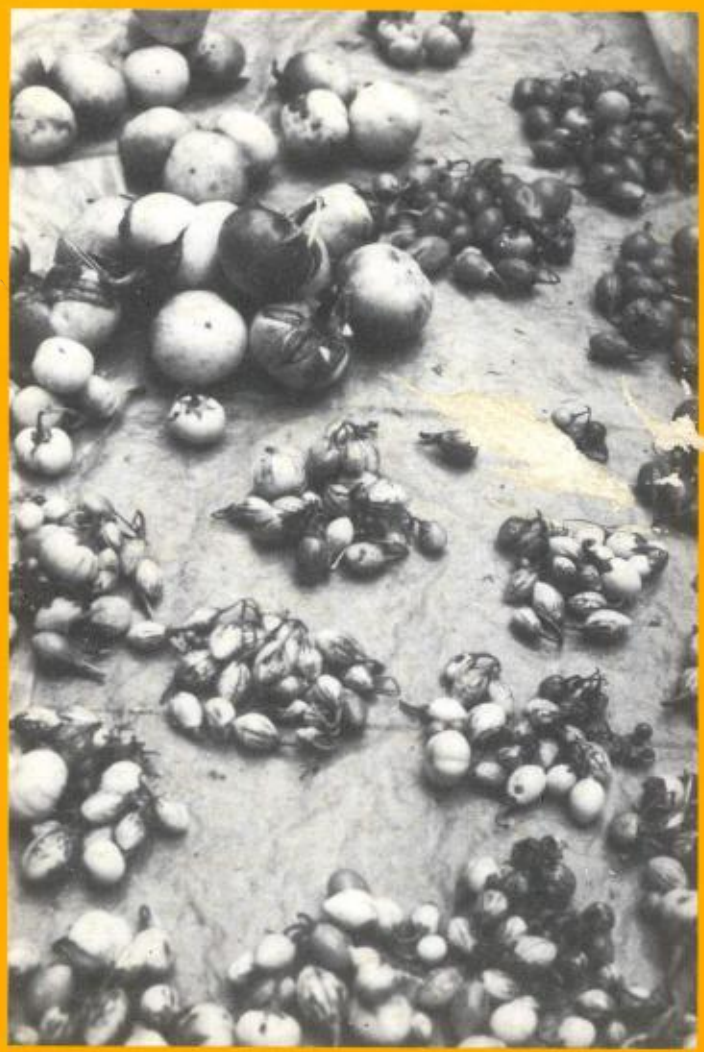
PLANT GENETIC RESOURCES - NEWSLETTER
RESSOURCES GENETIQUES VEGETALES - BULLETIN
RECURSOS GENETICOS VEGETALES - NOTICIARIO

81/82

IBPGR

INTERNATIONAL BOARD FOR PLANT GENETIC RESOURCES
CONSEIL INTERNATIONAL DES RESSOURCES PHYTOGÉNÉTIQUES
CONSEJO INTERNACIONAL DE RECURSOS FITOGENETICOS



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE
ORGANIZACION DE LAS NACIONES UNIDAS PARA LA AGRICULTURA Y LA ALIMENTACION

The *Plant Genetic Resources Newsletter* is published under the joint auspices of the International Board for Plant Genetic Resources (IBPGR) and the Plant Production and Protection Division of the Food and Agriculture Organization of the United Nations (FAO). Contributions in English, French and Spanish are considered, and if accepted, will be published in the original language, with a summary in the other two. Further notes on contributions are given on the inside back cover

Cover photograph: There is a wealth of genetic diversity within *Solanum macrocarpon* (rear) and *Solanum aethiopicum* Gilo group (front) in the markets of Côte d'Ivoire. Each heap contains a mixture of fruits of different sizes, shapes, colours and flavours to add culinary interest to the subsequent delicious stew. See the article by Richard Lester *et al.* on pp. 17-26 of this issue.

Plant Genetic Resources Newsletter

No. 81/82
March/June 1990

Contents

Ev. Sinskaya — a Centenary

Her major activities in the field of establishing and studying world collections of plant genetic resources (1889-1965)

A. Filatenko[1]

The 25th of November 1989 was the centenary of Professor Evgeniya Nikolayevna Sinskaya's birth. Sinskaya was a close associate of N.I. Vavilov throughout the period he worked at the All-Union Institute of Plant Industry (VIR), which is now named after him.

Evgeniya Sinskaya and Nikolai Vavilov were graduates of the 'Petrovka' (the Moscow Agricultural Institute, now the Timiryazev Agricultural Academy) and studied during the pre-revolutionary period in Russia.

Brought up in the best traditions of the Russian intelligentsia, Vavilov and Sinskaya had much in common and understood each other but, more than anything else, the aspiration to study broad, fundamental issues bound them together.

In 1919 Sinskaya studied the Volga meadows, as an expert on the cultivation of meadows, for the Saratov province administration. At the same time she carried out research on agrobiological characteristics of the Cruciferae family at the Saratov division of the Bureau of Applied Botany, headed by Vavilov.

In 1921 Sinskaya, with a group of other scientists from Saratov, moved to Petrograd, where she greatly helped Vavilov in organizing the institute. He entrusted her with the organization of sections and departments, the development of research plans and methods for them, the selection and training of scientific personnel and the coordination of new work. She played an active part in the foundation of the Cuban, Maikop and other experimental stations of VIR.

Ev. Sinskaya worked at VIR for more than 40 years, 20 of them collaborating closely with Vavilov. In his 'Reference on the Doctor of Agricultural and Biological Sciences, Evgeniya Nikolayevna Sinskaya', written in 1940, Vavilov noted that "being an excellent organizer of research work, Ev. Sinskaya established a whole school of research". A great number of studies on fodder, oil and vegetable crops were carried out under her direct guidance.

In Petrograd, she continued her studies on genetics and systematics of the Cruciferae, begun in Saratov, the results of which she published in a number of articles and a fundamental monograph, 'Oleiferous and Root Crops of the Cruciferae Family' (1928).

During many years of work at VIR, Sinskaya organized and personally carried out various collecting missions in different regions of the country: the Caucasus, central Asia, Polesye, the Volga region, the forest-steppe zone of the European part of the USSR and in the Far East and Japan. The accessions of numerous crop plants collected by her greatly extended the world collections of VIR — the golden fund of breeding. She participated in collecting missions until her old age.

Much of her creative activity was used to set out the purpose and objectives of establishing and studying world collections of useful wild and cultivated plants. Vavilov and Sinskaya carried out extensive research on the underlying principles of the evolutionary process and species formation in the 1920s. In 1931 both scientists published works (N.I. Vavilov, 'Linnean Species as a System'; Ev. Sinskaya, 'On Studying Species Dynamics and Relationships with Vegetative Cover'). A systematic approach was adopted for both works, which were complementary to each other. Vavilov's concept of the species has a genetic and geographic character while Sinskaya's concept is evolutionary and ecological. Sinskaya continued her studies until the end of her life. She also provided an understanding of the way in which the components of species such as ecotype, population, eco-element, etc. were formed (Dynamics of the Species, 1948; The Species and its Structural Parts on Various Levels of the Organic World, 1979, etc.).

Theoretical propositions and methods recommended by her are widely used in the taxonomy of cultivated plants. She produced a thorough taxonomy of the Cruciferae crops. Many leguminous plants as well as flax became the objects of her great attention. She described new species of alfalfa, *Trigonella*, radish, *Lallemantia* and other crops.

She always stressed that taxonomy at VIR was not an end in itself but a means of developing natural plant resources. She directed the VIR scientists' work on taxonomy for almost 20 years (1946-65). Developing Vavilov's concept of the species as a complex morphological and biologically dynamic system, she studied the variability of individual plants and the formation of both natural populations and larger organic systems — species — taking into

[1] N.I. Vavilov All-Union Scientific Research Institute of Plant Industry, 44 Herzen St., Leningrad 190000, USSR

account the general principles of the development of systems. Her discovery of the 'law of spiral evolution in the phylogenetic history of genera'* became very important for understanding the evolutionary development of plants, their phylogenesis and the peculiarities of species formation.

After 1939 Sinskaya gave paramount importance in her studies to the problem of populations in higher plants: "It is the particular population which is the scene of processes creating the ecotype and species; here, so to say, the pulse of the species life is throbbing — only from here is it possible to retrace the origin and development of the species". Her theory of populations was based on a synthesis of data on genetics, ecology, comparative physiology and experimental taxonomy. "It is one thing to direct the process of inheritance to obtain a required character, and another thing to change the magnitude of its reaction in the desired direction. We know almost nothing yet about how to do the latter and the problem cannot be solved only by studying the correlation of characters to the structure and chemistry of chromosomes."

Her work in collecting a valuable stock of crop plants and her fundamental research, which helped advance plant genetic resources, were closely connected with Vavilov's activity. Making a presentation at a ceremony celebrating Vavilov's 75th anniversary, Sinskaya gave eloquent testimony to the fact that Vavilov's ideas were being developed and argued that there was a definite direction in which those ideas should be developed. She warned of the possible danger of making some of his propositions into a dogma: "Let us try to think as Vavilov would have thought today".

To move further along the path outlined by Vavilov and to finish everything he had no time to finish was what she considered to be her duty and that of every scientist at VIR. She continued his work on defining the boundaries of the centres of origin of cultivated plants, on determining historical links between them, and carried out a comparative analysis of the cultivated floras of the centres. The first draft of 'At the Dawn of Agriculture',** published in 1969, was ready as early as 1950.

Sinskaya made a thorough analysis of the composition of cultivated flora in various geographical regions. She refined and developed criteria to define centres of origin. Vavilov first of all studied species composition of particular cultivated plants and the botany of varietal composition of particular Linnean species. Sinskaya also differentiated between crop plants depending on whether they belonged to genera originating in that particular centre or to genera having one of the primary, or larger or smaller secondary, centres of their development there (Fig. 1). She defined the composition of aboriginal crop plants in each centre and revealed mutual influence and mutual penetration of cultivated floras in the main centres of origin on the basis of new agricultural and archaeological data.

Vavilov often stressed that the centres of initial cultivation of most crop plants were closely related to floristic areas. Sinskaya recognized the need to replace the terms 'focus' and 'centre' of origin of cultivated plants with a wider term, 'historical and geographical region' or 'geographical region of historical development of cultivated flora'. In 1935 Vavilov also introduced the notion 'region of the introduction of various plants into cultivation'.*

It was Sinskaya who first defined the African region of development of cultivated flora, which had not been fully studied in Vavilov's time.

She introduced a new notion into the geography of cultivated plants — region of influence — and proved the agriculture in those regions to be subordinate to the main areas of origin of cultivated plants. She defined North America as a large region of influence where agriculture was formed on the basis of the crops of the Mexican and the central American subregions and later the ancient Mediterranean region. The cultivated floras of Ethiopia, central and north Europe, the Russian Plain and through it Siberia were formed under the influence of the ancient Mediterranean region. A large number of species from the east Asian cultivated flora are also found in the Russian Plain and Siberian regions of influence.

Considering the geography of cultivated flora in a wide historical context, Sinskaya made a substantial contribution to the development of Vavilov's ideas on the centres of origin of cultivated plants. She greatly enlarged the register of cultivated plants as well as of their relatives — potentially useful for cultivation and still used in certain areas of the world — a fact of great importance for the exploration of new plant resources and the improvement of existing crops.

Sinskaya's work in the field of taxonomy, species formation and problems of higher plant populations, as well as her ecological and geographical studies, was aimed at increasing the efficiency of genetic resources utilization of cultivated plants, as were Vavilov's studies. Solutions to practical breeding problems will continue to be provided by developing the great potential contained in Vavilov's and Sinskaya's scientific heritage.

* Dynamics of the Species. Moscow, Leningrad. 1948.

** Historical Geography of Cultivated Plants. (At the Dawn of Agriculture.) Leningrad. 1969.

* N.I. Vavilov's Teaching on Historical and Geographical Foci of the Development of Cultivated Flora. In: Problems of the Geography of Cultivated Plants. Moscow, Leningrad. 1966.

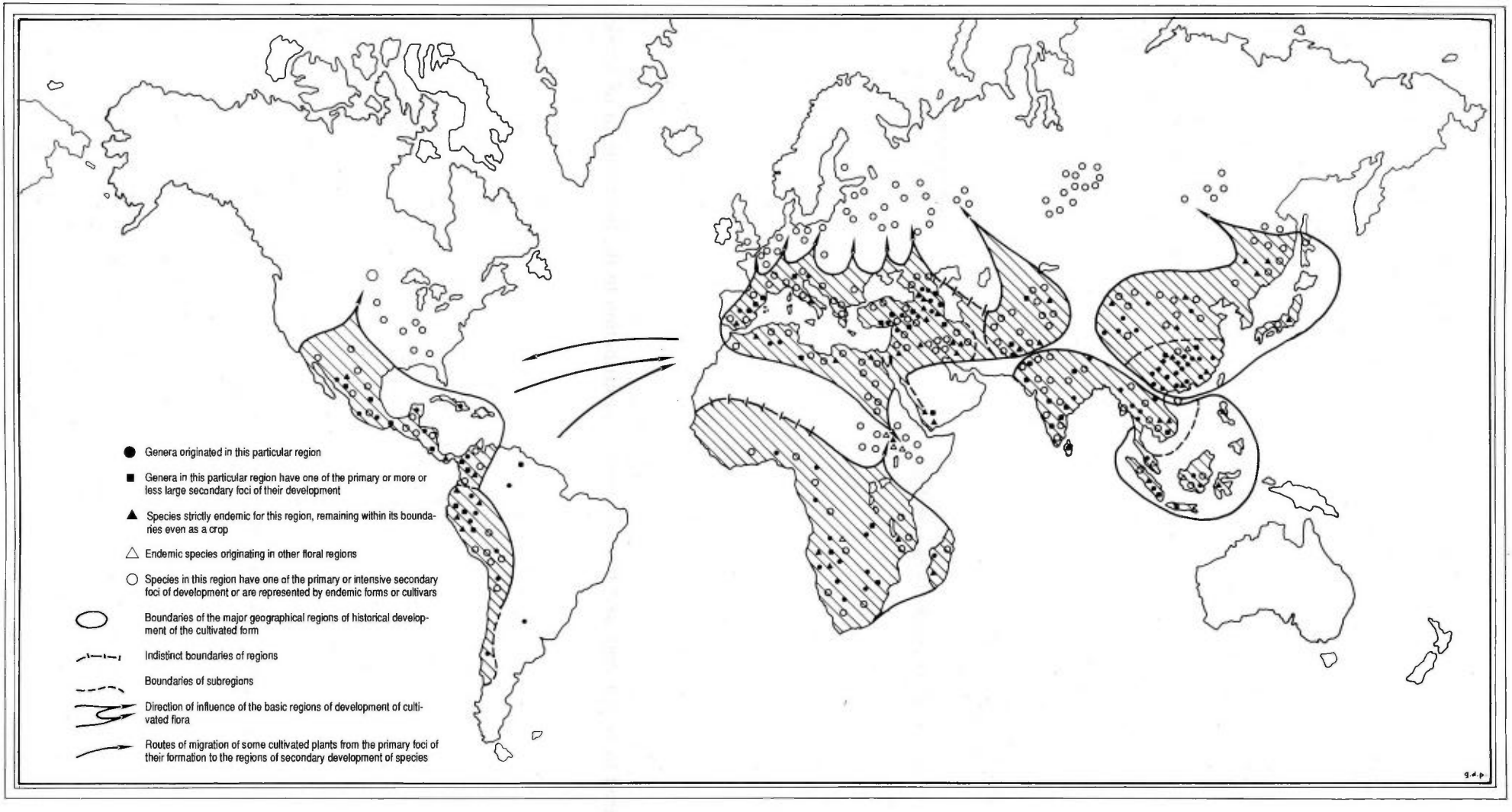


Fig. 1. Geographical regions of development of cultivated flora. Adapted from E.N. Sinskaya: *At the Dawn of Agriculture*

Shoot-tip culture and third-country quarantine to facilitate the introduction of new *Musa* germplasm into West Africa

D. Vuylsteke[1], J. Schoofs[2], R. Swennen[1], G. Adejare[3], M. Ayodele[3] and E. De Langhe[4]

Summary

Tissue culture is increasingly being used as a vehicle for the safe exchange of *Musa* germplasm. However, certain pathogens, e.g. banana bunchy-top virus (BBTV), may pass undetected through *in vitro* culture. To meet the urgent need for introducing new desired germplasm for *Musa* breeding and reduce the risk of pathogen transfer, a germplasm-movement strategy based on two independent safeguards, viz. shoot-tip culture and third-country quarantine, was adopted. More than 270 *Musa* accessions have been introduced into Nigeria, including 33 with Black Sigatoka resistance. BBTV has not been diagnosed in any of the introduced materials.

