flattened higher up. Infrequent branching of the stems occurs low down and they grow to a height of 12-14 inches. The leaf sheaths are keeled and clasp the stem but loosely. Auricles
BOTHRIOSCHOA FERMUSA.

Av. height of plant.

Av. number of panicles per plot.

Length of av. Stolon.
are absent but the ligule is present as a large bifid membrane. The leaf blades are narrow, \( \frac{1}{4} \) inch, linear and from 5-7 inches long. The stolons are round and spread up to 3 ft. The nodes are made conspicuous by a dense fringe of white hairs.

The inflorescence is a panicle with a distinct main axis and numerous (10-12) racemous branches. The lower branches exceed the length of the main axis. These branches are themselves sometimes branched once. The spikelets are arranged in pairs, one being on a pedicel, sterile and awnless, while the lower sessile spikelet is fertile and bears a geniculate awn some \( \frac{2}{3} \) inches long. In this species the lower glume of the sessile spikelet is noticeably pitted. In the fertile spikelet there are two florets, the upper fertile and the lower male. The lower glume has short hairs at its margins giving the inflorescence a hairy appearance. The inflorescence is greenish purple in colour with white hairs.

Growth and Development.

*B. pertusa* was planted out as root cuttings in November 1954. One hundred percent take was obtained from the cuttings which began to grow well from the start. After the first month there was little increase in height and it was noticed that from the axils of the upper leaves stolons began to develop. Over the weeks these stolons increased in length until they reached the soil, they then produced adventitious roots at the nodes and began to spread along the surface of the soil. In many cases these stolons broke up to form new plants and very soon the original plant had lost its identity and the plot was covered by a good sward. As an attempt to measure the rate of spread of this grass the length of the stolons were measured weekly.

In this grass flowering was very weak. The greatest flush of flowers was at the outset of the dry season but even then there were only 9 flowers on the whole plot.

Seed appeared to be set satisfactorily on the few
flowers that did appear but with only one sample was any germina-
Economic uses and Yields.

\textbf{B. pertusa} is a useful grazing grass giving a good
dense cover after only two months when planted out from root
cuttings. It is low growing and cannot be expected to give
as much bulk as such grasses as \textit{Echinochloa pyramidalis} or the
Setarias, but because the stems never become woody it should be
well utilised by stock.

At Serere in Uganda it is said to be one of the most
promising grasses tried in the \(\frac{1}{2}\) acre grazing trials and may
replace \textit{Chloris gayana} in the drier areas (Catford 1951, Uganda
1947).

It is an indigenous grass to Nurpor in the Punjab and
is said to be fairly high up in the succession and supresses
\textit{Cynodon dactylon} when grown together.

Propagation and Seeding ability.

The ability of \textit{B. pertusa} to set viable seed in Trinidad
is not at all certain. Flower production was weak this season
but on the other hand those flowers that did appear did set seed.
On examination the seed was found to be very poorly filled, which
pointed to too early harvesting. If harvesting was too late the
seed shattered. Bagging of the heads with linen and plastic
bags was tried but the fineness of the culms made it difficult,
and no viable seed was caught in that way. One viable sample was
obtained by cutting the flowering culms at the base and allowing
the whole thing to dry out, but even then only 2\% of the seeds
germinated. It is felt that the reasons for poor germination
are by no means fully explained by the harvesting technique and
more work should be done on this subject.

Vegetative propagation is relatively easy although
some of the plant should protrude above the soil. Being stoloniferous the planting distances could be a good deal wider than for normal bunch types. Planting at 1ft x 1ft. was found to be far too close and it is felt that 3ft. x 3ft. would give good results.

Recommendations.

While the seed production of B. pertusa remains as it is, it is felt that it cannot be recommended for Trinidad conditions. Vegetative propagation for the bulk obtained would be too expensive. If vegetative propagation is to be used one would benefit more by planting a grass such as Echinochloa pyramidalis or even Brachiaria brizantha.

Origin and Distribution.

It is a grass widely distributed throughout Tropical and South Africa but has received most recognition as a pasture grass in Uganda, Kenya, Tanganyika and the Belgian Congo. It is also found in the subtropical states of the United States of America for example Texas, and has given good results in Hawaii.

B. brizantha is found as a valuable constituent of natural pasture in the scattered Free State Grassland of Kenya, frequently in bush thickets and forest verges. It requires a moderately high rainfall of over 30" e.a. (Edwards 1958), although in Hawaii, in a rainfall area of 20-60 inches, it has stood up to drought better than Paspalum species and Cynodon Cynodon (Mosby 1928). In East Africa it grows equally well at sea level or up to 7,000 ft. In Hawaii it was grown at 9,500 ft. (Hawaii 1942).

In Trinidad, grown in observation plot scales it did not appear to be affected by either irrigated conditions for periods of up to a week during the wet season. During the dry season there was no sign of drought damage, apart from one or two lower leaves dying back.
BRACHIARIA BRIZANTHA Stapf.

Common names:- Palisade grass, Kifuta grass (Hawaii), Kimbua (Wanjari), Nagosaguta (South Mugirango), Flag grass (Rhodesia).

Taxonomy:-

Brachiaria brizantha Stapf. is a member of the family Gramineae, the sub-family Panicoideae and the tribe Paniceae.

The genus Brachiaria Griseb., contains 80 species confined to the Tropics and Sub-tropics in both hemispheres. About 50 of these species occur in Africa and have been divided into six sections by Stapf.

The genus contains annuals and perennials occurring under both wet and dry conditions (Bews 1929).

Origin and Distribution.

It is a grass widely distributed throughout Tropical and South Africa but has received most recognition as a pasture grass in Uganda, Kenya, Tanganyika and the Belgian Congo. It is also found in the sub-tropical states of the United States of America for example Texas, and has given good results in Hawaii.

B. brizantha is found as a valuable constituent of natural pasture in the Scattered Tree Grassland of Kenya, frequently in bush thickets and forest margins. It requires a moderately high rainfall of over 30" p.a. (Edwards 1953), although in Hawaii, in a rainfall area of 20-60 inches, it has stood up to drought better than Paspalum species and Cynodon dactylon (Hosaka 1948). In East Africa it grows equally well at sea level or up to 7,000 ft. In Hawaii it was grown at 2,200 ft. (Hawaii 1942).

In Trinidad grown on observation plot scale it did not appear to be affected by water logged conditions for periods of up to a week during the wet season. During the dry season there was no sign of drought damage, apart from one or two lower leaves dying back.
Morphological description.

*B. brizantha* is an open tufted perennial growing from 3'-4'6" tall. It has a stout shortly rhizomatous root-stock, producing many geniculately ascending unbranched tillers. The stems are stout and many jointed, and the nodes are slightly swollen. The upper leaf sheaths are hairless and clasp the whole internode firmly. The lower leaf sheaths are longer than the internode and clasp the stem loosely above the second node. Auricles are absent and the ligule is present as a short dense fringe of hairs. The leaves are hairless and have a faintly purple serrated margin, with a prominent green midrib. The blades are broad, \( \frac{1}{2}'' - \frac{3}{4}'' \) and taper to a fine point. The lower leaves are 2-3 inches long and increase in length upwards to 14-15 inches long. The leaves are notably rigid, harsh and dark green giving the plant a spiky appearance.

As the grass did not flower during the limited period available for this project the floral descriptions are adapted from Edwards (1950), Bews (1929) and Hubbard (1943).

The inflorescence is a non-sphacelate panicle with a well developed main axis. From the main axis branch 2-8, straight or arching, dense, onesided, spikelike racemes, 2-6 inches long. The spikelets are arranged, in a single row on one side of these branches which are hollowed one side and rounded the other. The spikelets are solitary on very short, rough pedicels and fall entire at maturity. They are 4-6 m.m. long, awnless and the lower glume is half the length of the spikelet and 7-11 nerved. There are two florets, lower male and upper perfect. The lemma of the lower floret is as long as the spikelet, flattened, and hollowed on the back. There are three stamens and the anthers are 3m.m. long. The lemma of the upper floret is as long as the spikelet, oblong and sometimes with a short blunt incurved point. It is notable that the paleas of both florets have broad flaps on the sides.
BRACHYARIA BRIZANTA.

**Av. Total height of plant.**

**Av. number of tillers per plant.**

**Av. number of leaves per plant.**
Growth and Development.

Because of the absence of viable seed the root sets of *B. brizantha* were planted out in early November. Although the root sets were planted 4-5 to a hole as soon as 100% stand had been obtained they were thinned to one per hole and thereafter represented a single plant. Weekly measurements were then taken, to ascertain the rate of growth and the stages in development of the grass, throughout the season. These measurements involved the total height of the plant and the number of tillers, leaves and flowers produced. In order to avoid the presentation of a mass of purely relative figures these weekly measurements are in the form of a graph, which presents more clearly the general trends.

After a week the root sets had struck successfully and buds began to develop both intra- and extra-vaginally in the axils of the old lower leaves.

Initially the plant tillered slowly but leaf growth was extremely vigorous. For the first month and a half growth in total height was very rapid, mainly due to the spiky upright nature of the leaves. After this the height actually began to decrease due to the plants becoming more prostrate and the tuft opening up. At no time in the season was the grass ever as prostrate as *B. decumbens*, a useful species of the same genus.

The plant has not yet flowered but from outside observer's reports and according to Evans (1954) it can be expected to flower in late May. If that is the case *B. brizantha* will be the most periodic, as far as flowering is concerned, of all the grasses dealt with in this project, most being capable of flowering throughout the season. The well demarcated flowering period will facilitate the harvesting of seed on a commercial scale, provided the grass sets seed in Trinidad, which is doubtful.

As an attempt to induce flowering of *B. brizantha* at an earlier date a small Randomised block experiment was laid out
using micro-plots of 4'x3' to test the effect of growth regulating substances. Success had been achieved by Clark and Kerns (1942) in initiating the flowering of Pineapples in Hawaii by using alpha-naphthalene acetic acid, alpha-naphthalene acetamide and naphthalene-thio-acetamide as did van Overbeek (1945 and 1946) and Cooper (1942) in Florida. Flower initiation using hormone sprays is now standard practice with the Cabizona pineapple to control marketing problems. Tomatoes sprayed with 2-3-5 tri-iodo bezoic acid have been induced to produce literally thousands of flowers.

In the experiment with B. brizantha four chemicals were used at two concentrations, 10 p.p.m. and 100 p.p.m. applied at the rate of 50 gallons per acre. Two control plots were included which were sprayed with the equivalent amounts of water giving a total of 10 treatments replicated 4 times.

The following were the treatments applied.

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>CONCENTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain water</td>
<td>200 c.c.</td>
</tr>
<tr>
<td></td>
<td>400 c.c.</td>
</tr>
<tr>
<td>2-3-5 Tri-iodo bezoic acid</td>
<td>10 p.p.m.</td>
</tr>
<tr>
<td></td>
<td>100 p.p.m.</td>
</tr>
<tr>
<td>Alpha naphthalene acetamide</td>
<td>10 p.p.m.</td>
</tr>
<tr>
<td></td>
<td>100 p.p.m.</td>
</tr>
<tr>
<td>Beta naphthoxy acetamide</td>
<td>10 p.p.m.</td>
</tr>
<tr>
<td></td>
<td>100 p.p.m.</td>
</tr>
<tr>
<td>Alpha naphthalene acetic acid</td>
<td>10 p.p.m.</td>
</tr>
<tr>
<td></td>
<td>100 p.p.m.</td>
</tr>
</tbody>
</table>

The treatments were applied on the 15.2.55 when the area concerned was well grown and standing some 3 ft. high. To date (10th May) no flowers have been produced on the entire experimental area.

