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Spittlebugs

Field evaluations of forty ecotypes of grasses for their resistance to spittlebugs (of the genera *Aeneolamia, Deois, Zulia* and others) were initiated at Carimagua. The first observations showed *Brachiaria ruziziensis* CIAT 654 and 656 and *Brachiaria* sp. CIAT 6058 as the most susceptible ones to the attack of spittlebug nymphs and adults. *A. gayanus* CIAT 6053, 6054, 635 and 621, however, showed low levels of infestation by nymphs and no adults (Table 25).

The effect of grazing on populations of spittlebug nymphs and adults was studied. The preliminary data show a greater reduction in the number of nymphs than of adults. This situation could be explained on the basis of adult activity that may allow them to escape or move from the site where the animal is grazing. These studies will be intensified.

Table 25. Infestation of spittlebug (*Aneolamia varia*) nymphs and adults on severity grass accessions at Carimagua.

Species	CIAT. No.	Spittlebug nymphs/ 10 m^2	Spittlebug adults/ 25 m^2
Brachiaria sp.	6058	9.60	1.54
Brachiaria ruziziensis	656	5.83	1.23
Brachiaria ruziziensis	654	4.61	1.20
Andropogon gayanus	6053	0.07	0.07
Andropogon gayanus	6054	0.10	0.07
Andropogon gayanus	635	0.27	0.03
Andropogon gayanus	621	0.13	0.00

Entomological Evaluation in Regional Trials

Visits to several countries (Bolivia, Brazil, Colombia, Ecuador, Peru, Venezuela) were made in order to evaluate the regional trials established in different ecosystems regarding insect pest problems. Results show species of Homoptera/flea beetle complex, Chrysomelidae and Hemiptera, as common insect pests in most of the ecological regions. Also, the frequency distribution of insect orders is similar to the general pattern of insect pests registered in the population dynamics studies carried out at Carimagua and CIAT-Quilichao. It is important to point out that beneficial insect populations, represented by several orders and species, are abundant in all locations. This suggests a good possibility of using biological control in an integrated pest management scheme for tropical pastures in Latin America. To date, forage legumes are more frequently affected by insect pests than grasses. *S. capitata,* one of our promising legumes has shown consistent resistance or tolerance to the stemborer *Caloptilia* sp., considered as a key pest of the genus *Stylosanthes*. In the case of grasses, *A. gayanus* has not shown any serious insect pest up to the present time.

SEED PRODUCTION

The Seed Production Section continues to meet two basic objectives: (1) seed increase of experimental lines to be used by the Program and its collaborators and (2) development of relevant technology for commercial seed production.

During 1979, major emphasis was placed on expanding grass and legume areas for seed multiplication purposes. The total area harvested increased significantly as well as the total volume of seed produced. The technology development efforts were restricted to the initiation of the field experimental phase of the regional seed production potential project and to the quantification of certain aspects of seed handling of *Andropogon gayanus.*

Seed Increase

Seed increase activities are confined to accessions nominated by the Program's Germplasm Committee. An initial production target is related to the five categories assigned and reflects an estimate of seed required to establish new experiments to fulfill the next evaluation phase by other program sections. In the case of accessions in categories IV or V, an additional production target may be undertaken to fulfill a defined experimental proposal. Actual crop areas established are defined by interrelating the seed production target for the particular accessions with the seed multiplication rate for the species in the particular location where it is to be grown.

In the case of new germplasm very often the supply of planting material (seed or vegetative material) limits the seed multiplication area which can initially be established. This requires the use of single plant transplanting, and vegetative propagation or successive cycles of crop expansion following seed harvesting. The net effect is a general lag phase of one to two years before the production target is attained.