Introduction

The great majority of edible bananas belong to the *Eumusa* series of the genus *Musa* and their ploidy and genomic constitution are designated by letters which relate to the two parent species, *Musa acuminata* (A) and *Musa balbisiana* (B) (Simmonds and Shepherd, 1955).

In sub-Saharan Africa, a clear regional distinction between types of cultivated *Musa* can be observed: highland beer and cooking bananas of AAA genomic constitution dominate in upland East Africa (Sebasigari, 1987) and plantains (*Musa* spp., AAB group) in the West and Central African lowlands. As a result of a long history of cultivation, the variation in the West and Central African plantain complex far exceeds that found in Asia or the Pacific (De Langhe, 1964; Swennen, 1990), where *Musa* is assumed to have originated (Simmonds, 1966). This suggests that the West and Central African regions are a secondary centre of diversity for plantain.

In recent years, African banana and plantain production has been dramatically affected by the appearance and spread of the virulent Black Sigatoka leaf spot disease. The fungal pathogen *Mycosphaerella fijiensis* attacks the leaves, causing severe defoliation by leaf necrosis and eventually reducing yields by 30-50% (Stover, 1983). In Africa, Black Sigatoka was first reported in Zambia in 1973 (Raemaekers, 1975), but it was not until the early 1980s that the fungus spread into Central and West Africa (Frossard, 1980; Wilson and Buddenhagen, 1986). There, all plantain cultivars have been found to be susceptible (Swennen and Vuylsteke, in press a, b). Black Sigatoka had spread to all East African banana-growing countries except Uganda by 1986-87. At least some important East African highland bananas are susceptible (Sebasigari and Stover, 1988; Vuylsteke and Swennen, 1988).

The disease is thus emerging as a pan-African epidemic. Due to the apparent lack of resistance in the African *Musa* genepool, Black Sigatoka has become the overriding constraint to *Musa* cultivation and poses a major threat to food security in the plantain- and banana-growing regions of Africa. Chemical control of the disease is possible, but it is socio-economically unsound, because the bulk of the crop is produced by small farmers who cannot afford expensive, imported fungicides.

The rapid spread of Black Sigatoka has given impetus to efforts aimed at the genetic improvement of *Musa* (Persley and De Langhe, 1987). The International Institute of Tropical Agriculture (IITA) seeks to introduce *Musa* genetic resources in order to:

— obtain diploid sources of Black Sigatoka resistance for use in the genetic improvement of plantains, and

— acquire Black Sigatoka-resistant starchy bananas (mainly of ABB genomic composition) that could be multiplied and distributed as an alternative to susceptible plantains.

The transfer of plant propagation material from one country or continent to another involves the concomitant risk of inadvertently disseminating plant pests and pathogens (Chiarappa and Karpati, 1984). Therefore, many countries have adopted a very conservative attitude towards plant introduction, which has led to severe impediments in the movement of plant materials, particularly in vegetative form (IBPGR, 1988).

Most bananas and plantains are vegetatively propagated in order to retain cultivar characteristics and because seed production is erratic. As well as being bulky, conventional propagules, usually in the form of

[1]International Institute of Tropical Agriculture (IITA), Oyo Road, PMB 5320, Ibadan, Nigeria
[2]Laboratory of Crop Physiology and Tropical Crop Husbandry, Katholieke Universiteit Leuven (KUL), Kardinaal Mercierlaan 92. 3030 Leuven, Belgium
[3]Nigerian Plant Quarantine Service, Moor Plantation, PMB 5672, Ibadan, Nigeria
[4]International Network for the Improvement of Banana and Plantain (INIBAP), Parc Scientifique Agropolis-Montpellier, Bât. 7, Bd. de la Lironde, 34980 Montferrier-sur-Lez, France

suckers or corms, also suffer the disadvantage that they may transport many economically important banana diseases and pests (Stover, 1977). Hence international movement of such propagules would require lengthy post-entry quarantine procedures, severely hampering germplasm movement.

Recent developments in the technology of *in vitro* plant tissue culture have made it possible to utilize aseptic methods for the international exchange of clonal materials, thereby significantly improving their health status (Kahn, 1977, 1986; Roca *et al.*, 1979). *In vitro* transfer has thus become increasingly important as a means of minimizing hazards of disease introduction, particularly for non-viral pathogens. In the case of *Musa*, shoot-tip cultures are very suitable for international movement of germplasm because (1) the mass of plant material involved in the exchange is greatly reduced, (2) the plant material is contained, thus impeding contact with or release of pests or pathogens and, most importantly, (3) they overcome nearly all of the problems associated with non-obscure pests and pathogens (Dale, 1988).

Although distribution of materials in the form of *in vitro* cultures is at present the only acceptable means of intercontinental movement of *Musa* germplasm, *in vitro* culture alone cannot guarantee a pathogen-free status. Berg and Bustamante (1974) reported 75% success in eliminating cucumber mosaic virus from banana by heat therapy and shoot-tip culture. However, the most serious banana virus disease, caused by the banana bunchy-top virus (BBTV), may pass undetected through *in vitro* culture (Dale, 1987, 1988). Drew *et al.* (1989) reported that characteristic BBTV symptoms persisted in 73% of plants regenerated from shoot-tip cultures, 16 months after initiation from infected plants. Due to the relatively large size of usable explants, virus elimination through shoot-tip culture does not appear to be very successful. Serological and molecular detection techniques for BBTV are currently under development (Dale, 1987, 1988) but have not yet been elaborated.

BBTV is essentially confined to the Asian-Pacific basin, but occurs in a few countries in Africa (Burundi, Gabon, Rwanda and Zaire) (Stover, 1977; Fouré and Manser, 1982; Sebasigari and Stover, 1988). It is, at present, not known to occur in West Africa.

To avoid plant health hazards connected with the introduction of new germplasm to Nigeria, a new strategy for the exchange of *Musa* genetic resources that minimizes risk of pathogen transfer was developed by the International Network for the Improvement of Banana and Plantain (INIBAP, 1987) and IITA. This strategy, which is based on shoot-tip culture and third-country quarantine, was endorsed by the Nigerian Plant Quarantine Service. The methodology and results of this considerable joint effort are outlined in this paper. They served as a basis for the FAO/IBPGR technical guidelines for the safe movement of *Musa* germplasm, which were developed at a meeting held in Los Baños, Philippines, in September 1988 (Frison and Putter, 1989).

Materials and Methods

Intermediate quarantine

All *Musa* germplasm destined for introduction into Nigeria is routed via a transit centre in a non-banana-producing country. Such a transit centre, serving as an intermediate quarantine station, was established by INIBAP at the Laboratory of Crop Physiology and Tropical Crop Husbandry, Catholic University of Leuven, Belgium. The centre receives germplasm mostly in the form of suckers shipped by surface or airmail, but airmailed and hand-carried *in vitro* plantlets are also accomodated. The bulk of the material was obtained from established *Musa* collections (field genebanks and working collections) throughout the world, while some accessions have been acquired during prospecting missions by R.S.

Upon arrival, *in vitro* material is duplicated; one part is stored *in vitro* and the other part used to regenerate plantlets for planting in the glasshouse. If suckers are received, shoot-tip cultures are initiated and duplicated for storage and transfer to the glasshouse. For each introduction received at the INIBAP transit centre *in vivo* screening for visual BBTV symptoms is performed on one to four regenerated plants grown in the glasshouse for a minimum of six months. Such a period of intermediate quarantine seems adequate. Indeed, Drew *et al.* (1989) recently demonstrated that micropropagated bananas that were symptomless at five months after establishment in the glasshouse remained free of recognizable symptoms when grown to maturity in the field.

To find out if BBTV would be expressed under the glasshouse conditions of the transit centre in Belgium obviously infected banana and plantain materials obtained from Gabon (Libreville area) were introduced to the centre and monitored under those conditions in Belgium. The suckers continued to show typical BBTV symptoms (Fig. 1).

Fig. 1. Symptoms of banana bunchy-top virus (BBTV), expressed under greenhouse conditions of the INIBAP transit centre at K.U. Leuven, Belgium, on infected plantain materials obtained from Gabon

Plants are also inspected for symptoms of cucumber mosaic virus (CMV). Accessions showing any disease symptoms are eliminated. *Mycosphaerella, Fusarium* and *Pseudomonas* infections should either be removed by the aseptic culture initiation procedure or become self-evident by appearing as contaminants on the culture medium.

Shoot-tip culture

Micropropagation of *Musa* by shoot-tip culture has been adequately described elsewhere (Krikorian and Cronauer, 1984; Jarret *et al.*, 1985; Vuylsteke and De Langhe, 1985; Vuylsteke, 1989, and references cited therein). A brief summary follows. Cultures are initiated by isolating tissue blocks, 1-2 cm in diameter containing the shoot-tips, from buds and suckers. The tissue blocks are surface disinfected by washing with ethanol (95%) for 15-30 seconds, followed by soaking for 15-20 min in 0.5-1.0% (w/v) sodium hypochlorite (with a wetting agent) and rinsing three times with sterile deionized water. Shoot-tips, about 5 mm in diameter and bearing five to seven leaf primordia, are excised aseptically from the tissue blocks, fragmented in two halves, and transferred to glass test tubes containing 20 ml of a modified Murashige and Skoog (1962) medium with 0.4 mg l^{-1} thiamine, 10-20 mg l^{-1} ascorbic acid, 0.18 mg l^{-1} indole-3-acetic acid (IAA), 2.3-4.5 mg l^{-1} 6-benzylaminopurine (BAP), and without inositol. The medium is solidified by addition of 5 g l^{-1} agar or 2 g l^{-1} 'Gelrite'. The pH is adjusted to 5.8 prior to autoclaving at 121°C (1.05 kg cm^{-2}) for 15-20 min. Cultures are incubated at 26-30°C in continuous light of about 3000 lux (at the transit centre) or on a 15 h light/9 h dark cycle (at IITA). The above medium, with a high cytokinin concentration (BAP at 2.3-4.5 mg l^{-1}), is also used for the multiplication of shoot-tip cultures through serial subculture. Plant regeneration from shoot-tip cultures is accomplished on the same basal medium, but with a reduced level of BAP (0.23 mg l^{-1}). IAA may also be replaced by l-naphthaleneacetic acid (NAA, 0.19 mg l^{-1}).

At the INIBAP transit centre, all germplasm (currently over 500 accessions) maintained in shoot-tip culture form is stored under slow-growth conditions at 15°C and 12 h of 1000 lux light (Banerjee and De Langhe, 1985).

Preparation of germplasm for shipment

Germplasm consignments for shipment from the transit centre are prepared from apparently healthy shoot-tip cultures of accessions that have undergone a minimum of six months intermediate quarantine. Cultures are transferred to fresh medium seven to ten days before shipment. This enables detection and elimination of cultures that become accidentally contaminated during the last aseptic handling at the transit centre.

Initially, the culture vessels used for shipment were glass test tubes (150 × 25 mm) capped with cellulose stoppers or Kaputs® and sealed with Parafilm®. These were later replaced by airtight 40 ml containers (55 × 25 mm) made of hard, transparent plastic and with a screwcap closure (Fig. 2a). Vessels contain 20 ml of multiplication medium, modified by increasing the concentration of gelling agent (7 g l^{-1} agar) to avoid disturbing the medium during transit.

Normally two cultures in separate containers are shipped per accession. These are packed in boxes lined with shock-absorbent material (Fig. 2b). Consignments include a list of the shipped germplasm with associated data: species or cultivar name, genome, accession number and time spent under slow-growth conditions. A phytosanitary certificate, with the additional declaration that mother plants were inspected and found to be free of any disease symptoms, is issued by the Ministry of Agriculture (Plant Protection Service) of Belgium. A plant import permit, issued by the Nigerian Plant Quarantine Service, accompanies all shipments.

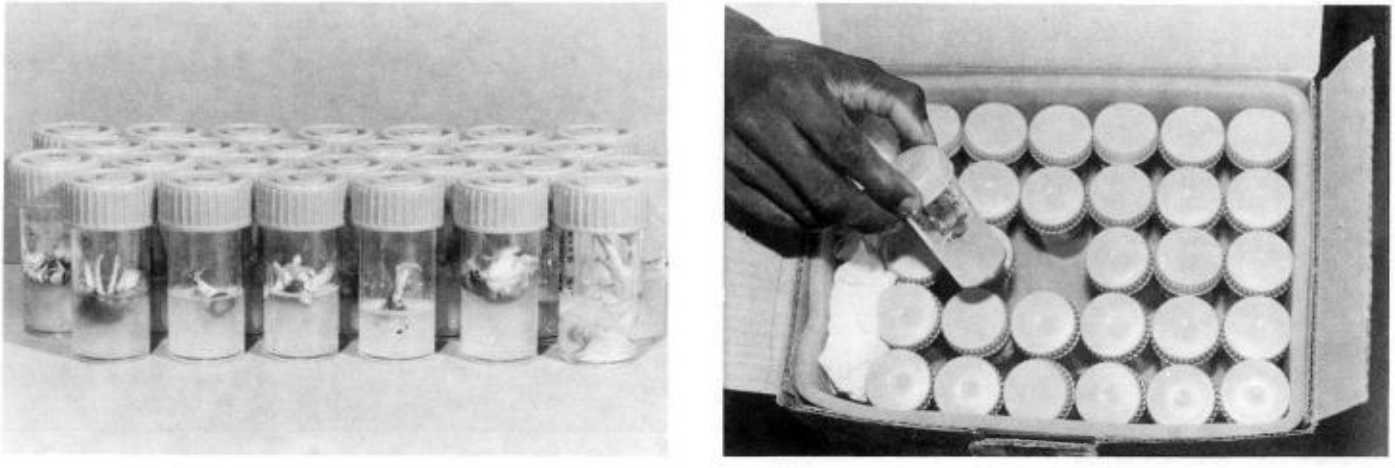


Fig. 2. (a) Left, plastic containers with *Musa* shoot-tip cultures, and (b) Right, carton box, containing 30 cultures, used in *Musa* germplasm shipment. Photographs were taken upon arrival at IITA, Nigeria, following two weeks in transit

Germplasm transfer and port-of-entry inspection

Musa germplasm shipments from Belgium to Nigeria (and *vice versa*) always involve hand-carriage by air. Upon arrival in Nigeria, shipments are sent to the Plant Quarantine Service in Ibadan for inspection. Vessels containing microbial contamination are discarded, and cultures showing unsatisfactory growth are also withheld. The remaining cultures are usually released within a few days and transferred to the IITA substation at Onne, near Port Harcourt, Rivers State, Nigeria, for plant regeneration and incorporation into the *Musa* field collection. The collection is also maintained *in vitro* and gradually transferred to medium-term storage using slow-growth techniques (18-22°C and 12 h light of 3000 lux).

Results and Discussion

Between July 1985 and October 1989, over 20 germplasm shipments totalling more than 600 culture tubes were introduced to Nigeria through the Nigerian Plant Quarantine Service, thereby adding 277 *Musa* species and cultivars to the IITA collection, which now numbers 376 accessions. Up to 26 different accessions have been sent in a single shipment. Table 1 gives the breakdown of the newly introduced accessions according to genomic constitution and their country of origin.

At least 33 introductions (Table 2) have shown resistance to Black Sigatoka. Amongst these, the ABB cooking banana cvs. Fougamou, Gia Hui, Nzizi and Pelipita are being rapidly multiplied *in vitro* for distribution to national programmes in Nigeria in an INIBAP-supported project. The AA diploids Calcutta 4 and Pisang Lilin are useful sources of Black Sigatoka resistance for IITA's plantain breeding programme (Swennen and Vuylsteke, in press c).

Shoot-tip cultures typically spent about 15 days in transit from the day of collection at the transit centre

Table 1. Numbers of *Musa* accessions, introduced into Nigeria as in *vitro* cultures, according to genomic constitution and country of origin

Country of origin	*Eumusa* accessions												Non-*Eumusa* accessions	Total
	AA wild	AA cv	AAA	AAAA	AB	AAB	ABB	AAAB	AABB	BB	Unknown	Other		
Africa														
Burundi			31		2	13	1							47
Cameroon						21								21
Congo						4								4
Cote d'Ivoire	6	1	1	1		5	7					1		22
Gabon		1		1		14	4							20
Americas														
Brazil[1]		2												2
Costa Rica	4	2				3	2			1	2			14
Honduras	6	45	10			12				1			1	75
Asia														
Malaysia			1											1
Philippines						3	2							5
Sri Lanka							1							1
Thailand			1											1
Europe														
Austria[2]		2					2							4
Belgium[3]		1	2								1			4
France[4]	10	22	4			2		2	1	5	1		1	48
FRG[3]											1			1
Oceania														
Australia	1					1	2						1	5
Fiji		1												1
Unknown							1							1
TOTAL	27	77	50	2	2	78[5]	22	2	1	7	5	1	3	277

[1]Originally from Papua New Guinea.
[2]Originally from Honduras.
[3]True origin unknown.
[4]Includes Guadeloupe; bulk originally from Papua New Guinea via Brazil.
[5]Includes 69 plantains.