It is thus concluded that application of the growth promoting substance at that time of the year had no effect in
inducing flowering.

Economic uses and Yields.

In a review of the present grassland situation in Trinidad *B. brizantha* is described as being one of the most promising grasses for Trinidad (Howes and Campbell 1953) although no yield nor nutritive value figures are available.

In Kenya, at the Grassland Research Station, Kitale, a vigorous strain of *B. brizantha* has been discovered which promises to be good for grazing and leys. It has not passed through the initial plot stages and is being used in grass-legume trials (Kenya 1953). It is also suitable for the Ol Joro Orok district (Kenya 1951).

In Tanganyika at Mwapwa it is a grass that often invades Star grass pastures forming an excellent mixture and plays an important role in mixed natural pastures. (van Rensburg 1950). At Morogoro farm it has been found useful for facing bench terraces (Tanganyika 1952).

In Uganda at Kawanda it is described as one of the most promising local grasses, very palatable and standing up well to grazing but not producing much bulk (Uganda 1946 and 1950).

*B. brizantha* has been introduced to Hawaii from Texas and has proved drought resistant under their conditions, producing abundant dark green leaves and remaining green throughout the summer (Hūsaka 1948 and Hawaii Agric. Expt. Sta. 1943).

In the Belgium Congo it is said to be a very promising grass and palatable at all stages of development when tried at the Yangambi Research Centre.

Propagation and seeding ability.

Although *B. brizantha* from all accounts will flower in Trinidad during May or June it is not yet clear if it sets any seed or if the seed is viable. A "seed" sample harvested during May and June 1954 was examined and every seed was found to be blind, and was really a sample of dried out spikelets. This may
have been due to premature harvesting but it is suspected not to set seed.

At Katanga in the Belgian Congo it is one of the grasses recommended for seeding (Quarre 1945) although elsewhere in the Belgian Congo it appears to be propagated by cuttings (Belgian Congo 1951).

A dense clean stand has been established from seed at the Kawanda Experiment Station in Uganda, while it is said to be a promising grass for seed production in Tanganyika (Uganda 1950, van Rensburg 1950).

In Kenya at Ol Joro Orrok it sets seed shyly but there is a programme to improve seed setting ability by selection of ecotypes (Kenya 1951, 1952, 1953).

B. brizantha is easily propagated by root cuttings in Trinidad but it is a laborious and expensive method.

Recommendations.

B. brizantha grows well in Trinidad and appears to be tolerant to conditions of wetness and drought. Whether or not it is to be recommended depends largely upon its ability to produce viable seed as it does not produce sufficient bulk to warrant the expense of vegetative propagation. It is possible that better seed producing strains could be imported from Africa. No information has been found as to the seed setting ability of the Hawaiian or Texas strains but it is suspected that they too are propagated vegetatively.
ECHINOCHLOA PYRAMIDALIS Hitchc. and Chase.

Common names:- Antelope grass, Nyeki (Kikuyu) Ikigugu Rinundi (Kyimbila).

Taxonomy:-

Echinochloa pyramidalis Hitchc. and Chase belongs to the family Gramineae and the sub-family Panicoideae which is characterised by the fact that the spikelets fall entire from their pedicels singly or in groups. The spikelets have one terminal fertile floret with a male floret below it. It belongs to the tribe Paniceae which is the largest tribe of grasses with 1,300-1,400 species mostly Tropical or Sub-tropical with a few temperate species. (Bews 1929).

Origin and Ecology.

This grass was introduced to Trinidad as a root cutting from the Prinshof Grass Breeding Station, Pretoria, South Africa, in June 1953. It is a common grass throughout Tropical Africa and has been introduced into South America and Guadeloupe (Hitchcock and Chase 1917).

It is usually found in wet areas such as river banks and grassy swamps and according to Stapf: -"It forms the chief constituent of the great water meadows of the inundation region of the Niger and Lake Chad and also enters largely into the "sudd" of the Nile and other African rivers".

In spite of its semi-aquatic origin plants introduced to the Central Veld and Pasture Station, Southern Rhodesia, from Pretoria, have stood up well to drought and have commenced growing early in the season (Kennan 1950). A strain of E. pyramidalis named "Sikubu" has been collected on the flood plain near Bambatsi and shows exceptional tolerance to extremes of wetness and drought. It has hairless on the leaves and stems which is a decided advantage over the strain grown at the Imperial College and the Limpopo and Nata River strains, which have objectionable prickly hairs (West 1952).
The strain grown at the Imperial College has similarly shown tolerance to conditions of flooding and drought although no very severe drought was experienced, as can be seen from the rainfall figures in the appendix.

Morphological Description.

_E. pyramidalis_ is a reed-like perennial bunch grass with stems from 4'6" to 5' high and has a short stout rhizomatous root system.

The stems are succulent and fleshy at an early age but soon become coarse and fibrous, the lower portions and the lower leaf sheaths being covered with stiff white hairs making handling difficult.

The leaf sheath is overlapping and encloses the entire internode and may have a purplish tinge at the base. Auricles are absent but the ligule is present as a fringe of stiff dirty white hairs which decrease in size from the bottom of the plant upwards. The leaf blades are broad at the base 1/2"-3" and taper to a long fine point having a total length of 10"-14". The midrib is white and prominent while the leaf margins are serrated.

The panicle is erect and 4-6 inches long having numerous short dense side branches 1/2"-2" long borne on a stiff hairless main axis. On the side branches the spikelets are borne densely in four rows there being 9-12 spikelets per row. The spikelets are plump but finely pointed on a very short stalk and vary in colour from green to purple. The upper glume is as long as the spikelet and pointed, having 5-7 nerves with minute hairs. The lower glume is half the length of the spikelet and 5 nervied.

The spikelet consists of two florets the lower being male and containing three well developed anthers, and the upper being hermaphrodite with a large bilobed feathery stigma. The lemma is tough and shiny in the upper flower and clasps the palea
which is tough when compared to the male floret where it is membranous and transparent.

**Growth and Development.**

In early November 1954, because of the absence of seed *E. pyramidalis* was planted out from root cuttings. Weekly observations were made using a sample of ten plants and the emergence of leaves, tillers and flowers were noted. Leaf emergence was noted by cutting the tips of leaves already emerged and counting new ones each week. The tillers were counted on the sample plants, the average number of panicles per row was counted and the total height of the plant recorded.

In order to ensure that a complete stand was obtained 3 to 4 root cuttings were planted per hole, 1'x1', and this consequently hampered developmental studies as it was not known from how many plants the recorded leaves, tillers and panicles came; consequently as soon as the cuttings had struck they were thinned to one cutting per hole.

After a week there was 100% take of all cuttings and the buds on the axils of the leaves had begun to develop and produce the new tillers. Bud emergence was both intra- and extra-vaginal. By two weeks three leaves had appeared and the plant had grown from the cutting of 6 inches to 10 inches in height. After the first month the total height of the plant was 34 inches, there were 4 tillers and 23 leaves. Throughout the wet season on an average two tillers were produced per month with 1½-2 leaves produced per week. It was noteworthy that vegetative growth almost ceased from the month of February onwards the plants remaining static and the stems becoming very woody and fibrous. Although water logging occurred no adverse effects were noted and during the dry season apart from the general slowing down of growth with maturity, there were no signs of drought damage.

The first panicle emerged approximately 1½ months after planting and panicle emergence reached a maximum by the
end of February. There was, however, only a poorly marked flush and throughout the whole season there were panicles in the plot at all stages of development.

Economic uses and Yields.

In Uganda on the Kawanda Experimental Farm grazing plots, using a strain of Lango origin, *E. pyramidalis* is described as a grass standing up well to grazing, having given 506 grazing days per acre, with a good top stand but poor bottom. It gives good bulk but its palatability is only rated as fair (Uganda 1947).

In the Belgian Congo at the Yamgambi Research Station it is described as being only more or less palatable even in the young stages (Belgian Congo 1950) and as a ley it appears to benefit only the surface layers of the soil (Kuczarow 1949).

As a silage grass in Southern Rhodesia it has out yielded Maize the traditional silage crop, while under irrigation at Denalequin, New South Wales it has yielded over 6 Tons/acre. Yields of 5.44 Tons/acre have been obtained at the Central Veld and Pasture Station, Southern Rhodesia, when grown on soil no longer suitable for crop production.

Below are the analysis of the grass from Kenya and Southern Rhodesia:

<table>
<thead>
<tr>
<th>Southern Rhodesia Age ?</th>
<th>Kabete Kenya Age 3 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Ash.</td>
<td>Total Ash.</td>
</tr>
<tr>
<td>Acid Sol. Ash</td>
<td>Fibre</td>
</tr>
<tr>
<td>P205</td>
<td>Sol. C. - H.</td>
</tr>
<tr>
<td>Ca O</td>
<td>Ether Extract</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>Crude Protein</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>10.22 %</td>
<td>12.9 %</td>
</tr>
<tr>
<td>5.76 %</td>
<td>27.9 %</td>
</tr>
<tr>
<td>5.76 %</td>
<td>42.8 %</td>
</tr>
<tr>
<td>0.68 %</td>
<td>2.0 %</td>
</tr>
<tr>
<td>4.80 %</td>
<td>15.3 %</td>
</tr>
<tr>
<td>111.4 lbs/acre</td>
<td></td>
</tr>
</tbody>
</table>

(Kennan 1950). (Edwards 1951).

This strain was imported to Southern Rhodesia from the Prinshof Grass Breeding Station, Pretoria, and may possibly be the same as
that grown at the I. C. T. A. No chemical analysis has been done as yet at the I. C. T. A. and the above figures are only indicative and may differ considerably in Trinidad.

No yield figures are available for Trinidad as it was grown on such a small scale, but it is evident that it will produce a large bulk of material. In a small observational trial it was readily eaten by Zebu oxen although rather stalky. However no importance should be attached to this observation as it was probably curiosity on the part of the Zebras.

Propagation and seed setting ability.

In all the centres so far mentioned propagation has been vegetative and in none of the literature has propagation by seed been used, although West (1952) does mention seed production as being under investigation in Southern Rhodesia and Edwards (1951) states seed production to be poor. It is thus not clear if the strains of *E. pyramidalis* being used set seed or not. It is known from various sources however, that in parts of Northern Nigeria and the Sudan the grain is eaten by the Natives in times of want (Hubbard 1926, Bews 1929, Badcock 1955) indicating that there is at least one strain which sets seed, although it is not known if this seed is viable.

In Trinidad *E. pyramidalis* does not set seed although when tested with 2% iodine solution and neutral red stain both pollen and ovules appear to be viable. This may be due to the fact that the species is markedly self-sterile and that by the importation of a single root sent from Pretoria and subsequent vegetative bulking up, there exists a completely homozygous population in Trinidad, each plant being quite incompatible with each other.