Production areas are located at CIAT-Palmira, CIAT-Quilichao and Carimagua to exploit climatic and edaphic differences and also to distribute risk and effort. All processing, storage and distribution activities are centered at CIAT-Palmira. All three locations experience little day-length variation due to their common low latitude (3-4°N). Rainfall distribution is bimodal at CIAT-Palmira and CIAT-Quilichao (where irrigation is available), while at Carimagua rainfall is unimodal with a prolonged growing season. With the inherent sensitivity of forage species to climatic and edaphic factors, the relationship between actual seed yields and potential seed yield varies with each species.

A summary of the main seed increase activities during 1979 is presented in Table 26. Seed of a total of 39 accessions (37 legumes and 2 grasses) was increased. The legumes were essentially located at

Table 26. Seed increase activities during the year (October 1978-1979).

Description	Location: CIAT-Palmira	CIAT-Quilichao	Carimagua	Average or sum
Number of introductions				
Grasses	2	2	1	2
Legumes	4	33	4	37
Crop areas (ha)				
New	12	6	25	43
Total	15	9	27	51
Seed harvesting				
Area (ha)	17[1]	16[1]	7	40
Method (%)				
Manual	90	80	100	90
Mechanical	10	20	0	10
Distribution of seed				
Requests (No.)	-	-	-	
CIAT	-	-	-	143
Outside	-	-	-	57
Total weight (kg)				
CIAT	-	-	-	4002
Outside	-	-	-	137
Seed Produced (kg)				
Grasses	2185	812	388	3385
Legumes	468	1080	426	1974
Total	2653	1892	814	5359

1 Areas of certain accessions were harvested twice.

CIAT-Quilichao to allow concentration of small plot management but four high priority accessions were also planted at Carimagua on a scale appropriate for combine harvesting. Grasses were multiplied over all three locations but with the larger area at CIAT-Palmira. A record total new crop area of 43 ha was successfully established this year. These areas include a significant additional production target relating to *Andropogon gayanus*. The total area established for seed production purposes now reaches 51 ha.

With a trend toward increasing average plot size of the higher category accessions, it was possible to increase harvesting by mechanical means. This trend represents a significant operational development as the section has reached its absolute capacity in terms of manual harvesting. Mechanical harvesting capacity was further improved with the addition of a tractor-mounted suction harvestor. This machine provides both an alternative and supplementary harvest method for some species under experimental increase conditions. It has particular potential for harvesting *Desmodium heterophyllum*. Processing the large volumes of *Andropogon gayanus* has been a slow and dirty operation. While the mechanical deawner has functioned well, it needs to be complemented by mechanical handling and dust control measures in the processing line.

Total volume of seed production was 5359 kg with the largest volumes corresponding to *A. gayanus, Stylosanthes capitata, S. hamata, D. ovalifolium, Zornia latifolia, Codaricolyx* (syn. *Desmodium*) *gyroides* and *D. heterophyllum* (Table 27).

The new storage facilities have allowed basic organization of seed stocks in terms of storage and inventory control. Dry seed is stored in sealed containers. Seed distribution has involved responding to a total of 200 requests and the delivery of 4586 kg of seeds.

Table 27. Summary of forage seed produced by species between October 1978 and October 1979.

Species	Number of accessions	Total weight of seed (kg)
Legumes		
Aeschynomene sp.	1	1
Centrosema spp.	5	8
Codariocalyx gyroides	1	46
Desmodium ovalifolium	1	61
Desmodium heterocarpon	1	10
Desmodium heterophyllum	1	25
Glycine wightii	2	15
Pueraria phaseoloides	1	4
Stylosanthes capitata	10	1190
Stylosanthes hamata	1	550
Stylosanthes humilis	1	1
Stylosanthes guianensis	1	2
Stylosanthes viscosa	1	1
Zornia latifolia	10	60
Total legumes		1974
Grasses		
Andropogon gayanus	1	3382
Panicum maximum	1	3
Total grasses		3385
Total all accessions	39	5359

1 Legumes: seed or seed in pods, > 95% purity.
2 Grasses: seed, > 40% purity.

By the standard international definition, purity refers only to those spikelets which contain the confirmed presence of a caryopsis. Awns, empty spikelets, vegetative plant parts, sand and soil are assigned to the inert matter fraction. This is the most precise and desirable definition. However, when separation work of the working sample for purity analysis is conducted manually, spikelet by spikelet, this task is both laborious and time consuming.