Table 2. *Musa* accessions with resistance or tolerance to Black Sigatoka disease, introduced into Nigeria as shoot-tip cultures

Genome and name of accession	Level of resistance[1]	Country of origin
AA_{wild}		
M. acuminata	+ +	Costa Rica
M. acuminata T_2	+ +	Côte d'Ivoire
M. acuminata T_3	+ +	Côte d'Ivoire
M. acuminata ssp. *malaccensis*	+ +	Côte d'Ivoire
M. pahang	+ +	Côte d'Ivoire
M. paradisiaca var. *seminifera*	+ +	Belgium
M. siam	+ +	Côte d'Ivoire
M. tavoy	+ +	Côte d'Ivoire
Pa Patthalong	+ +	France
Pa Songkla	+ +	France
M. acuminata ssp. *malaccensis* (Pahang)	+ + +	France
M. acuminata ssp. *truncata*	+ + +	France
Calcutta 4	+ + +	Costa Rica
Long Tavoy	+ + +	France
Pa Musore	+ + +	France
AA_{cv}		
Figue Sucrée	+	Gabon
Pisang Berlin	+ +	France
Pisang Madu	+ +	Costa Rica
Tjau Lagada (V-34)	+ +	Costa Rica
Pisang Lilin	+ + +	Belgium
Tuu Gia	+ + +	France
BB		
M. balbisiana (CATIE 10852)	+	Costa Rica
M. balbisiana (I-63)	+ +	Honduras
AAA		
Ouro Mel	+ +	France
Km 5	+ + +	Côte d'Ivoire[2]
AAAA		
Champa Nasik	+ +	Côte d'Ivoire
IC2	+ +	Gabon
AAB		
Muracho	+	Philippines
Pisang Kelat	+ +	Côte d'Ivoire
ABB		
Nzizi	+	Côte d'Ivoire[2]
Pelipita	+	Costa Rica
Bom	+ +	Côte d'Ivoire
Fougamou	+ +	Gabon
Foulah 4	+ +	Côte d'Ivoire
Gia Hui	+ +	Côte d'Ivoire

[1](+) tolerant; (+ +) highly tolerant; (+ + +) resistant.
[2]Older accessions not introduced under the present scheme.

in Belgium to arrival at the IITA-Onne substation, with a recorded minimum and maximum of eight and 23 days respectively. Such long periods of transit do not seem to affect the cultures adversely. Of the total of 20 shipments, officials of the Nigerian Plant Quarantine Service have retained contaminated cultures on seven occasions. Because each accession is usually duplicated in two separate containers, the accession is not necessarily lost in each case. Actual losses are of seven accessions from four shipments. Partial loss of shipments due to culture contamination is most likely to occur during air transit, even when hand-carried in the aircraft's passenger cabin. This phenomenon has been ascribed to fluctuations in atmospheric pressure during air travel (Roca *et al.*, 1979).

Recovery of plants from shipped *in vitro* cultures has been successful for 91% of the introductions, indicating that a wide range of *Musa* genotypes can be micropropagated using a single protocol (Vuylsteke, 1989). Culture deterioration, mostly due to excessive tissue blackening, was the cause of failure in the remaining 9%, but replacement cultures of the lost accessions were reintroduced in subsequent shipments.

A potential hindrance to the transfer of valuable genetic resources when using *in vitro* techniques is the ubiquitous occurrence of somaclonal variation (Scowcroft, 1984). Although shoot-tip culture is generally considered to be an *in vitro* culture system with a low risk of genetic instability (Scowcroft, 1984), several reports of the incidence of off-types among micropropagated *Musa* have appeared recently (Hwang and Ko, 1987; Stover, 1987; Vuylsteke *et al.*, 1988). Out of 202 introductions for which plants have already been regenerated and added to the field collection, six accessions were affected by phenotypic variation. In only two of these did all five or six regenerated plants show off-type traits, resulting in the loss of the accession. However, the variant characters were transient in one of these two cases, as the first ratoon grew normal plants. In the four other accessions only some (15-65%) of the regenerated plants were variants. Off-type traits mostly involved vegetative characters such as leaf form or pseudostem colour, but in one clone an off-type with abnormal finger colour was observed. In two of the six cultivars showing variations, the variants were identified at the nursery stage and rogued before field planting.

Finally, but most importantly, we wish to stress that BBTV symptoms were never observed in any of the imported materials (nor in any accession of the germplasm held beforehand). Considering that 44 of the 202 field-planted *Musa* accessions originated from 'high-risk areas' (Burundi, Gabon and the Philippines) where BBTV is prevalent, it appears that the scheme of germplasm movement outlined above has been effective in avoiding BBTV introduction.

Although BBTV has been reported to pass through shoot-tip culture (Drew *et al.*, 1989) and symptom detection by eye at the whole-plant level is reputed to be unreliable (Dale, 1987, 1988), the fact that BBTV seems to be confined to specific localities in areas that are generally considered as infected is an advantageous factor to be taken into account in risk assessment. For example, Sebasigari and Stover (1988) found that in East Africa, BBTV is confined to a relatively small area covering the Bujumbura Valley (800-1200 masl) in Burundi and the adjacent Bugarama Valley in Rwanda and that it has not spread beyond this area.

The 47 introductions from Burundi (Table 1), however, were taken from the IRAZ (Institut de Recherche Agronomique et Zootechnique) collection at Gitega (1700 masl), which is about 100 km from the Bujumbura Valley. Thus, the risk of introducing BBTV to Nigeria when obtaining banana germplasm from the IRAZ collection is very low due to the specific epidemiology of the bunchy-top disease in Burundi.

The chances of pests or pathogens entering on newly imported germplasm is lower when the number of independent safeguards (i.e. those having different modes of action) is greater (Kahn, 1986). Two such safeguards, *in vitro* culture and intermediate quarantine inspection, are routinely applied in the introduction scheme outlined above. Obviously, another important precautionary measure taken is that materials are collected by *Musa* specialists from areas into which the virus has not yet spread and that materials taken do not show any symptoms of BBTV. The risk of accidental introduction of this virus into Nigeria is thereby greatly reduced.

Conclusion

The most significant impediment to the movement of *Musa* germplasm remains the risk of concomitant BBTV introduction. A genuinely safe method for germplasm transfer will not be available until reliable procedures for disease indexing have been developed so that plants and/or cultures can be certified to be pathogen-free. However, the rapid spread of Black Sigatoka disease into Nigeria and other West African countries and the lack of resistance to this disease in the African *Musa* genepool has necessitated the expeditious movement of genetic resources for use in a genetic improvement programme. In defining a germplasm introduction strategy, we adopted a combination of shoot-tip culture and third-country quarantine to minimize the risk of importing new disease. Valuable genetic resources, apparently free of BBTV, have been introduced into Nigeria. BBTV symptoms have not been diagnosed on them. Reliable indexing methods for this virus are currently being developed. These should in future be applied to all banana germplasm in order to reduce further the risk of inadvertent introduction of the virus during international distribution of *Musa* germplasm.

Acknowledgements

We are indebted to W. Dillemans (KUL), J.B. Sule and L. Oragwa (IITA) for technical assistance in the handling of shoot-tip cultures. Thanks are also due to the many scientists who made the genetic resources of their collections available for distribution. They are too numerous to mention individually. We thank S.Y. Ng (Tissue Culturist, IITA) for assistance in germplasm storage and H.W. Rossel (Virologist, IITA) for useful comments on the manuscript. The research and activities described in this paper are supported in part by grants from the Belgian Agency for Development Cooperation (ABOS/AGCD).

References

Banerjee, N. and De Langhe, E. 1985. A tissue culture technique for rapid clonal propagation and storage under minimal growth conditions of *Musa* (banana and plantain). Plant Cell Reports 4:351-354.

Berg, L.A. and Bustamante, M. 1974. Heat treatment and meristem culture for the production of virus-free bananas. Phytopathol. 64:320-322.

Chiarappa, L. and Karpati, J.F. 1984. Plant quarantine and genetic resources. *In* Holden, J.H.W. and Williams, J.T. (eds.). *Crop genetic resources: conservation and evaluation.* Allen and Unwin, London, pp. 158-162.

Dale, J.L. 1987. Banana Bunchy-Top Virus: a continuing threat. *In* Persley, G.J and De Langhe, E.A. (eds.). *Banana and plantain breeding strategies: Proceedings of an International Workshop held at Cairns, Australia,* 13-17 Oct 1986. ACIAR Proceedings No. 21, pp. 124-127.

Dale, J.L. 1988. The status of disease indexing and the international distribution of banana germplasm. In *IBPGR Advisory Committee on* In Vitro *Storage. Conservation and movement of vegetatively propagated germplasm:* in vitro *culture and disease aspects.* International Board for Plant Genetic Resources, Rome, pp. 43-46.

De Langhe, E. 1964. The origin of variation in the plantain banana. Mededelingen Landbouwhogesch. (Ghent) 29:45-80.

Drew, R.A., Moisander, J.A. and Smith, M.K. 1989. The transmission of banana bunchy-top virus in micropropagated bananas. Plant Cell, Tissue and Organ Culture 16:187-193.

Fouré, E. and Manser, P.D. 1982. Note sur l'apparition au Gabon d'une grave maladie virale des bananiers et plantains: le Bunchy top. Fruits 37:409-414.

Frison, E.A. and Putter, C.A.J. (eds.). 1989. FAO/IBPGR Technical Guidelines for the Safe Movement of *Musa* Germplasm. Food and Agriculture Organization of the United Nations, Rome/International Board for Plant Genetic Resources, Rome.

Frossard, P. 1980. Apparition d'une nouvelle et grave maladie foliaire des bananiers et plantains au Gabon: la maladie des raies noires, *Micosphaerella fijiensis* Morelet. Fruits 35:519-527.

Hwang, S.C. and Ko, W.H. 1987. Somaclonal variation of bananas and screening for resistance to *Fusarium* wilt. *In* Persley, G.J. and De Langhe, E.A. (eds.). *Banana and plantain breeding strategies: Proceedings of an International Workshop held at Cairns, Australia,* 13-17 Oct 1986. ACIAR Proceedings No. 21, pp. 151-156.

IBPGR. 1988. IBPGR Advisory Committee on *In Vitro* Storage. Conservation and Movement of Vegetatively Propagated Germplasm: *In vitro* Culture and Disease Aspects. International Board for Plant Genetic Resources, Rome.

INIBAP. 1987. Genetic Improvement of Bananas and Plantains and the INIBAP Project on International *Musa* Germplasm Exchange. Report of a Meeting of *Musa* Breeding Programmes with INIBAP. INIBAP/87/11. International Network for the Improvement of Banana and Plantain, Montpellier.

Jarret, R.L., Rodriguez, W. and Fernandez, R. 1985. Evaluation, tissue culture propagation, and dissemination of 'Saba' and 'Pelipita' plantains in Costa Rica. Scientia Hortic. 25:137-147.

Kahn, R.P. 1977. Plant quarantine: principles, methodology, and suggested approaches. *In* Hewitt, W.B. and Chiarappa, L. (eds.). *Plant health and quarantine in international transfer of genetic resources.* CRC Press, Boca Raton, pp. 289-307.

Kahn, R.P. 1986. Plant quarantine and international shipment of tissue culture plants. *In* Zimmerman, R.H., Griesbach, R.J., Hammerschlag, F.A. and Lawson, R.H. (eds.). *Tissue culture as a plant production system for horticultural crops.* Martinus Nijhoff, Dordrecht, pp. 147-164.

Krikorian, A.D. and Cronauer, S.S. 1984. Banana. *In* Sharp, W.R., Evans, D.A., Ammirato, P.V. and Yamada, Y. (eds.). *Handbook of plant cell culture,* Vol. 2. Macmillan, New York, pp. 327-348.

Murashige, T. and Skoog, F. 1962. A revised medium for rapid growth and bio-assays with tobacco tissue cultures. Physiol. Plant 15:473-497.

Persley, G.J. and De Langhe, E.A. (eds.). 1987. Banana and plantain breeding strategies: Proceedings of an International Work-

shop held at Cairns, Australia, 13-17 October 1986. ACIAR Proceedings No. 21.

Raemaekers, R. 1975. Black leaf streak-like disease in Zambia. PANS 21:396-400.

Roca, W.M., Bryan, J.E. and Roca, M.R. 1979. Tissue culture for the international transfer of potato genetic resources. Amer. Potato J. 56:1-10.

Scowcroft, W.R. 1984. Genetic Variability in Tissue Culture: Impact on Germplasm Conservation and Utilization. International Board for Plant Genetic Resources, Rome.

Sebasigari, K. 1987. Morphological taxonomy of *Musa* in Eastern Africa. *In* Persley, G.J. and De Langhe, E.A. (eds). *Banana and plantain breeding strategies: Proceedings of an International Workshop held at Cairns, Australia,* 13-17 October 1986. ACIAR Proceedings No. 21, pp. 172-176.

Sebasigari, K. and Stover, R.H. 1988. Banana Diseases and Pests in East Africa: Report of a survey made in November 1987. INIBAP/88/02. International Network for the Improvement of Banana and Plantain, Montpellier.

Simmonds, N.W. 1966. Bananas, 2nd edition. Longman, London and New York.

Simmonds, N.W. and Shepherd, K. 1955. The taxonomy and origins of cultivated bananas. J. Linn. Soc. Lond., Bot., 55:302-312.

Stover, R.H. 1977. Banana (*Musa* spp.). *In* Hewitt, W.B. and Chiarappa, L. (eds.). *Plant health and quarantine in international transfer of genetic resources.* CRC Press, Boca Raton, pp. 71-79.

Stover, R.H. 1983. Effet du Cercospora noire sur les plantains en Amérique centrale. Fruits 38:326-329.

Stover, R.H. 1987. Somaclonal variation in Grand Naine and Saba bananas in the nursery and field. *In* Persley, G.J. and De Langhe, E.A. (eds.). *Banana and plantain breeding strategies: Proceedings of an International Workshop held at Cairns, Australia,* 13-17 Oct. 1986. ACIAR Proceedings No. 21, pp. 136-139.

Swennen, R. 1990. Limits of morphotaxonomy: names and synonyms of plantains in Africa and elsewhere. *In* Jarret, R.L. (ed.). *Identification of genetic diversity in the genus* Musa. *Proceedings of a Workshop held at Los Baños, Philippines,* 5-10 Sept 1988. INIBAP, Montpellier, pp. 172-210.

Swennen, R. and Vuylsteke, D. Bananas in Africa: aspects of diversity and prospects for improvement. IITA/CNR/IBPGR/UNEP Workshop on Crop Genetic Resources in Africa, held at Ibadan, Nigeria, 17-20 Oct 1988. (In press, a)

Swennen, R. and Vuylsteke, D. Plantains in west and central Africa: importance, production constraints and prospects for improvement. Fourth West and Central African Root Crops Workshop, held at Lomé, Togo, 12-16 Dec 1988. (In press, b)

Swennen, R. and Vuylsteke, D. Aspects of plantain breeding at IITA. INIBAP Workshop on Sigatoka Leaf Spot Diseases, held at San José, Costa Rica, 28 Mar - 1 Apr 1989. (In press, c)

Vuylsteke, D. 1989. Shoot-tip Culture for the Propagation, Conservation and Exchange of *Musa* Germplasm. Practical Manuals for Handling Crop Germplasm *In Vitro*. 2. International Board for Plant Genetic Resources, Rome.

Vuylsteke, D. and De Langhe, E. 1985. Feasibility of *in vitro* propagation of bananas and plantains. Trop. Agr. (Trinidad) 62:323-328.

Vuylsteke, D. and Swennen, R. 1988. Preliminary report on the vigour and Black Sigatoka reaction of some east African bananas, cultivated under humid lowland conditions in Nigeria. Musarama 1(1):2-3.