Routine germination tests on wet filter paper and in "earth boxes" were carried out in case there were any seeds present, but in all cases there was no germination. Many samples
were examined throughout the season but not one yielded a single seed. The hard shiny lemma and the stiff palea looked on first examination like good full seed and only on close inspection were found to be completely empty. Both the anthers and stigmas protruded well outside the floret and pollon was liberated freely but no sign of fertilisation having taken place was seen.

The grass is easily though expensively propagated vegetatively from root cuttings, the short thick rhizomes striking fast. A small experiment was carried out in earth boxes to determine if stem cuttings could be used satisfactorily. Cuttings with one and two nodes were entirely covered or one node was allowed to protrude above ground. 60% success was achieved when one node was allowed to protrude while no plants emerged when the cutting was completely covered.

Recommendations for Trinidad.

_E. pyramidalis_ is obviously a grass capable of producing a large bulk of material under Trinidad conditions. It has been seen how the chemical composition can vary from place to place and the nutritive value in Trinidad has not been ascertained.

Although it is said to stand up well to grazing (Edwards 1951), being a reedlike bunch type, it is not a desirable type of growth for pastures.

A serious disadvantage is that it does not produce seed and has to be propagated vegetatively which is extremely expensive. This disadvantage may possibly be overcome by the importation of other strains which do set seed or alternatively, by new plants of the same strain, to overcome the suspected self-infertility. The importation of the glabrous "Sihubu" strain from Southern Rhodesia (West 1952) would be an improvement on the I.C.T.A. strain should the grass be adopted for use.

The semi aquatic properties of the grass together with
its drought resistance may make it suitable in those areas of Trinidad which experience seasonal flooding followed by dry spells.

Taxonomy.

The genus *Digitaria* Solier contains only one established species namely, *Digitaria adscendens* although three other species have been named. It belongs to the family Gramineae, the sub-family Bastafoideae and the tribe Paniceae.

Origin and Ecology.

Two importations of *Digitaria adscendens* have been made to the College, one in February and one from St. Augustine Experimental Station, Trinidad, and the other in April 1937 from the Department of Agriculture, West Indies. Both importations were in the form of seed. This grass, which has become common on many college grounds, including the College "Old Farm" as a weed and grassland, has a high stability at certain times of the year.

*Tapparum* is a term of Spanish origin common from Mexico to Colombia. It is applied to a species as a common weed, but there does not seem to be much evidence of it in Trinidad as although seed locomotion is fairly continuous throughout the year, vegetative spread is slight and it is in itself a useful plant. In Cuba it has adapted from cultivation in this way.

It is generally found in wet places at low altitudes but cannot be classified as a pampas grass.

Morphological Description.

*L. adscendens* is an annual or biennial growing to a height of 3" to 3 1/2". It is not markedly bunch grass, although it does have the bunch type of growth, and when planted close together gives a good cover. Stems are flattened and slightly swollen at the base with a deep groove up the internode. The
IXOPHORUS UNISETUS Schlecht

Common names: - Mexican grass

Taxonomy.

The genus *Ixophorus* Schelecht contains only one established species namely *Ixophorus unisetus* although three other species have been named. It belongs to the family Gramineae, the sub-family Panicoideae and the tribe Paniceae.

Origin and Ecology.

Two importations of *Ixophorus unisetus* have been made to the College, one in February 1947 from the St. Augustine Experimental Station, Trinidad, and the other in April 1947 from the Department of Agriculture, Venezuela. Both importations were in the form of seed. In the last eight years this grass has become common on road verges and plot boundaries on the College "Old Farm" as it sets seed freely and the seed has high viability at certain times of the year.

*Ixophorus* is a grass of Central American origin being common from Mexico to Colombia. It is described in these parts as a common weed, but there does not seem to be much danger from it in Trinidad as although seed production is fairly continuous throughout the year, vegetative spread is almost negligible, and it is in itself a useful plant. In Cuba it has escaped from cultivation in this way.

It is generally found in wet places at low altitudes but cannot be classified as a swamp grass.

Morphological Description.

*I. unisetus* is an annual or biennial growing to a height of 3' to 3'6". It is not markedly bunched, although it does have the bunch type of growth, and when planted close together gives a good cover. Stems are flattened and slightly swollen at the base with a deep groove up the internode. The
**IAOPHONUS UNISSETUS.**

Av. number of panicles per plant.

- Av. Height of plants.
- Number of plants germinated per plot.
stems are usually branched at the nodes and are extremely fleshy and succulent.

The leaf sheaths are folded with a prominent keel, and over-lap one another giving the stems a leafy appearance. The lower leaf sheaths are heavily pigmented, purple, and the nodes are pigmented all the way up the plant and swollen. Minute auricles are present and the ligule is a well developed membrane slightly pigmented. The leaf blades are up to 1" in breadth and 8-12 inches long tapering to a point and slightly keeled. The leaves are very soft and succulent with portions of the margins wavy.

The inflorescence is a panicle 5"-6" inches long having a well defined main axis bearing numerous spreading spike-like branches up to 2 inches in length at the base to ½ inch at the apex. Each branch is one sided, bearing a single row of closely grouped spikelets each subtended by a single bristle which exists after the spikelet has fallen. The spikelet consists of two florets, the upper fertile and the lower male. At maturity the lower palea becomes cartilaginous and winged, being much wider than the spikelet. This sterile palea persists with the seed, giving it its characteristic appearance. The seed on inspection appears roughened.

Growth and Development.

*J. unisetus* was planted both from cuttings and from seed in raised beds on the old farm.

The plot planted vegetatively took extremely well and grew vigorously throughout the remainder of the wet season; namely from November to January. A week after planting several of the plants flowered and the grass continued to flower throughout the season with a peak when the dry season began.

This was the only species grown that showed any marked set back due to drought. With the onset of dry weather growth ceased entirely and the lower leaves began to die off.
In the case of the plot sown from seed, half the plot had been treated with the equivalent of 10 tons per acre of pen manure. In the fertilized section of the plot germination was up to two weeks earlier than the unfertilized section. The germination period was from 2 weeks to 6 weeks after planting. The seeded plot was planted in the first week of December and appeared to be less susceptible to drought than the vegetative plot. It was notable however, that in only 4-5 weeks from germination many of the plants had run to seed.

A plot sown in February failed to germinate completely. This plot was irrigated from time to time, but it is not certain if it was a question of seed viability or drought.

Economic uses and Yields.

Because *I. unisetus* was only grown on micro-plots in this investigation, no yield nor nutritive values are known. It is a grass, however, that is extremely palatable at all stages and produces a fair amount of bulk. It has been used at the College in preliminary grazing trials and was completely eaten out in the first season. Unfortunately the trial was run in a paddock divided into three unfenced sections, each containing a different grass species and the cattle were allowed to graze over the whole area.

In Venezuela it is a grass occurring often in natural grazing and is considered to be useful (Mihelffy 1949).

In milk production trials in Hawaii Mexican grass *I. unisetus* proved to be more palatable and gave more milk per acre than Napier Fodder *Pennisetum purpureum*. It was also found to be higher in protein than all grasses tested excluding *Panicum purpurascens* (Henke 1943). Under Costa Rican conditions, as in Trinidad, growth was found to fall off considerably in February and March but responded well to irrigation. Here also it is said to have raised milk yields where it has been used and is a grass that is completely utilised (Esquivel G.R.).
Propagation and Seed setting ability.

*I. unisetus* is one of the few grasses studied which sets seed satisfactorily. On the plots grown for observation, and on adjacent plots the grass flowered practically continuously throughout the year. Seed samples were collected every month for germination tests and it was found that the quality of seed and germination percentage varied considerably with season, being higher in the dry months. The results of these germination tests together with those of other grasses will be found in section II.

Because of the high germination percentage *I. unisetus* was the grass used for a seed storage experiment and a quick viability test experiment described in section II, and the results from them apply directly to this grass.

In a preliminary small plot test, it was found that a seed rate of 25 lbs. to the acre gave rather too dense a stand and 15 lbs. of 24% germination seed is recommended.

Vegetative planting is possible though unnecessary. It is essential when propagating vegetatively to allow some of the cutting to protrude from the soil, hence it is thought to be a grass that would be easy to eliminate by ploughing.

Recommendations.

*I. unisetus* is an extremely palatable and well utilised grass giving a good ground cover. It is thought to be easily eliminated and is thus suitable for temporary leys. Its main advantage lies in the fact that it is easily propagated from seed, an essential factor in the economic use of any ley system.

*I. unisetus* is a grass that warrants further research and should not be rejected until yield and nutritive value figures have been obtained.

Because of its palatability and also its flowering habit *I. unisetus* would respond to a short rotational grazing system. It is thought that when it is again used in grazing or production trials that should be the system used.
**SETARIA SPHACELATA** Stapf. and Hubbard.

Common names:— Wooly finger grass (South Africa).

**Taxonomy:**

The genus *Setaria* Beauv. contains about 100 species found mainly in the warm parts of the world while a few do occur as weeds in temperate zones. The genus belongs to the family **Gramineae**, the sub family **Panicoideae** and the tribe **Paniceae**.

The species *Setaria sphacelata* is very variable and contains many widely differing types. These are at the moment grouped as strains or varieties of this species but it is thought that many may be unclassified species.

**Origin and Ecology.**

The seed of *S. sphacelata* was originally imported to the Imperial College as four so-called strains. One sample came from Tanganyika in January 1953, one from Uganda which failed, another from the Goldcoast which also failed and the fourth from Kenya in April 1953, known as the Nandi Strain. *S. sphacelata* is widely spread throughout Tropical and Sub-tropical Africa. Some strains are adapted for the drier areas and can be grown successfully where the rainfall is as little as 25" with reasonably good drainage (Liebenberg 1950), as for example the strain P. 1193 (Kennan 1950), and the du Toits-kraal type (Gildenuys 1950), while other strains do better in moister environments.

At this stage it may be prudent to attempt to explain the somewhat complicated collection of strains of *S. sphacelata* used commercially throughout Africa. In the literature reference is often made to strains by different names and causes a certain amount of confusion.

In 1937 at the Prinshof Grassland Research Station, a collection was made of several ecotypes from South and East Africa.
These strains showed very great variability in regard to size, stooling habit, seed production and susceptibility to Smut damage. The best of these were then selected for South African conditions and gave rise to the following strains being released P. 1193, P.1192, P.1191, P.1194 and P.1185 (Botha 1948). The Kasungulu or Kasungula strain referred to in East African literature is of course the same as the Kazungula strain mentioned in South African literature. What is not often realised, however, is that it is a synonym for the Prinshof strain P.1193, which originated from Bechuanaland. This strain is perhaps commercially the best developed. Similarly S. spacelata strain Kabula-bula is the Prinshof strain P.1185.

The Nandi strain grown in Nyasaland, Kenya and recently introduced to Trinidad, is similar in vegetative characters to the group of Prinshof strains P.1181, P.1200 and P.1191/5 and may be any one of them. These are generally speaking upright strains having shorter ears than most other types.

The type imported to Trinidad from Tanganyika seems to correspond more to the group of Prinshof strains P.1191, P.1192 or P.1193 and is probably the latter or Kazungula strain. Other commercial strains are the Bua River strain and New Bua River strain grown in Nyasaland and the du Toits Kraal type grown in the drier parts.