Investigations have continued to verify the utility of the definition and methodology referred to as Indirect (International) Purity. This method is based on the relationship between Caryopsis Content (the proportion of spikelets containing a confirmed caryopsis and expressed as percent based on number) and the Actual Purity (estimated by manual separation) of the spikelet

Seed Production Technology

Andropogon gayanus

Seed purity determination

In chaffy grasses, there are alternative definitions and methodologies to estimate the proportion of a seed lot consisting of pure seed. Purity determinations, however, are always defined on a weight basis.

fraction. This relationship has been quantified by linear regression using a basic data set of both Caryopsis Content and Actual Purity of the spikelet fraction as measured in 35 seed samples. The regression coefficient was estimated as 1.123 with a $R^2 = 0.9899$ (Figure 17).

The procedure to determine indirect (International) purity in any seed sample is to estimate (1) Spikelet Content (or Irish pure seed) and (2) Caryopsis Content. These observations are then used in the following formula:

$$\text{Indirect (International Purity)} = \underset{\%\ (\text{weight})}{\text{Spikelet Content}} \times \left[\underset{\%\ (\text{no.})}{\text{Caryopsis Content}} \times 1.123 \right] \div 100$$

$$= \left[0.0123 \times \text{Spikelet Content} \times \text{Caryopsis Content} \right] \%\ (\text{weight})$$

where Spikelet Content (or Irish purity) is defined on a 5 g random sample of the seed lot.

Caryopsis Content is determined upon 200 random spikelets (or Irish pure seeds).

1.123 is the regression coefficient expressing the generalized relationship between Caryopsis Content and International Purity of this species.

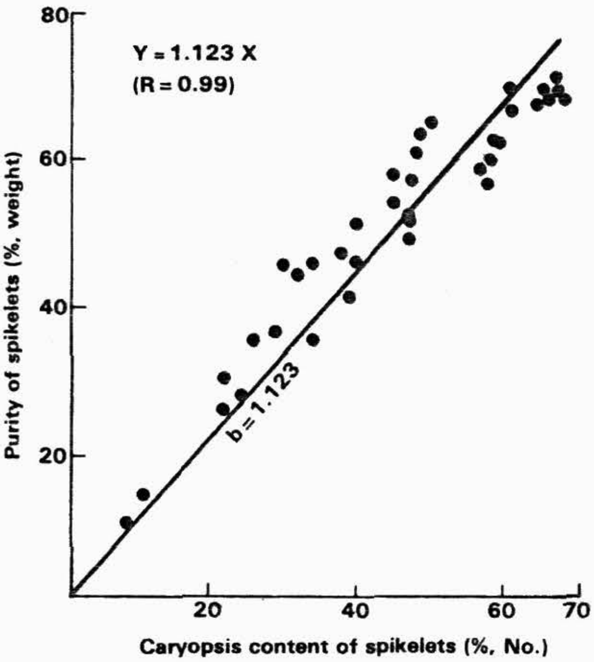

Figure 17. Regression of purity and caryopsis content of spikelets in *Andropogon gayanus* CIAT 621.

The degree of precision or relationship between purity as measured directly by manual separation and by the indirect formula method, was estimated by testing the correlation between values derived from 47 seed samples (Figure 18). A highly significant value of 0.98 was found. It was concluded that the indirect formula method does have sufficient precision to warrant its use.

The advantages of the indirect method are: (a) determinations can be made in 25% of the time required by the hand separation method; and (b) its precision is relatively high. The indirect estimate of purity depends heavily on the representativeness of the 200 spikelets which enter the determination of Caryopsis Content. Obviously, variation will be caused by sampling errors present with masses of light, fluffy seed.