Vuylsteke, D., Swennen, R., Wilson, G.F. and De Langhe, E. 1988. Phenotypic variation among *in vitro* propagated plantain (*Musa* sp. cv. AAB). Scientia Hortic. 36:79-88.

Wilson, G.F. and Buddenhagen, I. 1986. The Black Sigatoka threat to plantain and banana in west Africa. IITA Research Briefs 7(3):3.

Résumé

Culture d'apex de tige et quarantaine dans un pays tiers pour faciliter l'introduction de nouveau matériel génétique de Musa *en Afrique de l'Ouest*

La culture de tissus s'emploie de plus en plus comme moyen permettant d'échanger le matériel génétique de *Musa* sans risque de contamination. Toutefois, certains pathogènes tels que le virus du «bunchy-top» (BBTV) ne sont pas toujours détectés durant la phase de culture de tissus. Afin de pouvoir introduire rapidement le nouveau matériel génétique indispensable à l'amélioration de *Musa* et de réduire les risques de diffusion des agents pathogènes, une stratégie de transfert du germoplasme a été adoptée. Celle-ci s'articule autour de deux protections indépendantes l'une de l'autre: la culture d'apex de tige et la quarantaine dans un pays tiers. Plus de 270 obtentions de *Musa* ont d'ores et déjà été introduites au Nigéria, dont 33 dotées de résistance à la cercosporiose noire. Le virus du «bunchy-top» (BBTV) n'a été décelé sur aucune de ces introductions.

Resumen

Cultivo de yemas apicales y cuarentena en un tercer país para facilitar la introducción de nuevo germoplasma de Musa *en Africa occidentale*

El cultivo de tejidos se utiliza cada día mas como medio de sano intercambio de germoplasma de *Musa*. Sin embargo, ciertos patógenos como el virus del "bunchy-top" (BBTV) a veces escapan la detección durante la fase de cultivo de tejidos. A fin de poder introducir rapidamente nuevo germoplasma indispensable para el mejoramiento de *Musa*, mientras se reduce al riesgo de difusión de patógenos, se ha adoptado una estrategia de movimiento del germoplasma basada en dos salvaguardias independientes: el cultivo de yemas apicales y la cuarentena en un tercer país. Más de 270 introducciones de *Musa*, incluyendo 33 resistentes a la Sigatoka negra, han sido traidas a Nigeria. El virus del "bunchy-top" no se ha diagnosticado en ninguna de las introducciones.

GENIS-PCC: Documentation of dispersed working collections

Th. Hazekamp and Th.J.L. van Hintum[1]

Summary

GENIS-PCC is an information system for the documentation on personal computer of dispersed working collections. The system was developed by the Centre for Genetic Resources the Netherlands. So far nine working collections of horticultural and agricultural crops have been documented using GENIS-PCC applications. Small documentation systems such as GENIS-PCC can play an important role in processing information on small, dispersed collections.

Introduction

GENIS-PCC is an information system for the documentation of dispersed working collections. GENIS stands for GENetic resources Information Systems, a group of applications developed at the Centre for Genetic Resources, the Netherlands (CGN) for the documentation of genetic resources (IBPGR, 1987; van Hintum, 1988). The GENIS-PCC (= Personal Computer/Cropversion) applications are developed to support researchers in the documentation of their own germplasm collections. These are usually single-crop collections maintained at breeding research institutes, which are not (yet) part of the collections held at CGN. Most information on working collections is stored in fieldbooks, notebooks etc. Computerization would increase the accessibility of this information, leading to more efficient use and management of germplasm collections. Computerization of routine activities, such as making planting lists or reproducing pedigree schemes, could also increase working efficiency.

To help researchers, CGN decided to support the documentation of dispersed working collections. In this way the experience of CGN could be shared by other institutes. The advantages of this approach were twofold. First, documentation could be started in the short term and was readily available to the breeder. Second, CGN would be able to include already documented material more rapidly into its collections.

The GENIS-PCC applications are not only limited to the documentation of collections. Systems designed for breeders should also be able to handle more practical tasks, such as generating planting lists, pedigree schemes and periodic reports (Konzak *et al.*, 1970).

Small documentation systems such as GENIS-PCC can act as components in a larger information network, providing information on small collections to a wider audience. They may also serve as a starting point for the development of an integrated national information system for genetic resources.

This article gives a short description of the general structure of GENIS-PCC applications and summarizes some of the crucial factors involved when implementing such systems.

System configuration

All PCC applications are based on the ORACLE relational database management system. The system stores information in two-dimensional tables with columns and rows. Information from different tables can be linked. ORACLE (version 4.1.17) can be used on IBM compatible XT and AT computers under MS-DOS version 3.2 or higher. It requires at least 512 Kbytes of RAM and a hard disk of at least 5 Mbytes. Use was made of GWBASIC for some of the report facilities. The menu facility PICOLO XV was used to create the overall menu structure.

Menu structure

The application is menu-driven, which makes it user-friendly. Without having to memorize complicated command sequences, users are able to navigate their way through the information system to find the information required. The main menu offers three options: entry/update of information; retrieval of information; and database management.

Validity checks are made when entering or updating information. These checks somewhat reduce the performance of the system.

Database management provides access to the user-friendly interface (UFI) and to report writing and backup facilities.

User interfaces

The information in the database system can be accessed in a number of ways. The easiest method is through the so-called interactive application processor (IAP). When using IAP a selected number of data fields is presented on the screen, usually in a custom-made layout. IAP can provide help texts for data fields or facilities to check validity of data entered. Besides IAP, the UFI can be used to access the database. UFI

[1] Centre for Genetic Resources the Netherlands, PO Box 224, 6700 AE Wageningen (now part of the Centre for Plant Breeding Research, CPO)

requires knowledge of the structured query language (SQL), but permits more flexible data access. SQL is a fourth-generation language and is relatively easy to learn. UFI contains several text-formatting commands, which make it possible to generate fairly complex reports.

Types of information

There are three types of information that are commonly present in GENIS-PCC applications:

Passport data

This type of data usually contains a taxonomical section and a section describing the geographical origin of the sample. Data fields like genus, species and subspecies name, donor and pedigree are common. Habitat data are recorded when breeding material was collected during expeditions.

Evaluation or characterization data

Often a distinction is made between standard and non-standard characteristics. Standard characteristics, which are part of a descriptor list, can be measured by recurrent observations. These data are stored in record together with a unique sample number and an experiment number. Non-standard characteristics can also be measured and recorded. Their low frequency does not justify the creation of a separate column in the standard evaluation set. A format was chosen in which all kinds of different evaluation results could be stored. It contains data fields (name of fields between brackets) describing which sample number was evaluated (SNR), in which experiment the evaluation took place (ENR), which characteristic or attribute was evaluated (ATTR), which method was used to describe the attribute (METHOD) and a value field containing the actual score of the observation or measurement (VALUE).

E.g.	SNR	ENR	ATTR	METHOD	VALUE
	8902	1	22	14	1

ENR = 1: Experiment performed at CGN, Wageningen in 1985 on peas.
ATTR = 22: Flower colour.
METHOD = 14.
VALUE = 1: 1 = white, 2 = purple, 3 = red.

This method of storing data on non-standard characteristics requires a lot of space for every observation, but this is a relatively minor drawback, since the datasets are usually of a very limited size.

Storage data

These data are used to facilitate the management of the material in storage. The information includes elements such as sample number, type of material, quantity, date of last rejuvenation, storage shelf/box, etc. Furthermore, tables containing auxiliary data are frequently present, for example the sequence in which samples are planted in a certain experiment. This information is used to generate planting lists and fieldbooks.

Although most data are entered by hand, some applications are equipped with interfaces to enable the loading of data that have been pre-processed using electronic devices like dataloggers.

Applications

So far seven GENIS-PCC applications are in use by researchers working on crops including carnation, eggplant, lily, maize, tomato, tulip, strawberry, sweet pepper and wheat. The size of the collections ranges from 200 to 7200 samples. The number of GENIS-PCC applications is expected to increase, since more and more researchers have become convinced that computerization of collection information is worthwhile.

Conclusions

Information systems are a synthesis of information and a technical and logical infrastructure enabling efficient and flexible use of that information. These two components have to be balanced to create a practical and useful information system.

When considering the information, the role of the crop specialists is crucial. Without their dedicated support no information system is viable. Generally speaking the crop specialists have to invest time and effort to prepare data for entry and check them afterwards before the system starts to pay off (Witcombe and Erskine, 1984). The eventual benefits depend to a large extent on whether the crop specialists familiarize themselves with the possibilities of the system. This is mainly a matter of direct experience. During the creation and implementation of the information systems, substantial logical and technical support is required. After a while support is reduced. However, information systems are dynamic applications that need periodic servicing to maintain or improve their informative capability. Most end users are not interested, and need not be interested, in the technical details of database maintenance. For dispersed collections a central database expert, who provides servicing and database modification when necessary, should be available. In this way database expertise can be shared by a number of users. Besides, the centralized development of information systems is more efficient. Quite a number of modules can be used more than once.

In the Netherlands the database expertise at CGN and the applications at the breeding institutes are located very close to each other. Because of this proximity, support is relatively easy. In situations where the geographical distance between the central database expert and the documentation sites is larger, other means of communication have to be chosen, like dedicated computer networks or modems in conjunction with ordinary telephone lines.

A network structure enables the integration of information. Separate documentation systems can be joined into a national germplasm information system like CENARGEN in Brazil (Esquinas-Alcazar, 1985) or GRIN in the USA (Perry, 1988). Integration should

lead to more efficient management and use of collections. The coordinating organization could also act as a well-informed gateway to the international genetic resources community, connecting national collections to the global genetic resources network.

Small documentation systems such as GENIS-PCC can play an important role in processing information on small, dispersed collections like some working collections. Although GENIS-PCC is based on ORACLE, the data structure could be implemented using other database management systems. By providing tailor-made applications to breeders, some breeding activities can be performed more efficiently. At the same time, the documentation of genetic resources is actively stimulated and information on valuable genetic resources can be made available to a larger scientific audience.

References

Esquinas-Alcazar, J.T. 1985. Los recursos fitogenéticos de Brasil. FAO/IBPGR Pl. Genet. Resources Newsl. 63:15-25.

Hintum, Th.J.L. van. 1988. GENIS: A fourth generation information system for the database management of genebanks. FAO/IBPGR Pl. Genet. Resources Newsl. 75/76:13-15.

IBPGR. 1987. Report of a *Beta* Workshop, European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources. International Board for Plant Genetic Resources, Rome.

Konzak, C.F., Walden, W.E. and Sousa, F.P., 1970. Problems and progress in the management of information on genetic resources. Seiken Ziho 22:91-97.

Perry, M. 1988. The germplasm resources information network. FAO/IBPGR Pl. Genet. Resources Newsl. 73/74:21-26.

Witcombe, J.R. and Erskine, W. 1984. Documentation of germplasm collections by computer. *In* Witcombe, J.R. and Erskine, W. (eds.). *Genetic resources and their exploitation — chickpeas, faba beans and lentils*. Martinus Nijhoff/Dr W. Junk, The Hague/Boston/Lancaster.

Résumé

GENIS-PCC: Documentation sur les collections de travail dispersées

GENIS-PCC est un système informatisé de documentation sur les collections de travail dispersées. Le système a été mis au point par le Centre de Ressources Génétiques des Pays-Bas. A l'heure actuelle, neuf collections de travail relatives à des productions végétales horticoles et agricoles ont été inventoriées en utilisant des applications de GENIS-PCC. De petits systèmes de ce genre peuvent jouer un rôle important dans le traitement de l'information disponible dans des collections dispersées.

Resumen

GENIS-PCC: Documentación de colecciones de trabajo dispersas

GENIS-PCC es un sistema de información para la documentación en ordenadores personales de colecciones de trabajo dispersas. El sistema fue elaborado por el Centro de Recursos Genéticos de los Países Bajos y, hasta el momento, se han documentado, utilizando las aplicaciones GENIS-PCC, nueve colecciones de trabajo sobre cultivos hortícolas y agrícolas. Los pequeños sistemas de documentación como el GENIS-PCC pueden desempeñar una función importante para la elaboración de datos sobre pequeñas colecciones dispersas.

African eggplants — a review of collecting in West Africa

Richard N. Lester[1], Peter-M.L. Jaeger[1],
Brigitte H.M. Bleijendaal-Spierings[2], Henk P.O. Bleijendaal[2]
and Henry L.O. Holloway[3]

Summary

Eggplants or aubergines are important fruit and leaf vegetables in Africa. Both *Solanum aethiopicum* (Scarlet eggplant) and *S. macrocarpon* (Gboma eggplant) were domesticated in Africa from indigenous wild species, and are grown abundantly especially in tropical Africa: *S. melongena* (Brinjal eggplant) from Asia is less popular. Recent collecting of eggplant genetic resources from West Africa and elsewhere is summarized. Suitable procedures for collecting, evaluation, regeneration and multiplication are discussed in the context of climates, agricultural systems, reproduction biology and dangers of genetic erosion.

Introduction

Since 1980, the International Board for Plant Genetic Resources (IBPGR) has sponsored eggplant collecting missions in five West African countries, namely Benin, Burkina Faso, Côte d'Ivoire, Ghana and Togo, but materials have also been collected in many other African countries, making about 1000 samples altogether (Table 1, Fig. 1). Specialist missions in the areas of greatest genetic diversity have been worthwhile since experts are needed to recognize and deal with the complex situations there and to adjust their collecting tactics appropriately in each area. Elsewhere valuable collecting has been done, even though misidentifications were common and very few wild species were collected by these non-specialists, possibly because they did not recognize these eggplant relatives. However, adequate collections of the wild relatives have been made by the Royal Botanic Gardens, Kew and other organizations and supplied to the Birmingham University Solanaceae Collection.

Scarlet and Gboma eggplants or aubergines (*Solanum aethiopicum* and *S. macrocarpon*) are important in Africa both as fruit and as leaf vegetables, whereas only the fruits of the well-known Asian Brinjal eggplant (*S. melongena*) are eaten. A careful survey (Siemonsma, 1980) showed that in West Africa eggplants are amongst the most important leaf and fruit vegetables after okra (*Abelmoschus* spp.). In the equatorial rain forest regions of coastal West Africa and the Zaire River basin mainly *Solanum macrocarpon* is grown, whereas *S. aethiopicum* Gilo group predominates in savanna regions throughout Africa and is very drought resistant. *Solanum aethiopicum* Kumba group is favoured in the Sahel region of West Africa, being grown in the brief wet season, or with irrigation in the dry season. Wild or weedy *S. anguivi* and other domesticated and weedy solanums occur occasionally in various parts of Africa.

Judging by the diversity of names for these eggplants in many languages, they are ancient crops in Africa. The greatest diversity of cultivars of both *Solanum aethiopicum* and *S. macrocarpon* is found today around Côte d'Ivoire in West Africa. East Africa is rich in wild *Solanum* species and domestication may have started there although the prickly and hairy smaller-fruited weedy progenitors, *S. anguivi* and *S. macrocarpon* subsp. *dasyphyllum* respectively, are found equally in both West and East Africa, usually in areas disturbed by man. The concept of a centre of origin in East Africa followed by diversification in West Africa has also been proposed for *Vigna unguiculata* (Ng and Marechal, 1985). However the concept of centres of origins of crops cannot be applied easily to African crops (Harlan *et al.*, 1976), because most of them appear to have been domesticated throughout extensive areas. The lack of obvious centres results from the generally undulating terrain draped with extensive belts of vegetation types, but within which are catenas of different agro-ecological habitats. Different tribes exploiting these different habitats have migrated across each other in various directions, taking with them preferred cultivars of all their crops. Today we are left with a confusing mosaic of uncertain patterns.

Until very recently taxonomic confusion and nomenclatural complexities prevented clear recognition of the various cultivated species of eggplants and their respective wild relatives, but the situation has now improved.

Solanum melongena L. was certainly domesticated from wild plants in southeast Asia. It has been widely

[1] Department of Plant Biology, University of Birmingham, PO Box 363, Birmingham, B15 2TT, UK
[2] Department of Tropical Crops and Horticulture, Agricultural University, PO Box 341, 6700 AH Wageningen, the Netherlands
[3] Plant Introduction and Exploration, Crops Research Institute, Agricultural Experiment Station, PO Box 7, Bunso E/R, Ghana

Table 1. Eggplants and their relatives collected in Africa

Abbreviations: a - *S. anguivi*; G - *S. aethiopicum* Gilo group; K - *S. aethiopicum* Kumba group; S - *S. aethiopicum* Shum group; m - *S. macrocarpon* subsp. *macrocarpon*; d - *S. macrocarpon* subsp. *dasyphyllum*; me - *S. melongena*; in - *S. incanum*; sc - *S. scabrum* etc; o - other spp.