The Prinshof strains have been grouped into three ecotypes by Gildenhuys (1950). Firstly the Gomoti/Mogogelo River ecotype containing strains P.1181, P.1200 and P.1191/5, the parent stock of which is thought to have originated from the Marshland surrounding the Gomoti and Mogogelo rivers in N.W. Bechuanaland between latitudes 19°-20° South; Average rainfall 14-18 inches per annum.

Secondly the Kazungula ecotype containing strains P.1191, P.1192,P.1193, from the swamps surrounding the junction of the Zambesi and Chobi rivers in Northern Rhodesia, between
latitudes 18° and 19° South; Average rainfall 26 inches.

The third ecotype contains stoloniferous types and is thought to have originated in the Transvaal Middleveld between latitudes 24° and 26° South; Average rainfall 20-30 inches.

To quote Gildenhuys (1950) "It should be pointed out that the available 'strains' have been demarcated on what may be termed broadly a functional basis, since the final basis of their evaluation was their apparent merit as desirable agricultural types".

Morphological Description.

As has been already discussed two "strains" of S. sphacelata are growing at the Imperial College and these are described separately.

S. sphacelata strain Nandi, is a perennial bunch type grass growing to a height of 4' - 4'6" when in flower. The root system is shortly rhizomatous and not very extensive. The tillers arise from the root stock and are almost immediately perpendicular, flattened at the base but becoming rounder higher up. The leaves are hairless, 6-8 inches long, ½ inch wide and flattened, tapering to a point. The leaf sheaths clasp the internode loosely and are folded. Auricles are absent, but a ligule occurs as a well developed fringe of hairs. The purple colouring on the lower leaf sheaths is not as prominent in this strain as in others. The inflorescence is spikelike with spikelets grouped in threes and surrounded by numerous bristles giving a tapering cylindrical effect. The inflorescence varies from 6" to 12" in length and is rusty brown in colour. Each spikelet contains three florets the upper being fertile and the lower male.

The Tanganyika strain of S. sphacelata differs in several vegetative features. It is also a perennial bunch type but the bunch is very much more open centred and many of the branches
S. TANIA SPHACELATA Tanganyika & Nandi Strains.

Number of panicles per plant.

- Av. number of tillers per plant from seed.

- Number of plants per plot from seed.
emerge horizontally to begin with. The strain is very weakly stoloniferous, aerial roots being sent down from lower nodes. The tillers are very markedly flattened and succulent especially at the base where they can measure up to 1 1/4 inches across. The leaf sheaths are broad up to 1 1/4 inches, folded and enclose the stem entirely giving the plant a sheathlike appearance. The leaf blades are markedly folded and hairless being up to 14" in length. The leaf sheaths are often narrower than the blade making a construction in the region of the ligule which is poorly developed. The purple pigment at the base of each tiller is very marked in this strain. The inflorescence is longer, up to 18", than that of the Nandi strain and also thicker. Spikelet and floral arrangements are identical. This strain of *S. sphacelata* appeared to be more variable than the Nandi strain especially when grown from seed, as extremely prostrate types and almost upright types occurred.

Growth and Development.

The two strains of *S. sphacelata* were planted out from root cuttings on raised beds on the old farm. Root cuttings were used initially to ensure a complete stand and because the seed available had not yet been tested for viability.

The Tanganyika strain root cuttings took extraordinarily well and grew vigorously throughout both seasons, while in an adjoining plot the Nandi strain took extremely badly giving only a 75% stand and remaining almost stationary for the first month. In the case of the Nandi strain growth was most abnormal. The buds in the axils of the old leaves on the cuttings began to develop and formed a tufted mass of leaves which looked extremely healthy. Thereafter the original stem dried off and consequently the new leaves died off too. Subsequent growth was then from the base of the plant and thereafter quite normal tillers were produced. In the case of the Tanganyika strain large "fans" of leaves and leaf sheaths were produced at each node of the cutting,
Economic uses and Yields.

*S. spachcelata*, with its numerous strains of differing growth habits, lends itself to grazing, hay making or silage.

Of the strains suitable for silage P.1185 has given yields of 25 tons per acre at Dohne, South Africa, out yielding maize the traditional silage crop (South Africa 1951). Strains P.1192 and P.1193 gave yields of 18.08 tons per acre and 23.91 tons per acre respectively at the Central Veld and Pasture Station for Matebeleland (Kennan 1950), P.1192 being out yielded as it is less drought resistant.

As a silage crop it has been introduced to Rabat in Morocco in favour of *S. nigrirostis* and yielded up to 20 tons per acre from two cuts without irrigation (Foury A 1953). In the Belgian Congo cut 5 times a year it has yielded as much as 45 tons per acre (Belgian Congo 1952) and has also yielded well in Tanganyika but is said to be more delicate than Elephant grass but more leafy and easier to handle (van Rensburg 1953).

For hay it is advisable to mow it just as the first seed haulms appear, as strains P.1185 and P.1194 become particularly fibrous when mature. The thin-stemmed P.1193 strain is the easiest with which to make hay (Botha 1948).

For grazing the du Toits Kraal, P.25 and P.317 strains are most suitable as they are stoloniferous and give better ground cover (Gildenhuyys 1950).

In the Belgian Congo at Nicha Experimental Station *Chloris gayana*, *Setaria spachcelata* and lucerne have given good results as a grazing mixture, as has *Setaria* with *Digitaria umfolozi*. (Belgian Congo 1949). In a later report (Belgian Congo 1951) success has been achieved with a mixture of *chloris gayana*, *S. spachcelata* and *Melinis minutiflora*. No specific strains have been mentioned in any mixture.
Propagation and Seed setting ability.

*S. sphacelata* is one of the more promising grasses as far as setting ability is concerned. Both strains flowered readily in Trinidad and produced viable seed. It was notable that with the onset of drier weather in February and March the viability of the seed rose. Germination percentages were however, on the whole, disappointingly low, varying with sample around 5% with one exceptionally high sample of 28% germination, which compares poorly to figures of 80% obtained in South Africa. It is thought that the low germination percentage was mainly caused by the presence of green immature seeds in the sample and this in turn is thought to be due to the harvesting technique. With a grass such as *S. sphacelata* it is impossible to get any panicle to be 100% ripe as flowering and seed setting is progressive from the extremities, but the harvesting technique can improve matters.

Initially all panicles were harvested, when the majority of the seeds were considered ripe, by cutting it from the stem immediately below the panicle. When the flower culms were cut at the base and made into a sheaf to dry out, germination percentages rose appreciatively. This was presumably due to the seeds which were immature at cutting drawing nutrients from the stem. It is recommended that this procedure should be followed in future.

In South Africa seed production has reached a commercial scale although seed samples are difficult to clean satisfactorily. The general practice for sowing is to mix the seed with fertilizer at the rate of 4-8 lbs. per acre and plant with a maize planter.

The various strains of *S. sphacelata* differ considerably in their seed setting ability and careful selection will no doubt give rise to homozygous high seeding types (Gildenhuyys 1950). In South Africa yields of 125-130 lbs. per acre of seed are obtained on a commercial scale.
It is interesting to note that the procumbent du Toits Kral type sets more seed than the bunch Kazangula type under South African conditions (Gildenhuys 1953). This is converse to the theory generally held.

Recommendations.

*S. sphacelata* is a grass which from its performance in small plots at the Imperial College appears to be well suited to Trinidad conditions. The Nandi strain admittedly appeared to be set back by water-logged conditions during the wet season but this was not the case with the Tanganyika strain, which appeared to thrive during both the wet and the dry season. It is an extremely palatable grass and from all accounts stands up well to grazing but gives a poor cover being tufted.

The main advantage is of course that, even with the relatively low germination, it is a pasture which can be established from seed, thus eliminating the expense of vegetative propagation.

Seed production can no doubt be improved by the importation of a bigger variety of strains and by selection from them.
SECTION II

THE USE OF 2,3,5 TRIPHENYL-TETRAZOLIUM CHLORIDE AS A MEASURE OF THE SEED VIABILITY OF MEXICAN GRASS IXOPHORUS UNISETUS.

Introduction.

The standard method of determining the viability of seeds by germination will generally give good results with very little labour. There are times however when this process may take too long and when a rapid test is needed, as for example in the case of seeds having a long dormant period or responding slowly to after ripening treatments.

Various methods of quick determination have been tried with varying degrees of accuracy. Physical methods based on the respiration of seed, its reaction to electric currents and its capacity to withstand the extraction of electrolytes and colloids have been tried but rejected as being too indeterminate.

Many methods depend on the detection of specific enzymes or groups of enzymes and here the exactness lies in the precision with which the transition from life to death can be detected. Methods based on the presence of diastase, catalase or phenolase enzymes lack precision, but dehydrase and peroxidase reactions appear to be satisfactory. Tests employing the peroxidase reaction are the benzedene and quaiacol tests and malachite green has also been used on peas. (Mackey 1950).

2,3,5 triphenyl-tetrazolium chloride and sodium biselenite tests are based on the dehydrase reaction and appear to be the the most useful.

Using the selenium stain Lakon developed what he called the topographical method of determining viability, and showed it to be a quick and reliable method to use with common cereals. It was seen that in many cases the embryo was only partly strained and hence some criterion of viability became
necessary. Lakon assumed firstly, that those areas of the embryo that stained were the seat of active enzyme reactions and alive, where as the unstained portion was incapable of growth. In the second place he assumed a seed to be viable only as long as all parts of the embryo essential for the development of the plant and not capable of being regenerated were alive (Hyde 1949). Thus for each species dealt with it is necessary to know the location and importance of all primordia in the embryo. Seeds with many seminal roots are not affected by the death of some primordia.

In 1941 Kuhn and Jerchel drew attention to the use of Tetrazolium salts for quick viability tests, and acting on this Lakon, after trying a number of salts, substituted 2,3,5 Triphenyl tetrazolium chloride for the poisonous selenium salts in this topographical method (Hyde 1949).

Tetrazolium salt or T.T.C., the common name for the chemical, was first prepared by von Peckman and Runge in 1894. It is a pale yellow crystalline powder, very soluble in water. It is advisable to keep it and the solution in a dark glass bottle as it is light sensitive and turns dark on exposure (Niles 1954). The use of Tetrazolium salt has a distinct advantage over many indicators as a viability test, since it is one of the comparatively few organic compounds that is coloured in the reduced state. In the presence of viable tissue the yellowish tetrazolium salt forms the insoluble bright red triphenyl formozan by the following reaction.

\[
N^- \text{N} - \text{C}_6\text{H}_5 - \text{C} + 2e + 2H^+ \rightarrow \text{C}_6\text{H}_5 - \text{C} + \text{H}^+ \text{Cl}^- \]

Colourless

Red

The procedure for testing viability as outlined by Lakon for Maize and followed, with certain modifications, by other workers, consists briefly of the following steps.
The grain is soaked over night and then bisected longitudinally through the embryo, half of each grain is then steeped in a 1% solution of Tetrazolium chloride at room temperature for three hours, results being obtained in 24 hours. Seeds are considered viable if the plumule, embryo axis and central portion of the scutellum react to the stain. This method has now been adopted by German seed testing stations for maize and cereals as routine and it is hoped to extend it to legume, cruciferous and certain grass seeds. (Lakon 1951).

However some workers still consider the method too inaccurate for general application and not suitable for small seeds. (Gadd 1951, Cottrel 1950).