The basic utility of the indirect method lies not in its capacity to measure purity in absolute terms but in the greatly increased capacity it offers to estimate yield of pure seed. In a program with both production and experimental objectives, there is a need to record both seed weight and purity of a large number of samples so as to determine pure seed yield. A purity determination, therefore, must be reasonably rapid and precise while not extreme in either regard.

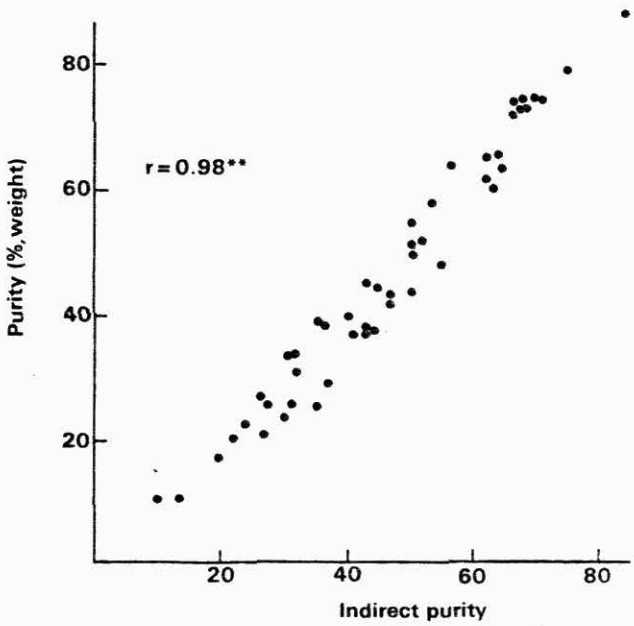

Figure 18. Correlation between direct and indirect estimates of seed purity in lots of clean seed of *Andropogon gayanus*.

Crop maturity patterns

A preliminary study of crop and seed maturity was conducted at CIAT-Palmira based upon replicated spikelet collections made at eight intervals during crop maturation.

Weight of harvested spikelets reached a maximum at 22 days after peak flowering and declined markedly after 36 days. The proportion of spikelets containing caryopsis ranged from 24-68%, indicating temporal variations in the overall efficiency of seed set, but was at a maximum at 43 days after peak flowering.

Weight of pure seed spikelets was at a maximum at 22 days after peak flowering and declined very markedly after 43 days. Unit weight of pure seed spikelets tended to decline constantly from a maximum of 292 mg/100 at 22 days after peak flowering to 250 mg/100 pure seed spikelets after 64 days (Figure 19).