Country	Year	Total	a	G	K	S	m	d	me	in	sc	o	Coll. code
IBPGR eggplant-collecting missions													
Burkina Faso	1982	56	2	3	42		4		4		1		J&B, J&T
Côte d'Ivoire	1982	377	22	257	15		52	3	23		5		BBS, HBI
Cote d'Ivoire	1985	163	19	92	32		15	4			1		KAL
Benin & Togo	1981	141	1	51	4	5	56	8	5	1	7	3	BUNSO
Ghana	1981-83	123	7	82	5		15	1	12			1	BUNSO
Other IBPGR missions and other sources													
Africa, E. & S.	1965-85	31								31			(Kew etc)
Burundi	1985	7		7									IRAZ
Cameroon	1985	6	2	3		1							(Westphal-S.)
Ethiopia		5								5			(Engels)
Liberia		19	1	18									LB-
Madagascar		5	3	2									(D'Arcy)
Nigeria		76		34			31		8		1	2	TB, TE
Nigeria	1981-2	52		46		1	4				1		TB/NH
Nigeria	1981	69		22			39		4		2	2	TB/NH
Nigeria	1982	56		49		5	2						TB/NH
Nigeria	1983-4	88		82			3				3		TB/NH
Senegal		2			2								(Daunay)
Sudan		1								1			(Croston)
Uganda		13	6	4		3							(Bukenya)
Zambia		9		6		3							ZFA
Zimbabwe		18					5	8		5			TGR
TOTAL		1317											

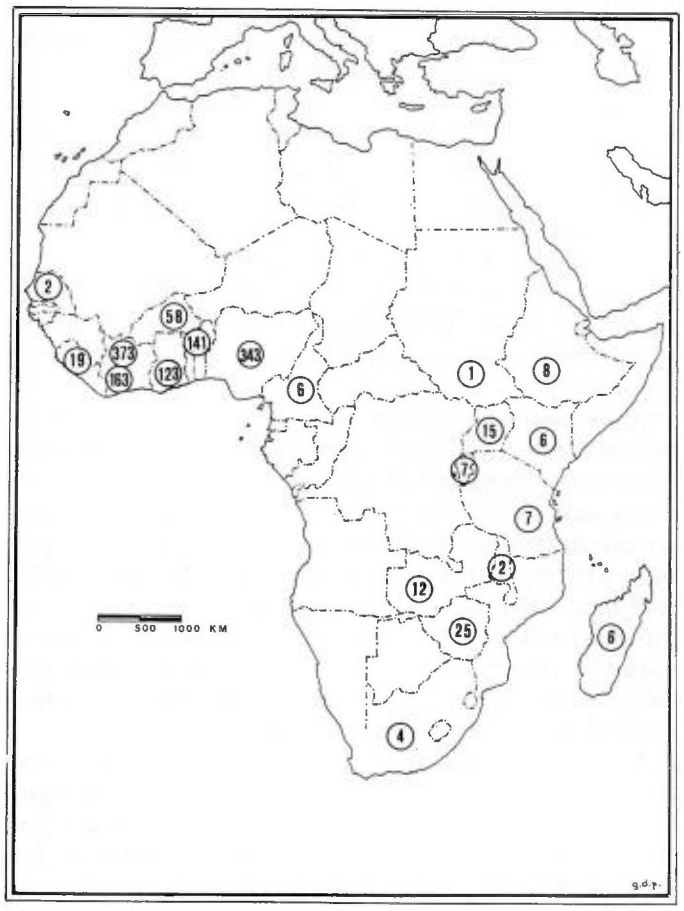


Fig. 1. Map of Africa, showing numbers of collections of eggplants made in various countries (see Table 1)

cultivated in Africa, north of the Sahara for at least 500 years, and more recently in southern Africa, but is seldom grown in equatorial Africa. Nevertheless Africa is rich in wild relatives: there are many species of savanna areas which may be included in *S. incanum sensu amplissimo,* which are of potential value for breeding with *S. melongena.*

Solanum macrocarpon L. (Fig. 2), with typically glabrous leaves, has been domesticated from *S. macrocarpon* subsp. *dasyphyllum* (Schum. & Thonn.) Jaeger ined., a weedy, prickly and hairy plant, but *S. sessilistellatum*, from primary vegetation in Kenya, is probably the original wild ancestor. Field observations in West Africa suggest that the weed was first kept for its fruit used in medicine and witchcraft, then cultivated and selected for palatable fruits, then for glabrous leaves and finally for small leaves which could be cropped frequently. Throughout most of the range the fruits are about 3-5 cm in diameter, subspherical, green, ripening to a clear orange; however in the Côte d'Ivoire region fruits may be up to 8 cm in diameter, or ovoid, or white or purplish when unripe, or brown or cracked or crazed when fully ripe (Fig. 2). Likewise plants with large, lobed leaves are found throughout tropical Africa, although they may be laciniate in Ethiopia and more robust in Zimbabwe, but dwarf plants with small entire leaves are limited to West Africa. In Côte d'Ivoire mainly the fruits are eaten, whereas in Togo the leaves are consumed.

Fig. 2. An accession of *Solanum macrocarpon* showing the typical large, edible, hair- and prickle-free leaves, large purple flower and cracked, orange fruit

Solanum aethiopicum L. has been domesticated from *S. anguivi* Lam. (=*S. indicum* auct. non L.) (Lester and Niakan, 1986; Lester *et al.*, 1986), which bears trusses of 10-15 red berries 0.7-1.0 cm in diameter (Fig. 3a). Several very prickly varieties are found in primary and secondary vegetation scattered throughout Africa. Prickle-free varieties (=*S. distichum* Thonn., *S. anomalum* auctt. non Thonn., *S. scalare* C.H. Wright, etc.) occur as weeds in forest areas of Côte d'Ivoire, Ghana, Uganda and some other regions. Although disseminated by birds, like bird peppers, they are cultivated when they grow spontaneously in gardens and the bitter fruits are used for flavour and for diverse medicinal purposes such as preventing malaria or increasing lactation.

Domestication commenced with selection and sowing of slightly larger spherical fruited varieties, and such primitive cultivars of *Solanum aethiopicum* L. Gilo group occur similarly in Côte d'Ivoire and Uganda and probably elsewhere. Subsequently much larger and ovoid or ellipsoid fruited cultivars (previously called *S. gilo* Raddi, *S. pierreanum* Paill. & Bois, *S. incanum* auctt. non L., etc.) were developed in West Africa (Figs. 3c,d,e, 4). In Côte d'Ivoire Gilo-*anguivi* intermediates (called Klongba in Baoulé) are common, with many bitter fruits on each truss like *S. anguivi*, but differing in being larger and/or ellipsoid or white

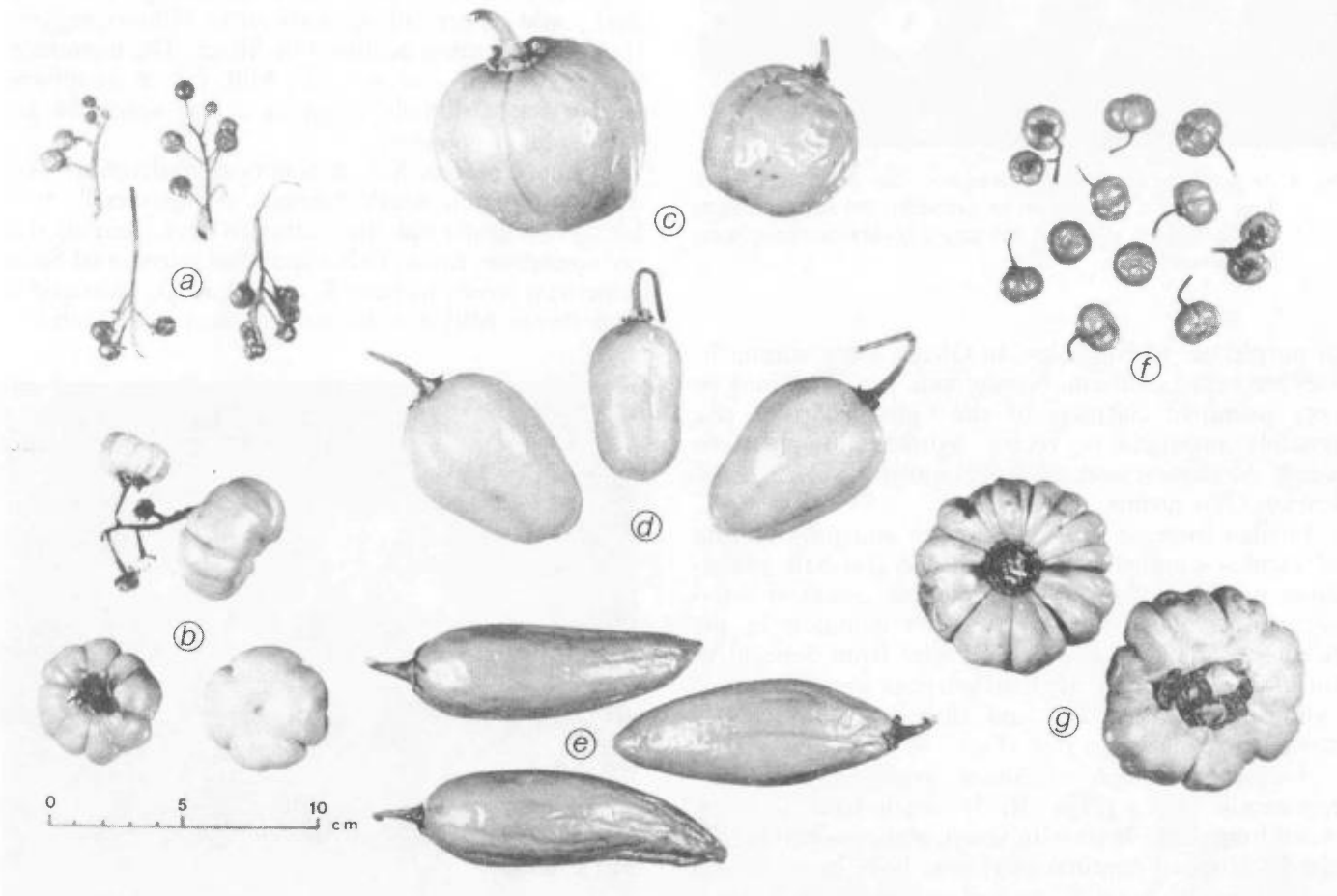


Fig. 3. Examples of fruits of scarlet eggplant, *Solanum aethiopicum*, and relatives; a - *S. anguivi*, from Ghana, with racemes of small bitter fruits; b - *S. aethiopicum* Aculeatum group, from Europe, with racemes of large, multilocular, bitter fruits; c, d, e - *S. aethiopicum* Gilo group, from Togo, with solitary spherical, ovoid and ellipsoid fruits; f - *S. aethiopicum* Shum group, from Uganda, with small, round, hard, bitter fruits; g - *S. aethiopicum* Kumba group, from Togo, with large, multilocular, sweet fruits

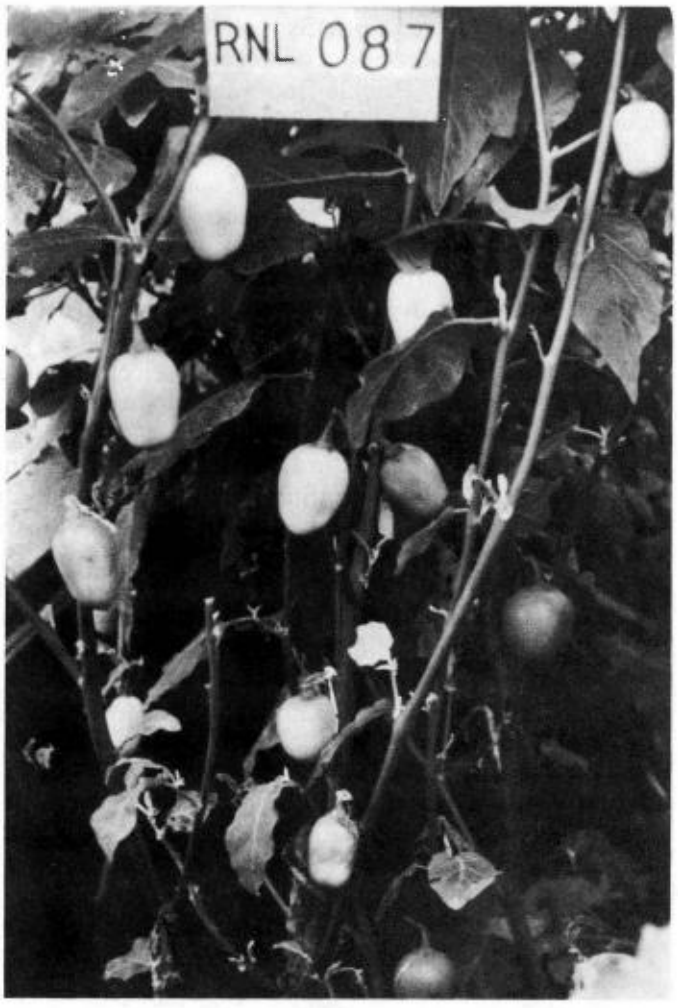


Fig. 4. An accession of *Solanum aethiopicum* Gilo group from Dadja, Togo, grown in Birmingham for evaluation and regeneration by hand pollination of bagged and tagged flowers, producing many well-formed fruits

or purple etc. when unripe. In Ghana these intermediates are called Amboni, Nsuapimah, etc. They may be very primitive cultivars of the Gilo group or else possibly products of recent hybridization between weedy *S. anguivi* and advanced cultivars of *S. aethiopicum* Gilo group.

Further increase in fruit diameter and proliferation of locules coupled with loss of the star-hair pubescence produced the very characteristic *Solanum aethiopicum* Kumba group of cultivars common in the Sahel region north of Côte d'Ivoire from Senegal to Burkina Faso. These are dual-purpose vegetables providing first leaf greens and then fruits which are stewed or even eaten raw (Figs. 3g, 5, 6).

Solanum aethiopicum Shum group (= *S. zuccagnianum* Dun.) (Figs. 3f, 7), small fruited, short, much branched plants with small, glabrous leaves that can be cropped continuously, may have been derived independently from *S. anguivi,* probably in Central Africa. They are not extensively grown.

The foregoing three species of eggplant, *S. melongena, S. macrocarpon* and *S. aethiopicum,* can be hybridized but the hybrids have low fertility (Daunay

Fig. 5. An irrigated field of *Solanum aethiopicum* Kumba group in Bobo-Dioulasso, Burkina Faso, grown as a leaf vegetable for the city market, or for export to France

et al., in press). Hybrids of the following species of *Solanum* with the former or with each other are completely sterile or impossible.

Solanum scabrum Mill. (= *S. guineense* auct. non L., etc.) is occasionally cultivated throughout Africa as a leaf vegetable, and elsewhere in the world for its black fruits. It is a distinct species from *S. nigrum* L., but both are hexaploids. The recent discovery of a tall, dark, wild variety of *S. scabrum* in Nigeria suggests that domestication occurred in Africa. The introduced diploid weed, *S. americanum* Mill. (= *S. nodiflorum* Jacq.) is occasionally eaten as a leaf vegetable and even sold in markets.

Solanum torvum Sw., a common pantropical weed originating from South America, is superficially similar to *S. anguivi* but the fruits are never scarlet: they are sometimes eaten. Other common introduced South American weeds include *S. erianthum* D. Don and *S. umbellatum* Mill. (= *S. rugosum* auct. non Dun.).

Fig. 6. Attractive 'Goyo Kumba' (*Solanum aethiopicum* Kumba group) fruits for sale in a Burkina Faso market

Fig. 7. Accessions of the leaf vegetables *Solanum aethiopicum* Shum group (left and centre) and Kumba group (right), being evaluated and regenerated in Birmingham. The normal Shum with small entire leaves and the unusual laciniate form were collected from neighbouring gardens in Ifada village, Benin

Cultivation and use of African eggplants

Because they are native vegetables and are unrecognizable when cooked, and also because they are not plantation crops appropriate to colonial trade, African eggplants have been gravely neglected by expatriate scientists, until the systematic survey of Siemonsma (1980) showed their importance in both the diet and the agricultural systems of indigenous African peoples.