Certain modifications and refinements have been added to Lakon's test. Ritvanen working with the seed of Phleum pratense 'scaled' the seeds initially and found it only necessary to cross section the seed near the embryo. Staining was done in the dark for 19-24 hours at 18-20°C, but it was found that 5 hours was sufficient time when kept at 45°C. Viable seeds were considered to be those with the embryo wholly stained or with everything but the main root stained. (Ritvanen 1953).

Hyde, working with Perennial rye grass Lolium perenne in 1952 in connection with "blind seed disease", sterilized the seed after soaking to prevent bacterial breakdown of the stain. The seeds were only bisected for two-thirds of the length of the seed and placed in the bromide salt of Tetrazolium. Various incubation temperatures were tried and different concentrations of the salt. It was found that good staining could be obtained in 5 hours after incubation at 30°C, using a 1% solution. The criterion of viability was that the central portion of the embryo axis, from which the lateral seminal roots arise, should react. (Hyde 1952).

Working with the seed of Chewings fescue Festuca rubra, the same author found that by merely puncturing the pericarp with a dissecting needle good staining could be obtained on the
surface of the embryo. The stain could be seen through the translucent lemma but partly stained embryos were dissected out for further examination. In this case the seed was considered viable if the plumule, the embryo axis down to the epiblast and $\frac{3}{4}$ of the visible portion of the scutellum reacted to the stain.

Bass, working with Kentucky blue grass seed *Poa pratensis*, soaked the seed after staining with lactophenol solution for two hours to render the lemma and palea more transparent. He used only a 0.05% solution of Tetrazolium chloride and found 7.6% of his results were outside the tolerances for seed testing. No indication of having tried a higher concentration is given. (Bass 1953).

*Paspalum notatum*, a notoriously difficult seed to test for germination, responds well to this stain if certain modifications are made to the test. Porter and Romm found that the viability of *Paspalum notatum* declined if pre-soaked for more than 3 days at 20°-30°C. To overcome this the seed was soaked for 16 hours at 20°C, then placed on a petri dish on moist filter paper at an alternating temperature of 20°C for 16 hours and 35°C for 8 hours over a period of 2-4 days. The seeds were then sectioned and soaked in a 1% solution of tetrazolium chloride for 8 to 24 hours. In a germination test to check the reliability of the tetrazolium test it was found that alternating temperatures of either 15°-30°C or 20°-35°C were favourable for the germination of *P. notatum* seed. (Porter et al 1947).

Tests were carried out in this project to determine the suitability of the Tetrazolium salt when applied to tropical grasses as, with the exception of work done by Porter et al. on *Paspalum notatum*, most investigations have been limited to temperate species. The seed of Mexican grass *Ixophorus unisetus* was chosen, not so much because of its commercial value but because samples of reasonably high viability were available.

The methods of treatment were adapted from work already mentioned in an attempt to find the most satisfactory treatment for this species.
Experimental procedure.

Three samples of *I. unisetus* were available. The samples had been harvested at different times and it was suspected that the viability from sample to sample varied. Initial standard germination tests were thus carried out and germination percentages of 24%, 56% and 71% were obtained. Each sample was then subdivided into three sub-samples each of 50 seeds.

The seeds characteristically attached to the entire spikelet and cartalaginous sterile palea were first thrashed out by rubbing vigorously between the palms of the hand, placed in 95% alcohol and floating off the extraneous material.

The seeds were then "dehusked" by removing the enclosing lemma and palea with forceps. In a trial it was found easier to remove these parts when the seed was dry rather than after soaking for 16 hours as then the embryos were easily damaged. The dehusked seeds were then soaked in tap water overnight for approximately 16 hours at room temperature of about 72°F.

The soaked seed samples were then treated by either sectioning completely in the region of the embryo, pricking with a dissecting needle, care being taken not to damage the embryo, or no treatment at all. Thus each sub-sample of a particular germination sample received one of the treatments.

All the samples were then placed in watch glasses and covered with a 1% solution of 2,3,5 Triphenyl-tetrazolium chloride and inspected hourly for staining. The watch glasses were not placed in the dark but out of direct sunlight at about 84°F.

Results.

Staining was noticed on some of the seeds only half an hour after emersion, while all the seeds had been stained after 4 hours.

It was found that the majority of embryos were completely and brightly stained. A few were completely but less brightly
stained and were also taken as being viable. A very small number was stained in small patches on both the plumule and the radicle while several had only the radicle faintly stained. These two groups were taken as being non-viable. Had more time been available for the experiment it was intended to test statistically this criterion of viability by correlation with the results from germination tests. However, this assumed criterion corresponds very closely to the germination figures and is hoped to be the correct one. Had every stained seed been included in the estimate of viability, the figure would have been grossly exaggerated. The test appeared to be rather more accurate in the case of the samples with a high percentage of viable seeds than in the case of the sample with low viability.

The results are given in tabular form below:

<table>
<thead>
<tr>
<th>Germination Test %</th>
<th>Seed Treatment</th>
<th>Tetrazolium Test %</th>
<th>Av.%</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 %</td>
<td>Cut</td>
<td>20 %</td>
<td>22.6 %</td>
<td>4 %</td>
</tr>
<tr>
<td></td>
<td>Pricked</td>
<td>26 %</td>
<td>22.6 %</td>
<td>2 %</td>
</tr>
<tr>
<td></td>
<td>No Treatment</td>
<td>22 %</td>
<td>22 %</td>
<td>2 %</td>
</tr>
<tr>
<td></td>
<td>Cut</td>
<td>58 %</td>
<td>58 %</td>
<td>2 %</td>
</tr>
<tr>
<td></td>
<td>Pricked</td>
<td>58 %</td>
<td>58.86%</td>
<td>2 %</td>
</tr>
<tr>
<td></td>
<td>No Treatment</td>
<td>60 %</td>
<td>60 %</td>
<td>4 %</td>
</tr>
<tr>
<td></td>
<td>Cut</td>
<td>72 %</td>
<td>72 %</td>
<td>2 %</td>
</tr>
<tr>
<td></td>
<td>Pricked</td>
<td>70 %</td>
<td>70 %</td>
<td>1 %</td>
</tr>
<tr>
<td></td>
<td>No Treatment</td>
<td>68 %</td>
<td>68 %</td>
<td>3 %</td>
</tr>
</tbody>
</table>

Summary and Conclusion.

It was found that I. unisetus reacted to the stain Tetrazolium chloride which gave a good indication of viability 4 hours after staining. The criterion of viability appears to be satisfactory judging from the comparison with the germination test. There appeared to be no difference in staining between the various treatments applied to the seed and hence in future
with this species the untreated seed should be used.

Although generally considered to be a laborious and skilled process of testing seed viability the tetrazolium chloride test in the case of *I. unisetus* proved to be an extremely easy and rapid method, that could be carried out by untrained laboratory staff.

Recently the increasing appreciation of the importance of good seed storage and handling has been directed towards grass seed storage. Work has been mainly directed towards methods of determining viability in a sample, rather than of retaining viability.

The work that has been done on the storage of grass seeds has mostly been carried out under laboratory conditions and hence it was the aim of this investigation to determine the effects of various conditions of temperature and seed moisture content under field conditions.

The moisture content of the seed greatly storage has been known for some time to affect viability. German et al., working with Italian rye grass *Lolium multiflorum* in New Zealand stored samples of seed at room temperature (Mean 65°F Range 40°F to 70°F) for four years in well ventilated buildings. To obtain the various humidity levels the seed was stored in desiccators containing differing concentrations of sulphuric acid. It was found that when the four-year seed stored at 9 to 11% humidity test little viability, at 15% humidity viability was retained for two years but was reduced rapidly at 16% humidity viability declined after 2 weeks and was totally lost after 3 years while at 19% humidity the sample lost 90% viability in 18 months. It was the moisture content that under these conditions seed samples would retain their viability without sealed storage if initially air dried at 100°F (Cheney et al. 1961).

Working with *Timothy Phleum pratense* Stenberger et al.
THE EFFECT OF STORAGE CONDITIONS ON THE VIABILITY OF 
GRASS SEED UNDER WET TROPICAL CONDITIONS.

Introduction.

Most of the classical works done on the viability of seeds such as Barton and Crocker's "20 years of Seed research" have been carried out either on vegetable, weed, or forest seeds and little early work appears to have been done on grass seeds.

Recently with the increasing realisation of the importance of grass as a crop, more attention has been directed towards grass seed research. Early work was mainly directed towards methods of determining viability in a sample, rather than of retaining viability.

The work that has been done on the storage of grass seeds has mostly been carried out under temperate conditions and hence it was the aim of this investigation to determine the effects of various conditions of temperature and seed moisture content under Tropical conditions.

The moisture content of the seed during storage has been known for some time to affect viability. Gorman et al., working with Italian rye grass Lolium Italicum in New Zealand stored samples of seed at room temperature (Mean 55°F Range 40°F to 70°F.) for four years at high and low humidities. To obtain the various humidity values the seed was stored in desiccators containing differing concentrations of Sulphuric acid. It was found that over the four years seed stored at 9 to 11% humidity lost little viability, at 13% humidity viability was retained for two years but then declined rapidly, at 16% humidity viability declined after 6 months and was totally lost after 3 years while at 19% humidity the sample lost 90% viability in 12 months. It was the authors conclusion that under these conditions seed samples would retain their viability without sealed storage if initially air dried to 12% (Gorman et al. 1951).

Working with Timothy Phleum pratense Shenberger et al.
also found that storage at high moisture contents of 17% depressed germination and that the effect was accentuated by hermetically sealed storage. (Shenberger 1952).

Temperature is another extremely important factor in the retention of viability and Bass (1953) working with Kentucky Blue grass Poa pratensis in Iowa combined this factor with moisture content. He found that the higher the moisture content of the seed/quickier it lost viability at high storage temperatures. Samples of 11% moisture were able to withstand temperatures of 60°C, without ill effect. The storage period, however, only ranged from 4-48 hours. In an experiment in New South Wales, Australia, to test the keeping quality of lucerne (Medicago sativa) seed under different climatic conditions; it was found that loss of viability was affected more by high moisture content of the sample than by high temperature, but again if both were high it was most destructive. In the sub-tropical area with a 64" Rainfall sealed storage was preferable to unsealed storage, while in the arid area 25" Rainfall it made little difference. (Myers 1952).

In Egypt with summer temperatures of 30-35°C. and 75% Relative Humidity Kochia indica seeds lose viability rapidly over 12 months. Seeds were kept in the laboratory open to the air at 30°C., at 30°C. over Calcium Chloride in a sealed container and at 38°C. in an oven opened to the air. It was shown again that loss of viability was accelerated more by high moisture than temperature, the best results being given by sealed storage over CaCl₂ at 30°C. (El-Shishiny 1953).

In Russia, working with Kochia prostrata good retention of viability was obtained at 15°C. over CaCl₂, with adequate aeration. Sealed storage was said to be definitely deleterious to viability retention.
Experimental design.

With this general knowledge of the effect of temperature and moisture content, it was decided in this investigation to have a factorial design with samples in a series of moisture contents, stored at different temperatures. Three temperatures for storage were available in the cold store in Port of Spain, namely 20°F., 45°F. and 60°F while one treatment would be storage at room temperature from 72-92°F.