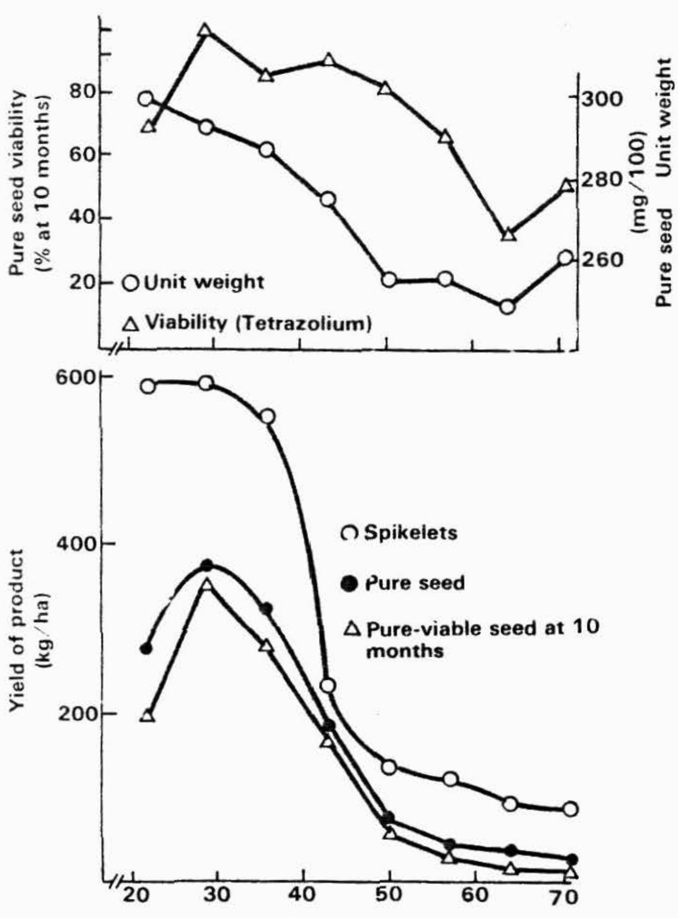

Figure 19. Characteristics of pure seed and yield dynamics during crop maturity of *Andropogon gayanus* CIAT 621, at CIAT-Palmira.

Both viability and germination of pure seed spikelets exhibited maximum values of approximately 90% (at 10 months post-harvest), while showing some tendency to decline from 50 days after peak flowering.

Both yield of pure seed and yield of pure viable seed increased to their maximum values which were recorded at 29 days after peak flowering and then declined rapidly, especially after 36 days when the rate of shedding was at a maximum.

The optimum point of harvest maturity should coincide with maximum yield of pure viable seed. On this basis, harvest maturity occurred approximately 29 days after peak flowering. As maximum yield of spikelets preceeded this point by approximately seven days, shedding of spikelets is initiated before optimum harvest maturity; in fact, spikelets will be shed at least two weeks before harvest maturity.

Seed processing

The seed mass of *A. gayanus* is light and adhesive because of the pilose and awned spikelets. This poses handling problems compared with other grasses. Bridging effects impede mechanical transfer to conventional hoppers or elevators while clumping reduces the rate and efficiency of passage across flat screens.

A mechanical deawner or modified hammer mill (where both hammers and interior cylinder are rubberized) has been used to homogenize particle size, remove awns and thereby allow improved flow rates and separation across an air screen cleaner.

A comparison was made of seed mechanically processed by the deawner and then the air screen cleaner, to seed only subjected to manual scalping after hand threshing. Results are presented in Table 28. The deawning function is obviously very effective provided the crude seed is dry when fed into the deawner. The increases in caryopsis content and purity indicate the ability of the air screen cleaner to eliminate dust, awns, and small particles of vegetative material but also many small or empty spikelets and florets. Bulk density is also increased by approximately 39% (relative basis). Germination is not reduced by the mechanical handling and may even be improved for an initial period. Longer term effects still need to be defined.

The data in Table 28 represents two extremes of alternative processing pathways. The actual crude

Table 28. Characteristics of unprocessed crude seed and mechanically graded seed in three lots of Andropogon gayanus.

Description	Crude seed[1]		Graded seed[2]	
	Mean	Range	Mean	Range
Deawned spikelets (%, No.)	28	22-34	94	88-98
Spikelet Content (%, weight)	71	67-75	92	88-95
Caryopsis Content (%, No.)	39	34-46	51	37-64
Purity (%, weight)	30	27-36	51	37-62
Germination (%, No., at 10 months)	21	8-43	39	34-45
Pure Live Seed Content (%, at 10 months)	6	2-15	20	13-28
Bulk density (kg/m^{-3})	47	45-49	65	59-71

1 Seed material after hand threshing, without any mechanical refinement.
2 Seed material after hand threshing, followed by one pass through a mechanical deawner and two passes through an air-screen cleaner.

Table 29. Locations, collaborators, and legume and grass introductions established in the regional seed production potential network.