In general, eggplants are cultivated in the same way as okra, mostly in multi-crop gardens and small fields together with *Abelmoschus, Manihot, Dioscorea, Corchorus, Sorghum, Pennisetum,* etc., but sometimes they are grown in single cultivar monoculture in market gardens, which may be irrigated, especially in the dry season (Fig. 5). Seedlings are raised in nursery beds and then transplanted. Although two or more cultivars, or even species of *Solanum,* may be sown together, subsequent wide spacing of mature plants in a multi-crop system, together with self-compatibility, provides virtually complete reproductive isolation of each cultivar. In most of Africa one farmer or even a whole village grows only one cultivar, but in some regions, notably Côte d'Ivoire, five or more cultivars may be grown in a single field: although distinguished by the local population they are easily confused by an outsider, resulting in mixed collections.

The vast majority of rural workers grow eggplants for home consumption, but may take excess production to local markets, whence it may be taken to larger markets, but most large towns are supplied by market gardeners growing a few selected cultivars, such as *Solanum aethiopicum* (Gilo group) 'Sodefel' in Côte d'Ivoire. When several cultivars, or even species, are grown close together in market gardens hybridization is rife. The resultant fruits are good for food, but useless as germplasm samples. Although large markets provide a quick survey of the main produce of a region, genetic resources of eggplants should not be collected from these markets, but rather from the people directly, preferably from single plants of each cultivar.

Collecting and regeneration procedures

The extremes of wet and dry seasons are severe in Africa. Crops can only be grown in the wet season unless they are irrigated, and most fresh vegetables are consumed then. Fortunately eggplants with ripening fruits persist into the dry season when the dirt roads are passable and the climate is more favourable for germplasm collectors.

Because they are vegetable crops, most of the fruits are consumed before maturity and only a few are left to ripen to produce seed for the next year. Thus eggplant collections seldom consist of sufficient seed for direct storage in genebanks, so regeneration and multiplication are essential. For this purpose even one fruit will provide enough seed. The traditional agricultural practice is to grow all the eggplants from single fruits selected from each cultivar. Since the plants are self-fertile this process has produced the remarkably homozygous cultivars found today, which might be faithfully reproduced even from a single seed. Thus, although contrary to general IBPGR recommendations, collecting single fruits is sufficient and, especially in market samples, this avoids mixed collections and the problems these cause during evaluation and multiplication, in deciding how to record, recognize and separate the components of an aggregate of biotypes. During regeneration it is of course essential that each accession be reproductively isolated from all others, preferably by manual pollination of bagged flowers (Fig. 4) but otherwise by using intervening vegetation between accessions.

IBPGR-recommended collecting procedures should be followed in most other details, preferably using the special eggplant collector's books. Fruits may be collected in polythene bags, then soon transferred to cloth bags and kept well ventilated and not too hot until they are fully ripe. Seeds are washed out using a sieve and spread out to dry on absorbent paper for one or two days. They must then be dried to 5-7% moisture, preferably using silica gel or oven-dried grains or pulses, but a warm, ventilated oven about 35° C is satisfactory in dry climates. They must be stored dry over silica gel and preferably cold, otherwise viability is lost rapidly. Traditional methods of seed preservation include skewering fruits on a stick, then sun drying; the seeds within dried fruits can be kept for several years.

Genetic erosion

The main causes of genetic erosion of small farmers' vegetable crops are replacement of the indigenous cultivars by exotic cultivars or other crops or else displacement of the villagers by war, pestilence or famine. The IBPGR-sponsored programme to collect genetic resources of eggplants in recent years sampled a good proportion of these indigenous cultivars before they were lost. Famine and war are now wreaking havoc in several countries. In the more fortunate

countries, such as Côte d'Ivoire, development and prosperity have improved communications and urbanization. There is therefore a shift to market gardening with widescale production of relatively few cultivars, a trend that will continue. In particular, *Solanum aethiopicum* (Gilo group) 'Sodefel', which has been promoted by the government agency since about 1980, is being grown very widely for market and is even displacing locally preferred Kumba group cultivars in northern Côte d'Ivoire. Virtually no improvement breeding has yet been done anywhere in Africa, but when new varieties or merely higher yielding heterotic F_1 hybrids are produced and distributed, genetic erosion will accelerate. Surprisingly, *Solanum melongena* is not a threat since it is hardly used by the indigenous populations but is mostly consumed by expatriates or exported to Europe. A selected cultivar of *S. macrocarpon* is distributed from the horticultural institute at Douando, Porto Novo in Benin, but we are not aware of any other promotional schemes for this species.

Most of the wild and weedy relatives are in no danger of extinction, since they grow well in disturbed savanna vegetation, areas unlikely to be monopolized for intensive agriculture.

Eggplant collecting in Burkina Faso (Upper Volta), 1982

Collectors: Peter-M.L. Jaeger (Birmingham University) and J. Traore (IRAT, Farako-ba) or J. Belem (IVRAZ, Kamboinse) assisted by T. Ira (driver) and P.-M. Perret (Regional officer) (both then of IBPGR, Ouagadougou)

Report: Jaeger, 1982

Collection numbers: J & T 101-128 & 197-252, J & B 129-196, J 253

Itinerary and germplasm collected: ca 4800 km, 153 vegetable samples (58 *Solanum*)

Date	*Route*	*Coll. Nos.*
20-21 Oct.	Bobo-Dioulasso - Pa - Léo - Ouagadougou	J & T 101-128 (9)
24-30 Oct.	Ouagadougou - Nobéré - Tenkodogo - Koupela - Fada-N'Gourma - Bogandé - Koalla - Kaya - Djibo - Ouahigouya - Dedougou - Koudougou - Yako - Ouagadougou	J & B 129-196 (25)
2 Nov.	NE of Bobo-Dioulasso	J & T 197-200 (2)
3-8 Nov.	Bobo-Dioulasso - Banfora - Niangoloko - Kimini - Niangoloko - Sindou - Orodara - Kourouma - Ndorola - Bobo-Dioulasso - Klesso - Diebougou - Gaoua - Batie - Kampti - Bobo-Dioulasso	J & T 201-252 (21)
15 Nov.	Ouagadougou	J 253 (1)

Composition of germplasm collected

Because it was the dry season, most samples were obtained from farm stores; few were collected in the field.

Collecting was carried out in all climatic areas of Burkina Faso, from the dry northeastern, sparsely wooded savanna, with a three month wet season providing only 500 mm rain a year, to the slightly moister southeast, with two or three times as much rain and irrigated market gardening supplying towns here and abroad. The most abundant eggplant was *Solanum aethiopicum* Kumba group (74%) (Figs. 5, 6). Some variation was observed in fruit size (5-10 cm diameter), plant stature and colour. Three samples were hairy, like the Gilo group typical of more southern countries. Samples of *S. anguivi, S. macrocarpon, S. melongena* and *S. scabrum* were also collected.

Employment of fertile land for export crops, as well as drought and famine in less favoured areas, are the main factors eroding genetic resources.

Eggplant collecting in Côte d'Ivoire, 1982

Collectors: Ir. Henk P.O. Bleijendaal (Co-director) and Ir. Brigitte H.M. Bleijendaal-Spierings (Co-director), assisted by Boulabba Sawadogo (technician, guide, interpreter) and Abdoulaye Kabore (technician, driver, interpreter), all of the Centre Neerlandais, ORSTOM, Adiopodoume, Abidjan, and helped by students Miss N. Smit, Miss H. Schmiermann and Miss H. Verhagen of the Agricultural University, Wageningen and Mr P.-M.L. Jaeger of Birmingham University

Report: Bleijendaal and Bleijendaal-Spierings, 1983

Collection numbers: BBS 001-278, HBl A01-A95

Germplasm collected: 373 *Solanum* samples

Date	*Team and Route*	*Coll. Nos.*
25 Feb.	BBS, HBl & BS Abidjan - Azaguié - Diapé - Adzopé - Achokoi - Affery - Akoupé - Agboville - Abidjan	BBS 001-013
26 Feb.	BBS, HBl & BS Abidjan - Grand Bassam - Vonan-Komoué - Bonoua - Aboisso - Ayamé - Niameakrou - Abidjan	BBS 014-032
29 July to 2 Aug.	BBS, NS, BS & AK Abidjan - Tiassale - Divo - Lakota - Gagnoa - Sinfra - Yamoussoukro - Tiebissou - Bocanda - Dimbokro - Toumodi - Oumé - Divo - Abidjan	BBS 036-104
16-23 Aug.	HBl, BS & AK Abidjan - Gagnoa - Soubré - San Pedro - Tabou - Tai - Duékoué - Man - Odienné - Boundiali - Korhogo - Ferkéssédougou - Katiola - Abidjan	HBl A01-A95
21-26 Sept.	BBS, HS, BS & AK Abidjan - Ferkéssédougou - Ouangolodougou - Niéllé - Korhogo - Ferkéssédougou - Bouna - Bondoukou - Agnibilékrou - Abengourou - Adzopé - Abidjan	BBS 105-192
19 Nov.	BBS, HS, PJ & BS Abidjan - N'Douci - Sikensi - Dabou - Abidjan	BBS 193-210
27-30 Dec.	BBS, HS, HV & BS Gagnoa - Issia - Daloa - Séguéla - Mankono - Zuénoula - Bouaflé	BBS 211-278

Composition of germplasm collected

Although a high proportion of samples (62%) was collected in markets along main roads, an effort was made to collect in local markets on the special market days when farmers bring and sell their own produce. Even so, the result was often mixtures that required separation during evaluation and multiplication. Collecting in villages was from gardens or fields (24%) or from farm stores (14%).

Just over half of the samples were taken from the southern wet equatorial forest region (domain guinéen), where most of the *S. macrocarpon* was collected, chiefly in gardens and fields. In contrast, *S. aethiopicum* Gilo group was mostly collected in markets in the south, but in the more northerly, drier, tropical savanna region (domain soudanais) it predominated even among samples taken from the field. Very little collecting was done in the extreme northwest, so that area was reinvestigated by Kouassi and Lester in 1985.

Solanum aethiopicum Gilo group, including many smaller fruited Gilo-*anguivi* intermediates, was diverse and abundant, accounting for 68% of all samples, whereas the Kumba group (4%) was only found in the extreme north. No examples of Shum group were observed. *S. anguivi* (6%) was scattered throughout the country.

Solanum macrocarpon subsp. *macrocarpon* (14%) was the second most abundant eggplant and very variable, whereas *S. macrocarpon* subsp. *dasyphyllum* was very rare. Some unfamiliar cultivars of *S. melongena* (6%) were collected, which are used in the traditional cuisine: these may have been introduced in colonial times, or earlier by Arab traders. Some *S. scabrum* was collected (1%).

Eggplant collecting in Côte d'Ivoire, 1985

Collectors: Richard N. Lester (Birmingham University) and Auguste Kouassi (University of Côte d'Ivoire) assisted by Zoumana (technician) and Kouassi (driver)

Report: Lester and Kouassi, 1986

Collection numbers: (Kouassi, A & Lester) KAL 001-163

Itinerary and germplasm collected: ca 1800 km, 163 *Solanum* samples

Date	*Route*	*Coll. Nos.*
30 Nov.	Abidjan - Yamoussoukro - Katiola	
1 Dec.	Katiola - Ferkéssédougou - Korhogo	KAL 001-021
2 Dec.	Korhogo - Siempurgo - Boundiali - Mandinani - Seguelon	KAL 022-065
3 Dec.	Seguelon - Odienné - Touba - Man	KAL 066-109
4 Dec.	Man - Mont Tonkoui - Duékué - Daloa - Bouaflé	KAL 110-148
5 Dec.	Bouaflé - Pakpabo - Yamoussoukro - Abidjan	KAL 149-163

Composition of germplasm collected

Collecting concentrated in the northern, drier half of Côte d'Ivoire, especially near to Mali and Guinea, countries which have not yet been prospected for eggplants. Samples were mostly obtained from gardens (22%), fields (25%) or stores (41%), to complement the previous collecting done in markets.

Detailed field observations and enquiries indicated that the local people often cultivate several distinct cultivars in one field, yet outsiders might mistake these for a single landrace or a hybrid swarm. A woman near Katiola, for example, grew at least five cultivars of *Solanum aethiopicum* Gilo group in a multicrop yam field. The plants were spaced out and thus reproductively isolated, and her claim that they were distinct cultivars was probably true. The fact that she took a mixed bag of fruits to market but then selected them for different customer preferences, or that she did not have different names for the several cultivars, or that she gathered fruits from each cultivar as well as *S. macrocarpon* and sowed a mixture of seeds in the nursery plot before planting them out separately in the field, were almost irrelevant. Furthermore, in the same field she cultivated *S. anguivi* plants which grew spontaneously from seeds distributed by birds. Several similar cases were encountered elsewhere.

Solanum aethiopicum Gilo group (58%) was common throughout the whole area, whereas the Kumba group (20%) was limited to the extreme north, above 9°N. No Shum group was found. *Solanum anguivi* (12%) occurred throughout the area, but prickly, fully wild plants were only found near Seguelon. Intermediates between Gilo group and *S. anguivi* were occasionally cultivated.

Solanum macrocarpon subsp. *macrocarpon* (9%) was only found in the moister southern regions whereas weedy *S. macrocarpon* subsp. *dasyphyllum* was found twice, further north. *S. melongena* was never encountered in indigenous agricultural systems, and true *S. incanum* was not found. *S. scabrum* and *S. americanum* were found occasionally.

In remote villages there was little evidence of genetic erosion and traditional varieties prevailed, but in areas with good roads and especially near large towns, some market gardeners maintained a range of old cultivars, while others grew single cultivars, notably the one distributed by SODEFEL.

Eggplant collecting in Togo and Benin, 1981

Collectors: Richard N. Lester (Birmingham University), Henry L.O. Holloway and Forson Ayensu (Crops Research Institute, Bunso, Ghana) and Chougaba Tagoi (Dir. Res. Agronomique, Lomé, Togo).

Collection numbers: BUNSO 81/BE.001-059, /TO.060-191 & 192-207

Itinerary and germplasm collected: ca 3400 km, 207 samples (141 *Solanum*)

Date	*Route*	*Coll. Nos.*
14-17 Nov.	Bunso - Porto Novo - Ketou - Abomey - Adjahonme - Aplahoué - Lokossa - Comé - Abomey-	BUNSO 81/BE 001-052

	Calavi - Allada - Bohicon - Abomey - Klouékanmé - Abomey - Dassa-Zoumé - Parakou - Beterou - Djougou - Lama-Kara - Dapaong	
18-26 Nov.	Dapaong - Mango - Dapaong - Mango - Kante - Lama-Kara - Lassa-Ketao - Niamtougou - Pya - Sara-Kawa - Lama-Kara - Awandjelo - Kabou - Bassar - Sokode - Atakpame - Hiheatro - Notse - Tsevie - Gati - Lomé - Kévé - Agougadzepe - Kpalimé - Adeta - N'Digbe - Kpalime - Bunso	BUNSO 81/TO 053-191
19-21 Dec.	Bunso - Anecho - Kusigbe - Klologo - Amegnran - Afanyangon - Tabligbo - Tsevie - Lomé - Accra - Bunso	BUNSO 81/TO 192-207

Composition of germplasm collected

In Togo and Benin cultivation of traditional eggplants and other vegetables persists in villages even near main roads, which allowed good collecting without much travel on bad roads. Most samples (58%) were taken from fields and gardens of these villages, some (28%) were from village and small town markets; the remainder were from farm stores and fallow or wild vegetation.

Togo and Benin occupy the Dahomey Gap with relatively dry savanna woodland in the south and even drier grassland in the north, but a belt of hills cuts diagonally through the middle. Not only is the climate, vegetation and agriculture broken up, but many tribes are dispersed, often in small patches throughout the region, and with them their crop plants (Hamon and Charrier, 1983).

A remarkable diversity of eggplants was found for such a small area. *Solanum macrocarpon* subsp. *macrocarpon* (40%) was collected throughout both countries: apart from a small-leaved cut-and-come-again cultivar, which was particularly common in the south but also grown in the extreme north during the short rainy season, most of the samples appeared to be distinct cultivars. Some were primitive prickly or hairy types, and wild or weedy *S. macrocarpon* subsp. *dasyphyllum* was found in five places, each time with a different local name. Ten names were recorded for *S. aethiopicum* Gilo group and four for *S. macrocarpon* subsp. *macrocarpon*, but in the south the Ewe names, Agbitsa (for the former) and Gboma (for the latter) predominated.

Very great diversity in fruit shape was found in the *Solanum aethiopicum* Gilo group cultivars (39%), with large fruits ranging from long and narrow ellipsoid to broad subspherical (Figs. 3c,d,e). These were mostly in southern Togo. A few samples of the Kumba group were found as well as some Shum group, including a remarkable form with laciniate leaves in one garden in a remote village (Ifada) (Fig. 7). *Solanum anguivi* was found only once.