The moisture contents of the samples were to range from 0.5%, 2%, 6%, 12%, 18.5% to a sample with no moisture control. The experiment is to last for 4 years, two samples of 50 seeds for germination tests being taken every 3 months throughout the first year, every 4 months during the second year, every 6 months throughout the third year and a final sample at the end of the fourth year. The experiment has two replications.

Method.

The seed used in this experiment was that of Mexican grass *Ixophorus unisetus*, chosen because of its high initial viability and availability. It was originally decided to use the seed of *Setaria sphacelata* but by the time suitable chemical combinations of the dehydrating agent had been arrived at, the available seed had been used and tests had to be repeated using *Ixophorus unisetus*.

To get the seed sample to the desired moisture content 1 gram samples were weighed out into a test tube in which was placed different combinations of dehydrating agents separated from the seed by cotton wool and corked. These were then left for 3 weeks to reach equilibrium after which the seed was removed and tested for moisture by heating at 100°C. for 24 hours.

In order to get the right combinations of dehydrating agents three trials had to be run.

In the first test sodium carbonate was used in a range
of five combinations of the anhydrous and hydrated forms, from 5 grams Anhydrous with no hydrated to 1 gram Anhydrous with 4 grams hydrated.

In a second test the quantities were merely doubled, while in a third test Calcium Chloride and Sodium Carbonate were used in various combinations. From these combinations it was then possible to pick out the correct quantities of dehydrating agent to give the desired moisture content. The result of these combinations and the statistical analysis of the results are presented in the Appendix.

Initially it was intended, once the desired moisture content had been obtained, to keep the samples in sealed glass tubes of special design. During the course of the experiment however, it was found that after 3 weeks in a corked test tube with the dehydrating agent the seed samples reached equilibrium, added to which samples for germination tests could easily be taken from a test tube but not from a sealed glass tube. In order to get the ten germination samples from the 24 treatments, 240 glass tubes would have been necessary and would have added greatly to the cost of the experiment.

Once the required combinations were obtained a sample of *Ixophorus unisetus* was harvested and a standard germination test done which gave 85% viable seeds. Testube were then prepared to give the twenty four treatment combinations and placed in the appropriate temperature store.

The following results and statistical analyses are given in some detail as a guide to subsequent germination tests. This being the first germination test there is of course, in the analysis of variance, no variation due to the time of storage. This variation must thus be included, once more than one set of results are available.
<table>
<thead>
<tr>
<th>Temperature &amp; Moisture</th>
<th>$%$ Germination converted to Degrees (Fisher &amp; Yates)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Block 1</td>
</tr>
<tr>
<td>0.5% at 72°</td>
<td>59.3</td>
</tr>
<tr>
<td>&quot; &quot; 20°</td>
<td>69.7</td>
</tr>
<tr>
<td>&quot; &quot; 45°</td>
<td>26.6</td>
</tr>
<tr>
<td>&quot; &quot; 60°</td>
<td>36.9</td>
</tr>
<tr>
<td>2% at 72°</td>
<td>56.8</td>
</tr>
<tr>
<td>&quot; &quot; 20°</td>
<td>40.4</td>
</tr>
<tr>
<td>&quot; &quot; 45°</td>
<td>46.1</td>
</tr>
<tr>
<td>&quot; &quot; 60°</td>
<td>43.9</td>
</tr>
<tr>
<td>6% at 72°</td>
<td>50.8</td>
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<tr>
<td>&quot; &quot; 20°</td>
<td>45.0</td>
</tr>
<tr>
<td>&quot; &quot; 45°</td>
<td>56.8</td>
</tr>
<tr>
<td>&quot; &quot; 60°</td>
<td>48.4</td>
</tr>
<tr>
<td>12% at 72°</td>
<td>39.2</td>
</tr>
<tr>
<td>&quot; &quot; 20°</td>
<td>36.9</td>
</tr>
<tr>
<td>&quot; &quot; 45°</td>
<td>48.4</td>
</tr>
<tr>
<td>&quot; &quot; 60°</td>
<td>50.8</td>
</tr>
<tr>
<td>18.5% at 72°</td>
<td>39.2</td>
</tr>
<tr>
<td>&quot; &quot; 25°</td>
<td>33.2</td>
</tr>
<tr>
<td>&quot; &quot; 45°</td>
<td>30.0</td>
</tr>
<tr>
<td>&quot; &quot; 60°</td>
<td>26.6</td>
</tr>
<tr>
<td>No Control at 72°</td>
<td>23.6</td>
</tr>
<tr>
<td>&quot; &quot; 20°</td>
<td>29.3</td>
</tr>
<tr>
<td>&quot; &quot; 45°</td>
<td>43.9</td>
</tr>
<tr>
<td>&quot; &quot; 60°</td>
<td>25.1</td>
</tr>
</tbody>
</table>

Total | 1006.9 | 935.0 | 1941.9 |

Total S.S. | 86,408.77 | Correction Factor | 78,561.99 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>78,561.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7,846.78</td>
<td>Treatment S.S.</td>
<td>85,640.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78,561.99</td>
</tr>
<tr>
<td></td>
<td>78669.69</td>
<td>Replication S.S.</td>
<td>78561.99</td>
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<td>78561.99</td>
<td></td>
<td>7,078.63</td>
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<tr>
<td></td>
<td>107.70</td>
<td>Error S.S.</td>
<td>660.45</td>
</tr>
</tbody>
</table>
### INTERACTION TABLE

<table>
<thead>
<tr>
<th>% Moisture</th>
<th>Temperature Treatments</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20°C</td>
<td>45°C</td>
</tr>
<tr>
<td>0.5</td>
<td>139.4</td>
<td>57.3</td>
</tr>
<tr>
<td>2.0</td>
<td>77.3</td>
<td>91.1</td>
</tr>
<tr>
<td>6.0</td>
<td>78.2</td>
<td>126.5</td>
</tr>
<tr>
<td>12.0</td>
<td>48.4</td>
<td>99.2</td>
</tr>
<tr>
<td>18.5</td>
<td>66.4</td>
<td>66.6</td>
</tr>
<tr>
<td>No Control</td>
<td>55.9</td>
<td>88.9</td>
</tr>
<tr>
<td>Total</td>
<td>465.6</td>
<td>519.6</td>
</tr>
</tbody>
</table>

S.S. for Moisture Treatments 81,250.10  
78,561.99  
2,688.11

S.S. for Temperature Treatments 78,849.91  
78,561.99  
287.92

Interaction Moisture x Temperature S.S. 4,102.60

### ANALYSIS OF VARIANCE

<table>
<thead>
<tr>
<th>VARIATION</th>
<th>D.F.</th>
<th>S.S.</th>
<th>M.S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replications</td>
<td>1</td>
<td>107.70</td>
<td>107.70</td>
<td>3.75</td>
</tr>
<tr>
<td>Moisture Treatments</td>
<td>5</td>
<td>2688.11</td>
<td>537.62</td>
<td>18.72</td>
</tr>
<tr>
<td>Temperature</td>
<td>3</td>
<td>287.92</td>
<td>95.97</td>
<td>3.34</td>
</tr>
<tr>
<td>Moisture x Temp.</td>
<td>15</td>
<td>4102.60</td>
<td>273.51</td>
<td>9.52</td>
</tr>
<tr>
<td>Error</td>
<td>23</td>
<td>660.45</td>
<td>28.72</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>7846.78</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Both the Moisture treatments and interaction are highly significant as a cursory examination of the data would lead one to expect.

S.E. of Moisture Treatment TOTAL = 21.43
Summary of Results.

It can be seen from inspection of the Moisture treatment totals that viability has been retained better at lower moisture contents. There appears to be no advantage so far in reducing the moisture content of this seed below 6% for 3 months storage. It will be interesting to see if the optimum temperature becomes lower with time.

It is of interest to notice that the treatment with 0.5% moisture retained viability well, as the treatment was included as an extreme to discover the minimum moisture content the seed would tolerate.

Seed stored at 12% moisture although having a poorer viability than that below 6% was significantly better than either 18.5% or the treatment with no control, between which there was no difference.

Interaction between Moisture and Temperature treatments becomes apparent at the higher moisture content levels which retained viability better at lower temperatures.

Summary and Conclusions.

This experiment has been laid out to determine the optimum conditions of seed storage under wet tropical conditions, using the seed of *Ixophorus unisetus* as the test material. The experiment includes six moisture treatments ranging from seed samples having 0.5% moisture to those with 18.5% and no control
at all, four temperature treatments $20^\circ C, 45^\circ C, 60^\circ C$ and room temperature and all combinations of temperature and moisture giving 24 treatments, replicated twice. The experiment is to last for 4 years, germination tests being done on the treatments every 3 months in the first year, every four months in the second year, every six months in the third year and a final test at the end of the fourth year.

The results of the first test are presented and indicate that the moisture content of the seed is more important than storage temperature but that results are very poor when both are high.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grass anhydrous $\text{Ca}_2\text{CO}_3$</th>
<th>Grass hydrous $\text{Ca}_2\text{CO}_3\cdot10\text{H}_2\text{O}$</th>
<th>$X$ Moisture</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>9</td>
<td>4.19</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2.66</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>2</td>
<td>7.63</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>3</td>
<td>7.50</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4.10</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>6.31</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1</td>
<td>3.12</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>2</td>
<td>3.76</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>3</td>
<td>12.07</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>4</td>
<td>11.26</td>
<td>$p &lt; 0.05$</td>
</tr>
</tbody>
</table>

As the desired range of expected results had not yet been obtained a further experiment was carried out using combinations of Calcium chloride and dichromate. The results are as follows:
APPENDIX

Seed Storage Experiment.

In the first experiment to determine the right combination of dehydrating agents to achieve the desired range of seed moisture contents, Sodium carbonate, anhydrous Na₂CO₃ and hydrous Na₂CO₃·10H₂O, were used. The experiment was replicated three times and analysed statistically giving the results in the following table. The second experiment was made up of the same combinations of the chemical but the amounts were doubled, replication and analysis was the same.

Results of 1st and 2nd Experiments:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grams anhydrous Na₂CO₃</th>
<th>Grams hydrous Na₂CO₃·10H₂O</th>
<th>% Moisture</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>0</td>
<td>4.19</td>
<td>1&gt;2***</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>1</td>
<td>4.85</td>
<td>2&gt;3***</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>2</td>
<td>7.83</td>
<td>3&gt;4*</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>3</td>
<td>7.38</td>
<td>3&gt;5***</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>4</td>
<td>7.10</td>
<td>4&gt;5 N.S.</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>0</td>
<td>5.61</td>
<td>6&gt;7 N.S.</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>2</td>
<td>6.13</td>
<td>7&gt;8***</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>4</td>
<td>9.76</td>
<td>8&gt;9***</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>6</td>
<td>12.77</td>
<td>N.S.</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>8</td>
<td>11.85</td>
<td>9&gt;10 N.S.</td>
</tr>
</tbody>
</table>

As the desired range of moisture contents had not yet been obtained a further experiment was run using combinations of Calcium chloride and anhydrous Sodium Carbonate. The results are as follows:
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grams Calcium Chloride $\text{CaCl}_2$</th>
<th>Grams anhydrous $\text{Na}_2\text{CO}_3$</th>
<th>% Moisture</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>0</td>
<td>0.55</td>
<td>$3 &gt; 1^x$</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>2</td>
<td>0.77</td>
<td>$4 &gt; 1^{xx}$</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>4</td>
<td>1.15</td>
<td>$5 &gt; 1^{xxx}$</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>6</td>
<td>1.31</td>
<td>$4 &gt; 2^x$</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>8</td>
<td>2.050</td>
<td></td>
</tr>
</tbody>
</table>
Germination tests were carried out throughout the season between two moist filter papers in glass butter dishes. In some cases seeds were planted out at the same time in boxes containing soil and these results are referred to in the remarks column following as Box. In all cases 100 seeds constituted a sample for germination.