Location	Latitude	Altitude (m)	Collaborating institution[1]	Date of planting	No. of introductions established: Legume	Grasses
Bolivia						
Chapare	16°S	250	COTESU	Dec. 1978	9	3
Santa Cruz	17°S	200	CIAT	Jan. 1979	5	2
Brazil						
Brasilia	15°S	1007	CPAC	Dec. 1978	9	4
Felixlandia	18°S	600	EPAMIG	Jan. 1979	11	3
Sete Lagoas	19°S	700	EPAMIG	Dec. 1978	6	3
Colombia						
CIAT-Quilichao	3°N	1100	-	Oct. 1978	10	3
Valledupar	10°N	340	ICA	May 1979	3	5

1 COTESU, Cooperación Técnica del Gobierno Suizo; CIAT, Centro de Investigación Agrícola Tropical; CPAC, Centro de Pesquisa Agropecuaria dos Cerrados; EPAMIG, Empresa Brasileira de Pesquisa Agropecuaria de Minas Gerais; ICA, Instituto Colombiano Agropecuario.

seed samples in this study had received the benefit of a partial hand scalping of the threshing material, so averages for typical crude lots will be lower. The mechanically processed seed was all passed twice through the cleaner, whereas commercially it is highly probable that only one pass will be made and slightly lower values will result.

The relative demand for crude and graded seed will be influenced by the planting system used and the costs of seed transport. Crude seed will undoubtedly be used where seed is produced on the same farm and where mechanical planters are unavailable or too costly. Graded seed will facilitate more precise and mechanical planting and will reduce storage and transport costs. Where seed is combine-harvested mechanical scalping could be desirable before drying or deawning.

Regional Seed Production Potentials

As part of an overall assessment of regional seed production potentials, a field experimental phase was initiated in six regions during 1979. Actual regional locations and collaborators are shown in Table 29. The initial, emphasis was to initiate the project at locations in higher latitude regions with some seasonality of rainfall distribution and low frost incidence and to collaborate with institutions already active in germplasm evaluation.

The field experiment aims to define phenology, seed yields and the incidence of weeds, pests and diseases, while additional climatic, edaphic, agronomic and economic data are collected from other sources for each region.

The genetic materials included were nominated by both the collaborator and CIAT. Each material was sown in pure stands in 80m² plots with three replications.

Adverse seasonal conditions had negative effects on the number of entries established and within-site variability at Santa Cruz, Sete Lagoas and Valledupar. Weeds were a problem for the legumes at Sete Lagoas reflecting site history. The first year seed harvests of grasses and legumes were made at Chapare, Brasilia, Felixlandia CIAT-Quilichao and Santa Cruz, while only grasses were harvested at Sete Lagoas.

SOIL MICROBIOLOGY

The objective of the Soil Microbiology Section is to maximize the benefits of biological nitrogen fixation to adapted forages in the acid, infertile soils of tropical Latin America, with priority given to the legume/*Rhizobium* symbiosis. The research strategy is: (1) to maintain and enlarge the CIAT *Rhizobium* germplasm resource; (2) to evaluate the symbiotic nitrogen fixation potential of *Rhizobium* strains with adapted legumes; and, (3) to test the symbiotic potential of selected strains in field situations, initially at CIAT-Quilichao, Carimagua and Brasilia, and then in regional trials throughout the Tropical Pastures Program's target area.

Rhizobium Collection

The addition of 55 *Rhizobium* strains in 1979 brought the bank number to 2098. Information about the entire collection is recorded in a retrieval system detailed in the CIAT *Rhizobium* Catalogue.

Nodule collection, especially from *Zornia* spp., was carried out in the Llanos Orientales of Colombia (Meta and Vichada departments). Complete information for each site was collected and soil samples were taken for analysis.

Strain Selection

The five stages of *Rhizobium* strain selection have remained unchanged since 1977 (CIAT Annual Report, 1977).

Stage I (Aseptic tube culture)

Although Stage I testing was delayed due to unavailability of a growth chamber, alternate systems were explored.

In a hemotoxilin study with the Soil Nutrition Section, nodulation occurred in a non-aerated system, indicating the potential for replacement of the currently used agar plates with nutrient solution. Several nutrient solutions were tested and growth pouches were selected for a comparative study with the routine, enclosed-plant, agar tube method. The former system employs plastic bags filled with nutrient solution and a paper wick. One apparent advantage is that six times