Solanum scabrum and *S. americanum* were collected in several places. In two places modern cultivars of *S. melongena* were grown but not used, but older cultivars were used in one remote town (Bassar). The only sample of wild *S. incanum* from all of West Africa was found in the extreme north of Togo. Weedy *S. torvum* and *S. erianthum* were also found.

Usually only one cultivar of one species is grown in each garden in this region, but in one market garden village (Gatisou) samples were taken of *S. aethiopicum* Gilo group and Shum group, *S. macrocarpon* subsp. *macrocarpon* and *S. macrocarpon* subsp. *dasyphyllum*, *S. melongena* and *S. scabrum*.

There was little evidence of factors that may cause genetic erosion, except for the official distribution of a single cultivar of *Solanum macrocarpon* in southern Benin, and the large-scale importation of a few improved *S. aethiopicum* Gilo group cultivars from Ghana into the markets of Togo.

Eggplant collecting in Ghana, 1981-83

Collectors: Henry L.O. Holloway, Samuel Bennett-Lartey, Joseph Adu and Larbi Asare

Collection numbers: BUNSO 81/GH 208-420

Germplasm collected: 213 samples (123 *Solanum*)

Date	*Route*	*Coll. Nos.*
11 Dec. '81	Bunso - Nkwatia-Kwahu - Abetifi-Kwahu - Kwahu Tafo - Bunso	BUNSO 81/GH 208-212
14 Dec.	Bunso - near Koforidua (Nkurakan etc.)	213-219
16 Dec.	Bunso - Hweehwee-Kwahu - Suminakese	220-237
31 Dec. to 6 Jan. '82	(Bunso) - Tamale - Yendi - Tamale - Bolgatanga - Bawku - Tamale - (Bunso)	238-272
22-24 Oct.	Bunso - Nkwatia-Kwahu - [Bunso] - Adukrom - [Bunso] - Ho - Taviefe and 12 other villages up to 40 km N and W of Ho - Ho - Bunso	273-304
26-27 Oct.	Bunso - Kumasi area - Bunso	305-309
6-7 Nov.	Bunso - Accra area - Bunso	310-312
10-14 Nov.	Bunso - Kumasi - Techiman - Bole - Damongo - Tamale - Bunso	313-347
25 Nov.	Bunso - Suminakese - Bunso	348
2-3 Dec.	Bunso - Accra - Mankessim - Cape Coast - Mankessim - Odobeng - Bunso	349-358
12-15 Dec.	(Bunso - Kumasi - Tamale - Bolgatanga) Tumu - Nandom - Lawra - Wa - Sandema - (Bolgatanga - Kumasi - Bunso)	359-375
22-23 Dec.	(Bunso - Ho) Jasikan - Ketekrachi - Ho - Anum - Bunso	376-394
	Sandema [far north]	386
	Wurunai [far north]	395
	Gomoa Akropong	396

27 Jan. '83	Bunso - Kumasi - Mampong - Ejura - Amanteng - Atebubu - Kwame Danso - Bunso	397-402
4 Feb.	Bunso - Accra - Oyarefa - Peduase - Berekuso - Bunso	403-406
7 Feb.	Bunso - Oforikrom - Techiman - Oforikrom - Bunso	407-409
17 Feb.	Bunso - Accra - Takoradi - (Kodadwen - Nsuaem - Old Afansi - Kodjofaakrom) - Bunso	410-420

Composition of germplasm collected

Despite extreme difficulties in the period 1981-83 the team from the Crops Research Institute, Bunso, collected eggplants and okra throughout Ghana. Of necessity most collections were made in central and southern Ghana, but this was acceptable since other missions had prospected up to the borders in the three neighbouring countries.

Much of Ghana is dry with savanna vegetation. In 1982-83 the harmattan (a dust-laden wind) was extremely dry, fires caused devastation and the regeneration programme had to be postponed.

Some eggplants are grown on a large scale in Ghana to supply big markets there and in neighbouring Togo and Côte d'Ivoire, so care was taken to collect away from the main towns, mostly from fields (29%), gardens (36%) and farm stores (16%), and only a little (19%) from markets.

The most abundant and variable eggplant throughout Ghana was *Solanum aethiopicum* Gilo group (64%). Some Kumba group were found in the extreme north, but no Shum group. Some examples of *S. anguivi* and Gilo-*anguivi* were found just north and west of Kumasi.

Solanum macrocarpon subsp. *macrocarpon* (12%) was mostly restricted to the southeast Volta Region: *S. macrocarpon* subsp. *dasyphyllum* was only found in the extreme north of this region. *S. melongena* (10%) was collected along the south coast, but also near Tamale.

Eggplant collecting in other countries

Besides the collecting carried out by the special IBPGR-funded eggplant missions, samples have also been obtained from several other countries such as Liberia, Nigeria, Uganda, Zambia and Zimbabwe (Table 1, Fig. 1). Some samples were collected by IBPGR-funded missions and reports were submitted to Rome (Attere *et al.*, 1983; Badra, 1983, 1985; Badra *et al.*, 1982, 1983; Toll and Gwarazimba, 1983).

Even though relatively few samples have been collected from these countries, they are very valuable, as they represent the germplasm available in each country and indicate the total range of variation of each species throughout Africa. A particularly good range of samples, presenting an unexpected diversity of both cultivated and wild species, was obtained from Zimbabwe. Hardly any samples have yet been obtained from Zaire, but hopefully this deficiency will be made good by the current genetic resources collecting programmes there.

Multiplication and evaluation of eggplants

Field collections of eggplant germplasm are usually limited to several hundred seeds from a few fruits. In order to provide enough seed for conservation and utilization it is necessary to undertake multiplication, and at the same time evaluation is possible, using the IBPGR descriptors (Lester *et al.*, 1986; Lester *et al.*, 1989). So far about half of the collections of African eggplants have been or are being grown for regeneration and evaluation (Table 2). Many of them have been grown at Birmingham and studied in detail by MSc students on the course 'Conservation and Utilization of Plant Genetic Resources' (Lester *et al.*, 1986). Planted in unfertilized ground in the large unheated glasshouse provided by IBPGR, they grew as well as in tropical Africa, yet pest control was easier (Figs. 2, 4, 7). For regeneration, hand pollination of bagged flowers was essential but expensive, so usually only three to five fruits were obtained from the five plants of each accession (Fig. 4). Although limited, this regeneration conserved many collections of which all other materials had been lost.

The best regeneration in Africa has been done in Togo. Plants were grown with irrigation in the dry season, when pests were less serious, but treated with

Table 2. Regeneration and evaluation of eggplants from Africa

Collector(s)	Country	Regenerator	Site
Bleijendaals	Côte d'Ivoire	Bleijendaals	Abidjan
Bleijendaals	Côte d'Ivoire	Mergeai	Lomé
Jaeger	Burkina Faso	Bleijendaals	Abidjan
Jaeger	Burkina Faso	Horne	Ouagadougou
Jaeger	Burkina Faso	Lester	Birmingham
Holloway *et al.*	Togo, Benin, Ghana	Holloway *et al.*	Bunso
Holloway *et al.*	Togo, Benin, Ghana	Mergeai	Lomé
Holloway *et al.*	Togo, Benin, Ghana	Lester	Birmingham
Badra	Nigeria	Badra	Ibadan
Kouassi & Lester	Côte d'Ivoire	Kouassi	Abidjan
TGR, ZFA etc	Zambia, Liberia etc	Kouassi	Abidjan
TGR, ZFA etc	Zambia, Liberia etc	Lester	Birmingham

pesticides as well. Of each accession, 36 plants were grown in blocks. Some of the middle plants were left for open pollination, but most of them and all the peripheral plants were manually self-pollinated: bagging was not possible, therefore the corolla and anthers were removed from each flower so it was no longer attractive to insects, and the stigma was covered with pollen gathered from other flowers. Thanks to skilled yet cheap labour very good yields of seed were obtained. In most other countries manual self-pollination was impossible, so the plants of each accession were grown in plots isolated to a greater or lesser extent from other accessions by other crops grown between them, and then left to open pollination by bees.

Eggplant seeds are orthodox and if kept dry and cool will maintain high viability for many years. However, if kept at high moisture content and high temperatures, viability is lost in a few months (Mohamed *et al.*, 1988). High humidity and temperatures prevail in West Africa and many of the seed stocks stored there, both of original collections and after multiplication, have died. Nevertheless failure to germinate does not prove death. For example, two collections from Ghana that failed to germinate when sown three times in Birmingham subsequently grew when sown in Togo.

References

Attere, A.F.Y., Ndumba, E.K. and Mubiana, W. 1983. Collecting crops in Zambia. FAO/IBPGR Pl. Genet. Resources Newsl. 56:2-6.

Badra, T. 1983. Passport data of 1982 Vegetable and Fruit Germplasm Collection. Unpublished report NIR/72/007, National Horticultural Research Institute, Ibadan, Nigeria.

Badra, T. 1985. Passport data of horticultural germplasm collections made in 1983 and 1984. Unpublished report NIR/84/014, National Horticultural Research Institute, Ibadan, Nigeria.

Badra, T., Edema, A.A.O. and Nath, P. 1982, Vegetable and fruit collecting in Nigeria. FAO/IBPGR Pl. Genet. Resources Newsl. 50:41-44.

Badra, T., Edema, A.A.O. and Nath, P. 1983. Fruit and vegetable collecting in Nigeria. FAO/IBPGR Pl. Genet. Resources Newsl. 54:14-17.

Bleijendaal, H.P.O. and Bleijendaal-Spierings, B.H.M. 1983. Report of the Centre Neerlandais - IBPGR 1982 Eggplant-Collecting Mission in the Ivory Coast. Abidjan, unpublished report.

Daunay, M.-C., Lester, R.N. and Laterrot, H. The use of wild species for the genetic improvement of brinjal egg-plant *(Solanum melongena)* and tomato *(Lycopersicon esculentum)*. *In* Hawkes, J.G., Lester, R.N., Nee, M. and Estrada, N. (eds.). *Solanaceae: taxonomy, chemistry, evolution.* Royal Botanic Gardens, Kew. (In press)

Hamon, S. and Charrier, A. 1983. Large variation of okra collected in Benin and Togo. FAO/IBPGR Pl. Genet. Resources Newsl. 56:52-58.

Harlan, J.R., de Wet, J.M.J. and Stemler, B.L. 1976. Origins of African Plant Domestication. Mouton Publishers, the Hague, Paris.

Jaeger, P.-M.L. 1982. Report on the IBPGR Expedition to Upper Volta and Mali for the Collection of Eggplant and other Local Vegetable Germplasm. (Eggplant Collecting Mission cc. Ref.:82/74). Birmingham, unpublished report.

Lester, R.N., Hakiza, J.J.H., Stavropoulos, N. and Teixeira, M.M. 1986. Variation patterns in the African Scarlet Eggplant, *Solanum aethiopicum* L. *In* Styles, B. (ed.). *Infraspecific classification of wild and cultivated plants.* Oxford University Press, Oxford, pp. 283-307.

Lester, R.N. and Kouassi, A. 1986. Collection of Eggplants in Côte d'Ivoire, 1985. Report on IBPGR-RCU/CIV mission. Birmingham, unpublished report.

Lester, R.N. and Niakan, L. 1986. Origin and domestication of the Scarlet Eggplant, *Solanum aethiopicum* L., from *S. anguivi* Lam. *In* D'Arcy, W.G. (ed.). *Solanaceae: biology and systematics.* Columbia University Press, New York, pp. 431-456.

Lester, R.N., Niakan, L. and Mergeai, G. 1989. Descriptors for Eggplant/Descripteurs pour Aubergine. International Board for Plant Genetic Resources, Rome.

Mohamed, E.I., Lester, R.N. and Mumford, P.M. 1988. Viability of eggplant seeds. Trop. Agric. (Trinidad) 69:279-280.

Ng, N.Q. and Marechal, R. 1985. Cowpea taxonomy, origin and germplasm. *In* Singh, S.R. and Rachie, K.O. (eds.). *Cowpea research, production and utilization.* John Wiley, New York, pp. 11-23.

Siemonsma, J.S. 1980. Les legumes traditionnels en Côte d'Ivoire. Dans *Rapport annuel du Centre Néerlandais 1979-1980.* Agricultural University, Wageningen, Netherlands, pp. 8-34.

Toll, J. and Gwarazimba, V. 1983. Collecting in Zimbabwe. FAO/IBPGR Pl. Genet. Resources Newsl. 53:2-5.

Résumé

Aubergines africaines - Compte rendu de collectes en Afrique de l'Ouest

Les aubergines sont des légumes importants cultivés pour leurs fruits et leurs feuilles en Afrique. Les deux variétés *Solanum aethiopicum* (aubergine violette) et *S. macrocarpon* (aubergine Gboma) ont été développées en Afrique à partir d'espèces sauvages indigènes et sont largement cultivées, en particulier en Afrique tropicale; *S. melongena* (aubergine Brinjal) originaire d'Asie est moins répandue. On rend compte, dans cet article, de collectes récentes de matériel génétique d'aubergine en Afrique de l'Ouest et ailleurs. On étudie les procédures adaptées pour collecter, évaluer, régénérer et multiplier cette plante en fonction des climats, des systèmes agricoles, de la biologie de la reproduction et des risques d'érosion génétique.

Resumen

Berenjena africana: una revisión de las actividades de recolección en la Africa occidental

Las berenjenas son un importante fruto y hortaliza de hojas en Africa. Tanto *Solanum aethiopicum* (Berenjena morada) como *S. macrocarpon* (Berenjena Gboma) se aclimataron en Africa a partir de especies silvestres locales y se cultivan abundantemente sobre todo en el Africa tropical. *S. melongena* (Berenjena Brinjal) de Asia es menos popular. Se resumen aquí las recientes recolecciones de recursos genéticos de la berenjena procedentes de Africa occidental y de otros lugares, y se examina, dentro del contexto del clima, los sistemas agrícolas, la biología reproductiva y los peligros de erosión genética, los procedimientos adecuados para su recolección, evaluación, regeneración y multiplicación.

Genetic resources of the fodder legumes tagasaste and escobón (*Chamaecytisus proliferus* (L. fil.) Link *sensu lato*) in the Canary Islands

J. Francisco-Ortega[1], M.T. Jackson[1], A. Santos-Guerra[2] and M. Fernandez-Galvan[2]

Summary

Germplasm from 184 cultivated, semi-cultivated and wild populations of *Chamaecytisus proliferus* (L. fil.) Link (Fabaceae: Genisteae) was collected in the islands of El Hierro, La Palma, La Gomera, Tenerife and Gran Canaria (Canary Islands) between June and August 1989. Herbarium specimens, soil samples and *Rhizobium* nodules were also collected from most populations. The ecology of tagasaste and escobón is described. Seeds are conserved in the Centro de Conservación de Recursos Fitogenéticos, Apartado 1045, 28800, Alcalá de Henares, Madrid, Spain.

Introduction

Chamaecytisus proliferus (L. fil.) Link (Fabaceae: Genisteae) forms a taxonomic complex that is endemic to the Canary Islands. Within this complex, tagasaste (*C. proliferus* var. *palmensis* (Christ) Hansen & Sunding) is an outstanding fodder tree which is used widely in the Canary Islands and has achieved some importance in Australia and New Zealand. It is presumed that the genetic base of the material cultivated in Australia and New Zealand is very narrow. Most of the material cultivated in both countries is apparently derived from seeds sent from Tenerife through Kew to Australia in 1879 (Anon., 1891). Tagasaste is also found naturalized in the Republic of South Africa (Orpen, 1907), Portugal (Pereira-Countinho, 1913), Java (Backer and Bakhuisen, 1963), the Hawaiian Islands (Neal, 1965), California (Muntz, 1968), Kenya and Tanzania (Milne-Redhead and Polhill, 1971) and northern Africa (Quezel, 1987), which indicates that tagasaste could play an important role in agroforestry systems in different environments.