<table>
<thead>
<tr>
<th>Species</th>
<th>Date of harvest</th>
<th>Age of seed</th>
<th>No. of days to germinate</th>
<th>% germination</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Acroceras macrum</td>
<td>11.11.54</td>
<td>0 months</td>
<td>-</td>
<td>0.0%</td>
<td>Blind seed</td>
</tr>
<tr>
<td></td>
<td>17.1.55</td>
<td>0 months</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.3.55</td>
<td>0 months</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>2. Andropogon gayanus</td>
<td>8.4.54</td>
<td>9 months</td>
<td>17</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.1.54</td>
<td>13 months</td>
<td>5</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.11.53</td>
<td>15 months</td>
<td>10</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.12.53</td>
<td>14 months</td>
<td>5</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.3.54</td>
<td>9 months</td>
<td>2-10</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20.2.54</td>
<td>12 months</td>
<td>3-9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20.2.54</td>
<td>12 months</td>
<td>21</td>
<td>10%</td>
<td>Box</td>
</tr>
<tr>
<td></td>
<td>11.11.54</td>
<td>0 months</td>
<td>-</td>
<td>0.0%</td>
<td>Poorly developed</td>
</tr>
<tr>
<td></td>
<td>17.1.55</td>
<td>1 month</td>
<td>8</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20.2.55</td>
<td>0 months</td>
<td>-</td>
<td>0.0%</td>
<td>Too fresh</td>
</tr>
<tr>
<td></td>
<td>20.2.55</td>
<td>0 months</td>
<td>25</td>
<td>2%</td>
<td>Box</td>
</tr>
<tr>
<td></td>
<td>20.2.55</td>
<td>1 month</td>
<td>6</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18.3.55</td>
<td>1 month</td>
<td>3-6</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>3. Bothriochloa pertusa</td>
<td>11.1.55</td>
<td>0 months</td>
<td>-</td>
<td>0.0%</td>
<td>Blind seed</td>
</tr>
<tr>
<td></td>
<td>13.2.55</td>
<td>0 months</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>4. Brachiaria brizantha</td>
<td>27.10.53</td>
<td>14 months</td>
<td>-</td>
<td>0.0%</td>
<td>Blind seed</td>
</tr>
<tr>
<td></td>
<td>27.10.53</td>
<td>14 months</td>
<td>-</td>
<td>0.0%</td>
<td>Scarified</td>
</tr>
<tr>
<td>5. Brachiaria decumbens</td>
<td>21.7.53</td>
<td>19 months</td>
<td>-</td>
<td>0.0%</td>
<td>Blind seed</td>
</tr>
<tr>
<td></td>
<td>12.11.53</td>
<td>15 months</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>6. Chloris gayana</td>
<td>7.5.54</td>
<td>8 months</td>
<td>9</td>
<td>14%</td>
<td>Cold Store 45°F</td>
</tr>
<tr>
<td></td>
<td>9.3.54</td>
<td>11 months</td>
<td>7</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Date of harvest</td>
<td>Age of seed Months</td>
<td>No. of days to germinate</td>
<td>% germination</td>
<td>Remarks</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
<td>--------------------------</td>
<td>--------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>28.1.54</td>
<td>13</td>
<td>5-10</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>22.12.53</td>
<td>14</td>
<td>5</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>10.4.54</td>
<td>10</td>
<td>7</td>
<td>0.5%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>10.2.54</td>
<td>12</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>26.11.53</td>
<td>15</td>
<td>13</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>13.2.55</td>
<td>0</td>
<td>7</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>17.3.55</td>
<td>1</td>
<td>9</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>17.3.55</td>
<td>1</td>
<td>14</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>7. Cynodon Plectostachys</td>
<td>13.2.55</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>8. Dichanthium aristatum</td>
<td>10.4.54</td>
<td>9</td>
<td>-</td>
<td>0.0%</td>
<td>Awns active in moisture</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>12.1.55</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>9. Dichanthium caricosum</td>
<td>8.4.54</td>
<td>9</td>
<td>5-14</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>12.1.55</td>
<td>0</td>
<td>6-9</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>12.1.55</td>
<td>0</td>
<td>14</td>
<td>4%</td>
<td>Box</td>
</tr>
<tr>
<td>10. Echinochloa pyramidalis</td>
<td>7.12.54</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td>Blind seed</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>5.10.53</td>
<td>14</td>
<td>-</td>
<td>0.0%</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>4.2.55</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>11. Erichochloa polystachya</td>
<td>13.2.55</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>13.2.55</td>
<td>1</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>12. Heteropogon contortus</td>
<td>9.3.54</td>
<td>10</td>
<td>7</td>
<td>2%</td>
<td>V. immature</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>8.4.54</td>
<td>10</td>
<td>-</td>
<td>0.0%</td>
<td>Poor sample</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>26.11.53</td>
<td>15</td>
<td>-</td>
<td>0.0%</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>11.1.55</td>
<td>1</td>
<td>9</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>13. Ischaemum aristatum</td>
<td>24.4.54</td>
<td>9</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>20.1.55</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>17.3.55</td>
<td>0</td>
<td>6</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>14. Ischaemum timorensense</td>
<td>17.3.54</td>
<td>10</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>4.1.55</td>
<td>1</td>
<td>-</td>
<td>0.0%</td>
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</tr>
<tr>
<td>15. Ixophorus unisetus</td>
<td>7.12.54</td>
<td>0</td>
<td>21</td>
<td>18%</td>
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</tr>
<tr>
<td>&quot; &quot;</td>
<td>4.9.54</td>
<td>4</td>
<td>-</td>
<td>0.0%</td>
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</tr>
<tr>
<td>&quot; &quot;</td>
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<td>&quot; &quot;</td>
<td>12.10</td>
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<td>12</td>
<td>4%</td>
<td>Cold Store 20°F 12mths</td>
</tr>
<tr>
<td>Species</td>
<td>Date of harvest</td>
<td>Age of Seed Months</td>
<td>No. of days to germinate</td>
<td>% germination</td>
<td>Remarks</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
<td>--------------------------</td>
<td>---------------</td>
<td>---------</td>
</tr>
<tr>
<td>Ixophorus unisetus</td>
<td>8.11.54</td>
<td>0</td>
<td>11</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>9.2.55</td>
<td>0</td>
<td>8</td>
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</tr>
<tr>
<td>&quot;</td>
<td>15.3.55</td>
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<td>6-10</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>1.4.55</td>
<td>0</td>
<td>7-16</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>16. Melinis minutiflora</td>
<td>1.12.53</td>
<td>13</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>17. Panicum antidotale</td>
<td>4.2.55</td>
<td>3</td>
<td>11</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>13.2.55</td>
<td>1</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>18. P. maximum</td>
<td>13.2.54</td>
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<td>7</td>
<td>2%</td>
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</tr>
<tr>
<td>&quot;</td>
<td>1.2.55</td>
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<tr>
<td>19. Papalum dilatatum</td>
<td>4.5.54</td>
<td>8</td>
<td>-</td>
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</tr>
<tr>
<td>&quot;</td>
<td>18.3.54</td>
<td>10</td>
<td>7-14</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>18.1.54</td>
<td>1</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>20. P. pediculatum</td>
<td>13.2.55</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>21. Pennisetum pediculatum</td>
<td>8.4.54</td>
<td>9</td>
<td>4</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>15.1.54</td>
<td>1</td>
<td>7</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>2.12.53</td>
<td>14</td>
<td>7</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>27.10.53</td>
<td>14</td>
<td>7</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>20.2.54</td>
<td>12</td>
<td>3-7</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>8.3.54</td>
<td>11</td>
<td>3-14</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>22. Setaaria Sphacelata</td>
<td>4.5.54</td>
<td>8</td>
<td>7</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Kenya</td>
<td>14.12.54</td>
<td>1</td>
<td>4</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>10.1.55</td>
<td>1</td>
<td>8</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>13.2.55</td>
<td>0</td>
<td>10</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>1.3.55</td>
<td>1</td>
<td>6</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>4.4.55</td>
<td>0</td>
<td>4</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>23. Setaaria Sphacelata</td>
<td>1.12.54</td>
<td>0</td>
<td>14</td>
<td>26%</td>
<td></td>
</tr>
<tr>
<td>Tanganyika</td>
<td>7.12.54</td>
<td>0</td>
<td>12</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>11.11.54</td>
<td>3</td>
<td>14</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>22.3.54</td>
<td>10</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>10.1.55</td>
<td>1</td>
<td>13</td>
<td>17%</td>
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</tr>
<tr>
<td>&quot;</td>
<td>13.2.55</td>
<td>0</td>
<td>13</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>1.3.55</td>
<td>1</td>
<td>9</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>&quot;</td>
<td>4.4.55</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Date of harvest</td>
<td>Age cf Seed Months</td>
<td>No. of days to germinate</td>
<td>% germination</td>
<td>Remarks</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
<td>--------------------------</td>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>Ixophorus unisetus</td>
<td>8,11.54</td>
<td>0</td>
<td>11</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9, 2.55</td>
<td>0</td>
<td>8</td>
<td>56%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15, 3.55</td>
<td>0</td>
<td>6-10</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1, 4.55</td>
<td>0</td>
<td>7-16</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Melinis minutiflora</td>
<td>1,12,53</td>
<td>13</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Panicum antidotale</td>
<td>4, 2.55</td>
<td>½</td>
<td>13</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>P. maximum</td>
<td>13, 2.55</td>
<td>11</td>
<td>7</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Papalum dilatatum</td>
<td>4,5.54</td>
<td>8</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>P. maximum</td>
<td>18, 3.54</td>
<td>10</td>
<td>7-14</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>P. pediculatum</td>
<td>13, 2.55</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Pennisetum pediculatum</td>
<td>8, 4.54</td>
<td>9</td>
<td>4</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15, 1.54</td>
<td>1</td>
<td>7</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2,12,53</td>
<td>14</td>
<td>7</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27,10.53</td>
<td>14</td>
<td>7</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20, 2.54</td>
<td>12</td>
<td>3-7</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8, 3.54</td>
<td>11</td>
<td>3-14</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>Setaria Sphacelata Kenya</td>
<td>4, 5.54</td>
<td>8</td>
<td>7</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14,12.54</td>
<td>1</td>
<td>4</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10, 1.55</td>
<td>1</td>
<td>8</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13, 2.55</td>
<td>0</td>
<td>10</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1, 3.55</td>
<td>1</td>
<td>6</td>
<td>15%</td>
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</tr>
<tr>
<td></td>
<td>4, 4.55</td>
<td>0</td>
<td>4</td>
<td>3%</td>
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</tr>
<tr>
<td>Setaria Sphacelata Tanganyika</td>
<td>1,12,54</td>
<td>0</td>
<td>14</td>
<td>26%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7,12.54</td>
<td>0</td>
<td>12</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11,11.54</td>
<td>3</td>
<td>14</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22, 3.54</td>
<td>10</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10, 1.55</td>
<td>1</td>
<td>13</td>
<td>17%</td>
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<tr>
<td></td>
<td>13, 2.55</td>
<td>0</td>
<td>13</td>
<td>28%</td>
<td></td>
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<tr>
<td></td>
<td>1, 3.55</td>
<td>1</td>
<td>9</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4, 4.55</td>
<td>0</td>
<td>-</td>
<td>0.0%</td>
<td></td>
</tr>
</tbody>
</table>
From these germination figures it can be seen that the following species have given no viable seed this season.

**Acroceras macrum**
**Bothriochloa pertusa**
**Brachiaria brizantha**
**Brachiaria decumbens**
**Cynodon plectostachyos**
**Dichanthium aristatum**
**D. caricosum**
**Echinochloa pyramidalis**
**Erichloa polystachya**
**Ischaemum timorense**

Species that are capable of giving seed with viability above 10% appear to be

**Andropogon gayanus**
**Chloris gayana**
**Ixophorus unisetus**
**Pennisetum pedicellatum**
**Setaria sphacelata**.
BIBLIOGRAPHY - SECTION I

Australia, Council for Scientific and Industrial Research (1944).
Eighteenth Annual Report. p. 79
Canberra.

Australia, C.S.I.R.O. (1952)
Pasture Investigations at Regional Centres.
Fourth Annual Report.
Canberra.

Barton, Lela V. and Crocker W.
Twenty Years of Seed Research.
Faber and Faber Ltd., London.

Basutoland (1946).
Annual Report of the Department of Agriculture for the year ended 30th September, 1946.
Maseru

Belgian Congo (1948)
From Herb. Abstr. 20 p. 224

Belgian Congo (1949)
From Herb. Abstr. 21 p. 98

Belgian Congo (1951).
Annual Report for the Financial Year 1951.
From Herb. Abstr. 24 p. 116

Bews, J.W. (1929)
The World's Grasses
Longmans, Green and Co., London.

Botha J.P. (1944).
Nile Grass (Acroceras macrum)
Fmg. S. Africa. 1944 19 503
Botha, J.P. (1945).
Setaria Grasses for Eastern Transvaal.
Fmg. S. Africa 1945 20 273

Botha J.P. (1948).
Setaria Grasses.
Fmg. S. Afr. 1948 23 729-35

Botha J.P. (1953)
Grass on old Wattlelands in the Eastern Transvaal.
Fmg. S. Afr. 1953 28 270.

Pasture management in Uganda in relation to Western Equatoria (Sudan).
E. Afr. Agric. J. 1952 17 183-7

Clark, N.E. and Kerns, K.R. (1942)
Control of flowering with phytohormones.
Science 95 p. 273-279

Cooper, W.C. (1942)
Effect of growth substances on flowering of the pineapple under Florida conditions.
Proc. Amer. Soc. Lort. Sci. 41 93-8

Davel H.B. (1949)
Research in Agriculture
Fmg. S. Afr. 1949 24 565-71

Dueng-Huu-Thei (1946)
The burning of bush-wood and adaptations of the vegetation of the inundated basin of the middle Niger.

Edwards, D.C. and Bogdan, A.V. (1951)
Important Grassland Plants of Kenya.
Sir Isaac Pitman and Sons Ltd., Nairobi.

Edwards, D.C. (1950)
Grassland Research in Kenya.
E. Afr, Agric. J. 1950 15, 210
Esquivel, G.R.
Economic Study of Intensive Stock Raising
Rev. Instit. Def. Cafe, Costa Rica 16

Preliminary investigations on seed viability, storage and growth of potentially useful grasses under Trinidad conditions.
Postgraduate Thesis. I.C.T.A.

Fascolo E. (1949)
Beef Cattle. A stock centre at Jegu (Huri Belgian Congo)
Bull. Agric. Congo Belge, 1949 40 1901-6
Translation Herb. Abstr. 20 1950 767

Foury, A. (1953)
What is the forage value of the genus Setaria.
Terre. Maroc. 1953 27 315-19
Translation Herb. Abstr. 24 1954.2

Gildenhuys, P.J. (1950)
Grass breeding for rotational farming.
Fmg S. Afr. 1950, 25, 151-3

Gildenhuys, P.J.
Fertility Studies in Setaria sphacelata
Science Bulletin No. 314 Union of South Africa
Gold Coast Colony (1944)
Report of the Department of Animal Health for the year 1943-44
Accra 1944

Graham, T.G. (1951)
Tropical Pasture Investigations
Od. Agric. J. 1951 73 311-26

Guillemet P (1949)
Considerations sur L'erudition regressive des Terres de culture en Afrique Equatoriale Francaise.
Bull. Agric. Congo Belge, 1949 40
From Herb. Abstr. 20 1951 P. 66

Hawaii Agricultural Experiment Station (1943).
Report for the Biennium ending June 30, 1942 p. 79
Honolulu 1943.
Henke, L.A. (1943)
Roughages for dairy cattle in Hawaii
Hawaii Agric. Expt. Sta. Bull 93

Henning, P.O. (1949)
Silage Crops and Silos
S. African Science Bulletin 303 p. 17

Herbage Abstracts 1948 Nos. 59, 592, 817

Excerpts from Farmer's Weekly 1947

Bloemfontein.

Hitchcock, A.S. and Agnes Chase (1917)
Grasses of the West Indies

Hosaka, E.Y. and Ripperton, J.C. (1948)
Promising Pasture Species

Grass and its utilization in Trinidad.
Trop. Agric. Trin. 1953 30 Nos. 1-3, 3-14

Hubbard, C.E. (1943)
East African Pasture Plants, East African Grasses I & II.

Jackson, G. (1951)
Pasture and Grass testing investigations
Nyasaland Agric. quart J 1951, 10 No. 4 p. 113

Preliminary report on a comparison of several heavy yielding perennial grasses for the production of ensilage.

Kenya (1948)
Department of Agriculture annual report 1948 p. 288
Nairobi.

Kenya (1951).
Department of Agriculture annual report 1951 p. 102
Nairobi.
Nigeria (1944)
Ilorin Stock Farm
Herb. Abstr. 1945 15 p. 99

Nyasaland Agricultural Quarterly Journal
Grazing and grass testing investigations
Nyasaland Agric. Quart. J. 1951 10 No. 3 p. 77

Pasture Research Committee (1944)
Improved pastures on Sandveld vleis
Rhod. Agric. J. 1944 41 p. 407-11

Paterson, D.D. (1937)
Forage production in Trinidad.
Trop. Agric. Trin. 1937 14 337

Paterson, D.D. (1941)
Utilisation of fodder grasses in Trinidad.
Trop. Agric. Trin. 1941 18 p. 226

Paterson, D.D.
Grassland management in the West Indies.

Pears, H.L. (1948)
Growth substances and their practical importance in agriculture.

Pienaar, C.J. (1947)
Nile Grass

Quarre, P. (1945)
Pasture improvement and establishment of artificial pastures at Katanga.
Couits Special du Katanga, Congo Belge
From Herb. Abstr. 1946 16 130

Rattray, J.M. and Fitt, R.H. (1947)
Preliminary results in improving the Sandveld vleis on the Grassland Experimental Station, Marandellas.
Rhod. Agric. J. 1947 44 20-30
Pastures of Leverville and Kasanji.
Herb. Abstr. 18 1948, 12

A simple method of preparing clean grass seed for mechanical planting.
Rhod. Agric. J. 1952 42 p. 176

South Africa (1951).
Annual report of the Department of Agriculture for the year ending 31st August, 1951.
Fmg. S. Afr. 1951 26

Southern Rhodesia (1950).
Annual report of Director of Research and Specialist Services 1950.
Salisbury 1950.

Species for leys in medium altitude areas.
Quart J. Roy. Agric. Soc. Kenya No. 2

Tanganyika (1952).
Department of Agriculture Annual Report 1952.
Dar es Salaam 1953.

The drylands problem in the North-Eastern Cape Province.
Fmg. S. Afr. 1946 21 27

Uganda Protectorate (1946).
Annual Report of the Department of Agriculture for the period 1st April 1945 - 31 March 1946. P. 54
Entebbe.

Uganda Protectorate (1947).
Annual Report of the Department of Agriculture for the period 1st April 1946 - 31st March 1947 p.72
Entebbe.
Uganda Protectorate (1950).

Entebbe.

van Overbeek, J. (1945)

Flower formation in the pineapple plant, as controlled by 2, 4-D and napthalene acetic acid.
Science 102 621

van Rensburg, H.J. (1948)

The cultivation of introduced pasture plants.
E. Afr. Agric. J. 14 1948 3-9


Tanganyika work on fodder plants and grazing management.


Notes on grassland problems in Tanganyika and a brief outline of research work in progress.

West, O. (1952)

Promising new grasses for seeded pastures in Southern Rhodesia.
Rhod. Agric. J. 1952 49 p. 94

West Australia (1949)

Kimberly Research Station Progress Report 1947-49
J. Dep. Agric. W. Austr. 1950 27 200
BARTON, Lela V. and CROCKER, W. 
Twenty years of Seed Research.
Faber & Faber Ltd., London.

BASS, L.N. (1953)
2,3,5 Triphenyl tetrazolium chloride as an indicator of the viability of Kentucky blue grass seed.

BASS, L.N. (1953)
Relationship of temperature, time and moisture content to the viability of seeds of Kentucky blue grass.
Proc. Iowa. Acad. Sci. 1953 60

COTTRELL, Helen J. (1950)
Tetrazolium salt as a seed germination indicator.
Ann. App. Biol. 35 123

EL-SHISHIHY, E.D.H. (1953)
Effect of temperature and desiccation during storage on germination and keeping quality of Kochia indica seeds.
J. Exp. Bot. 4 403

Biochemical tests for Seed Germination.
From Herb. Abstr. 22 1218

GORMAN, L.W. and GREENWOOD, R.M. (1951)
Effect of moisture content on the viability of Italian ryegrass seed on storage.
N.Z.J. Sci. Tech. 33 Sect A. No.2 58-61

HYDE, E.O.C. (1949)
Methods for determining the viability of various seeds by tetrazolium staining 1. Chewings Fescue.
Methods for determining the viability of various seeds by tetrazolium staining 2 Perennial Ryegrass.

Lakon (1951).
Further studies of the topographical tetrazolium colour test and the determination of seedling vigour.
From Herb. Abstr. 22 1220

Mackey, J. (1950)
Chemical methods for rapid determination of the germinability of seed.

Myers, A. (1952)
Germination of stored lucerne seed. Results of 4 years Experiment (in N.S.W.).
Agric. Gaz. N.S.W. 1952 63 No.6 284-5

Niles, J.J. (1954)
I. The use of Triphenyl Tetrazolium Bromide in viability tests of Rice seed.

Preserving viability in seeds of Kochia prostrata.
Herb. Abstr. 21 131

Porter, R.H. et al.
The use of 2,3, 5 Triphenyl tetrazolium chloride as a measure of seed germinability.
Plant Physiol. 22 154.

Ritvaneer, T. (1953)
The Application of Tetrazolium chloride for rapid determination of germination capacity in seed of Phleum pratense.
From Herb. Abstr. 24 477.

Preliminary observations on viability of hulled Timothy seed.