Following an ecological and botanical survey in the Canary Islands in 1989, a preliminary classification of material collected can be made. This classification is provisional and is based on our first field observations. In the absence of any other taxonomy we have used the recent classification by Martínez (unpublished). However, through studies currently being undertaken at the University of Birmingham and the University of La Laguna (Tenerife), it is expected that definitive taxonomic categories will be described. The seven types are:

(1) Typical tagasaste (*Chamaecytisus proliferus* (L. fil.) Link var. *palmensis* (Christ) Hansen & Sunding).
(2) White tagasaste. Plants of this morphological group do not seem to fall within the range of variation described in previous taxonomic studies.
(3) Typical escobón *Chamaecytisus proliferus* (L. fil.) Link var. *proliferus*).
(4) White escobón of Tenerife. This morphological type does not seem to fall into any of the taxa previously quoted in the literature.
(5) Escobón of southern Gran Canaria. Although Martínez and other authors regarded this morphological type as *Chamaecytisus proliferus* (L. fil.) var. *perezii* (Hutchinson) Kunkel, this botanical combination is synonymous with *C. proliferus* (L. fil.) Link var. *canariae* (Christ) Kunkel.
(6) White escobón of Gran Canaria (*Chamaecytisus proliferus* (L. fil.) Link var. *canariae* (Christ) Kunkel).
(7) Escobón of El Hierro (the last botanical name was given within *Cytisus* as *C. proliferus* L. fil. var. *hierrensis* Pitard in Pitard and Proust (1908)).

Strategies for germplasm collecting

It is believed that tagasaste is predominantly outbreeding. Webb and Shand (1985) suggested that both allogamy and autogamy occur in tagasaste, and that selective abortion of selfed flowers might favour the retention of cross-pollinated embryos. Woodfield and Forde (1987) found similar results and they concluded that outcrossing plays a very important role in the reproductive biology of tagasaste. Consequently, germplasm was collected following procedures for outcrossing species suggested by Hawkes (1980) and Marshall and Brown (1983). Mass sampling was

[1] Plant Genetics Group, School of Biological Sciences, University of Birmingham, PO Box 363, Edgbaston, B15 2TT, Birmingham, UK
[2] Unidad de Ecología y Botánica Aplicada, Centro de Investigación y Tecnología Agrarias (CITA), Apartado 60, La Laguna, Tenerife, Canary Islands, Spain. Present address: Jardin de Aclimatación de La Orotava, Puerto de la Cruz, Tenerife, Canary Islands, Spain

carried out and seeds from 50 randomly selected plants per population were collected, whenever possible, and our aim was to collect alleles from as many environments as possible. Almost all the populations from the different environments of the islands were sampled, but this meant that seeds were collected sometimes from fewer than 50 plants. Collecting sites were about 3 km apart and were chosen following the patterns of geographical and climatic variation within each island. Emphasis was placed on collecting material from wild populations, since within forage plants it is expected that these are the major sources of genetic variation (Marshall and Brown, 1983).

Ten herbarium specimens were also collected from each population. These are held in the herbaria of the University of Birmingham (BIRM) and of the La Orotava Botanic Gardens (ORT).

Rhizobium nodules were collected from as many populations as possible and preserved according to the procedures of Date and Halliday (1979). At present they are preserved at −20°C at the University of Birmingham, UK.

A list of the species found growing at each collecting site was compiled according to the methods proposed by Braun-Blanquet (1932), since the islands have been studied intensively from a phytosociological point of view. General features of the habitat were recorded based on the indications of Hawkes (1983). Climatological data for each site were obtained directly from El Instituto para Conservación de La Naturaleza and from other published sources (Anon., 1975, unpublished; Rivas-Martínez, 1987).

Samples collected

A total of 196 samples was collected from 184 localities in the islands of El Hierro, La Palma, La Gomera, Tenerife and Gran Canaria by the team of the University of Birmingham and the Centro de Investigación y Tecnología Agrarias (CITA). Fig. 1 shows the areas where the different samples were collected. Table 1 summarizes the germplasm collected. No collecting was done in the islands of Fuerteventura and Lanzarote since these are too dry to support tagasaste and escobón.

The seeds have been deposited in the seed bank of the Centro de Conservación de Recursos Fitogenéticos, Apartado 1045, 28800, Alcalá de Henares, Madrid, Spain.

Distribution and frequency of *Chamaecytisus proliferus sensu lato* types

The distribution of wild tagasaste and escobón is closely associated with major vegetation types in the islands.

The laurel wood is the plant community found on the northern slopes of the islands between 800 and 1000 masl. It has *Laurus azorica* (Seub.) Franco and *Persea indica* (L.) K. Spreng as dominant species. The heath belt is found between 1000 and 1200 masl on the northern slopes of the islands. The most abundant species within this plant community are *Erica arborea* L. and *Myrica faya* Ait. The pine forest has *Pinus canariensis* Chr. Sm. ex DC. as the dominant species. This forest is found between 1500 and 2000 masl on the northern slopes of the islands and between 800 and 2000 masl on the southern side.

Table 1. Morphological types of *Chamaecytisus proliferus sensu lato* collected in the Canary Islands

Morphological type	Island	No. of samples
Tagasaste	EL Hierro	3
Escobón of El Hierro	El Hierro	2
Cultivated tagasaste	La Palma	19
Wild tagasaste	La Palma	5
White tagasaste	La Palma	6
'Tagasaste hibrido' (? tagasaste × white tagasaste hybrid)	La Palma	4
Tagasaste	La Gomera	2
Typical escobón	La Gomera	7
Tagasaste	Tenerife	15
Typical escobón	Tenerife	60
White escobón of Tenerife	Tenerife	3
Tagasaste	Gran Canaria	8
Wild white escobón of Gran Canaria	Gran Canaria	16
Semi-cultivated white escobón of Gran Canaria	Gran Canaria	2
'Escobón mulato' (? white escobón of Gran Canaria × tagasaste hybrid)	Gran Canaria	1
Escobón of southern Gran Canaria	Gran Canaria	43
TOTAL		196

(1) Typical tagasaste

Within the *C. proliferus* complex only typical tagasaste is cultivated. This plant is also known by the following names: 'tasagaste', 'satagaste' and 'escobón negro' (Gran Canaria), and 'tagasaste negro', 'tagasaste mollar' and 'tagasaste hembra' (La Palma). Pérez de Paz *et al.* (1986) claimed that this morphological type was also endemic in El Hierro, La Gomera and Tenerife. However, wild populations of typical tagasaste were found only in La Palma and we believe that it is endemic to this island and was subsequently introduced as a cultivated plant to El Hierro, La Gomera, Tenerife and Gran Canaria. Plants of typical tagasaste bear dark green, glabrous leaves and large seeds. This is the morphological form which is used as a fodder tree in Australia and New Zealand.

Wild populations of tagasaste are rather rare since rabbits and overgrazing have relegated them to inaccessible cliffs. Nevertheless this taxon seems to be associated with the communities of the sunny and open areas of the laurel wood and the heath belt zones of northern and northeastern La Palma.

Four different ways of cultivating tagasaste were observed:

- within clear areas in the pine forest of La Palma where there are no cultivated terraces;
- along the borders of cultivated terraces as a secondary crop, where the main crop is maize, barley, potato, onion or brassicas;

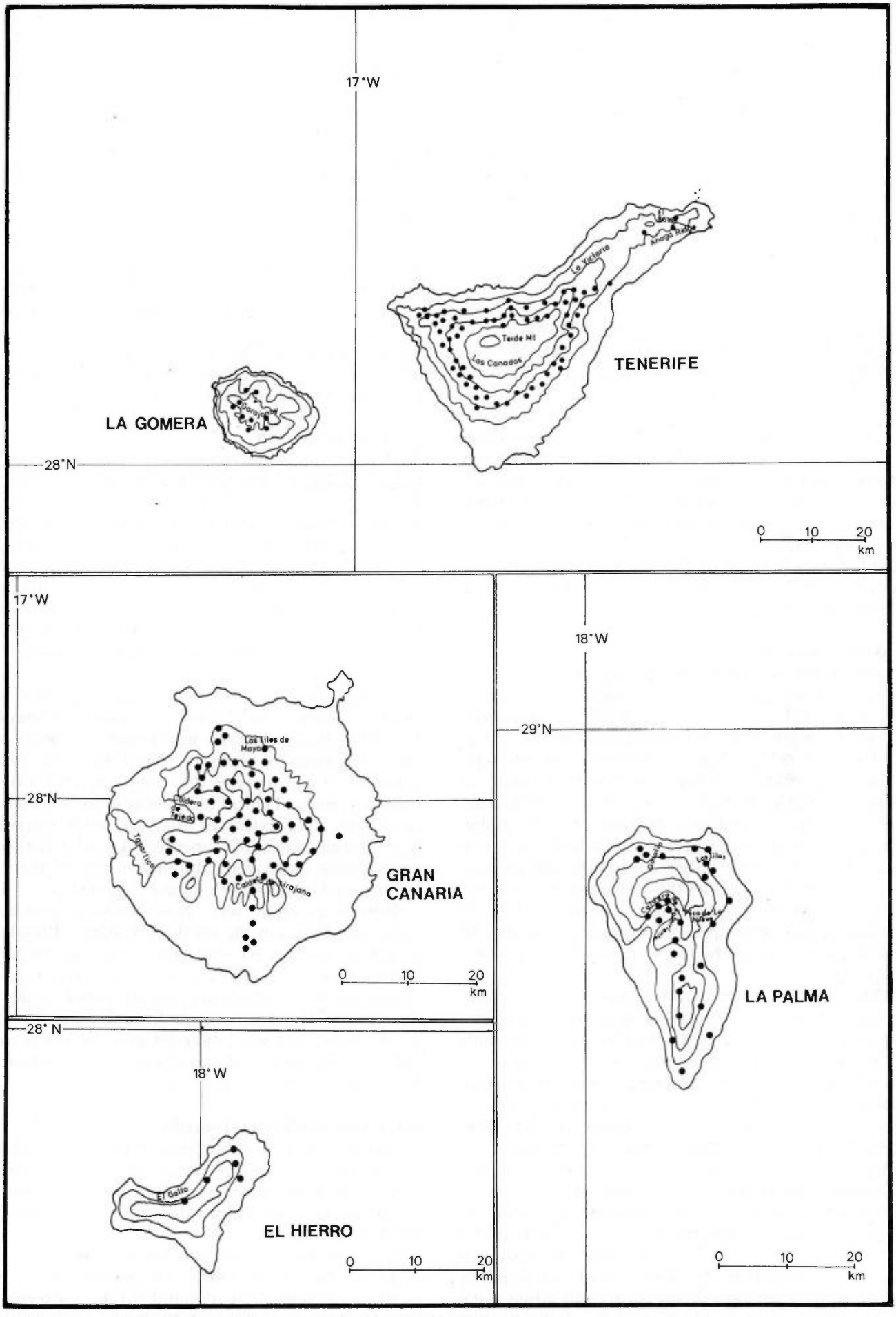


Fig. 1. Collecting sites of *Chamaecytisus proliferus sensu lato* in the Canary Islands

- associated with other crops such as fig, almond, peach, medlar, pear, apple, vine, maize or brassicas; and
- as a monoculture.

Other endemic plants were also found to be utilized as forages in some cultivated tagasaste sites. Species such as *Sonchus pinnatus* Ait. ssp. *palmensis* (Sch.Bip.) Aldridge or *Rumex lunaria* L. are cultivated together with tagasaste in some areas of La Palma and El Hierro. Other endemic species such as *Teline stenopetala* (Webb & Berth.) Webb & Berth. var. *stenopetala, Hypericum inodorum* Mill., *Adenocarpus foliolosus* (Ait.) DC. were observed in a semi-cultivated state in tagasaste fields in La Palma and Tenerife. Non-endemic species such as *Bituminaria bituminosa* (L.) Stirton and *Erica arborea* L. were also found semi-cultivated as associated forages with tagasaste in all parts of the archipelago.

Farmers of the El Paso district (La Palma) and La Caldera de Taburiente National Park (La Palma) told us that within tagasaste sites there are sometimes individual plants that cattle prefer because they are more tender. These specimens are known by the name 'mollar' and can be distinguished because they are easier to prune.

Small farmers from the Canary Islands usually cut tagasaste at the site of cultivation and take it as fresh forage to the cattle stalls.

(2) White tagasaste

Plants of this morphological group have large seeds and hairy, silver leaves. It is found within the arid pine forest of La Palma. This plant is known as 'tagasaste azul' in the north of La Palma whereas in the rest of the island it is called 'tagasaste blanco'. The best sites for white tagasaste were found within La Caldera de Taburiente National Park in La Palma. It formed extensive scrub towards the bottom of deep gullies ('barrancos') in an area where the pine forest is not so dense. This habitat has rather sandy soils and in some areas it can be regarded as the transition between the pine forest and the hygrophyllic communities of *Salix canariensis*. The latter species community can only be found on the banks of the few streams that exist in the archipelago.

White tagasaste is probably a frost-resistant plant. Specimens from one population were found within a frost area. Farmers from La Caldera de Taburiente and northern La Palma reinforced this view and stated that this was one of the differences between the two kinds of tagasaste. Plants of white tagasaste were also observed at 2400 masl in the Roque de Los Muchachos mountains within a zone which has frost during winter. On the other hand, white tagasaste was also found in areas regarded as frost free.

Wild typical tagasaste was observed growing together with white tagasaste within the scrub of La Caldera de Taburiente, although white tagasaste was much more abundant. Specimens with intermediate characters between typical tagasaste and white tagasaste were observed and it seems that hybridization occurs frequently between these types. Typical tagasaste was also seen as a cultivated plant within La Caldera de Taburiente. The few farmers who live there mentioned that both kinds of tagasaste were good forage although they preferred typical tagasaste.

Wood (1989) found that white tagasaste produced fewer seeds than typical tagasaste. However we observed that both morphological types produced many seeds and we found only one population of white tagasaste that bore few seeds. In early September 1989 we tried to collect seeds of frost-resistant white tagasaste outside the La Caldera de Taburiente in the dry pine forest of northern La Palma. Although large populations of white tagasaste were observed in Pico de La Nieve (Santa Cruz de la Palma district) and above Galería de Minaderos (Garafía district), none of the plants found had any pods. Local people told us that the pods had shed their seeds by August.

(3) Typical escobón

This form has narrow leaves and small seeds. It is found mainly within the area of the pine forest of Tenerife and of the low altitude shrubland of La Gomera. Pérez de Paz *et al.* (1986) stated that the dense reafforestation of *Pinus canariensis* and *Pinus radiata* D. Don accomplished in Tenerife from 1940-50 led to the disappearance of typical escobón from some zones of the island. Our first ecological studies indicate that typical escobón does not grow well within these reafforested areas since the habitat is too shady.

Typical escobón is called 'tagasaste criollo' in La Gomera, whereas in Tenerife it is known as 'escobón'. This morphological type was found not only within the clear areas of the pine forest but also forming dense scrub that replaces the forest when the latter has been cut down. Typical escobón can grow under frost conditions, and extensive escobón scrub reaches the high altitude areas of Tenerife. Typical escobón was never found cultivated, although many of the populations studied had been severely grazed.

Typical escobón was also observed growing in rather arid areas in the south of Tenerife. Populations found at the lowest altitudes were associated with species such as *Plocama pendula* Ait. and *Euphorbia obtusifolia* Poir, which are usually found under very dry conditions. This morphological type also has a weedy habit and was observed growing on roadsides and on abandoned cultivated sites in association with *Prunus dulcis* and *Ficus carica.*

(4) White escobón of Tenerife

Plants of this morphological type have small seeds and broad, hairy, silver leaves. It is found within the zone of the laurel wood and heath belt of Tenerife, but not as dense scrub which often follows the destruction of these communities.

It occurs quite rarely and tends to grow on sunny cliffs in the forest. Only one population of white escobón of Tenerife was found forming a scrub; that was in the upper part of El Batán, on the Anaga

Fig. 2. Collecting escobón in the high altitude scrub in Tenerife

Ridge, in the northeast of the island. Farmers in this area confirmed that white escobón scrub was once very common but almost all of it had been cut down.

We also found some cultivated tagasaste plants from Accession 167 that showed some leaf characters that seemed to indicate that introgression might have occurred from white escobón of Tenerife.

Fig. 3. Collecting escobón in the Canary pine forest in southern Tenerife

(5) Escobón of southern Gran Canaria

This escobón type has narrowly obtrullate, golden leaves and small seeds that are usually pale brown in colour. It is endemic in the pine forest of Gran Canaria where it is called 'escobón'. Some populations of this morphological group seem to be extremely drought tolerant. They were associated with species such as *Rubia fruticosa* Ait. or *Ceballosia fruticosa* (L. fil.) Kunkel, which are characteristic of the arid plant communities of the archipelago. Escobón of southern Gran Canaria has a weedy habit and quite often forms thick scrub that invades road slopes and abandoned, cultivated terraces.

(6) White escobón of Gran Canaria

This is found within the laurel wood area of Gran Canaria where it is known as 'escobón blanco'. Morphologically it is very similar to white escobón of Tenerife although it seems that the Gran Canaria group has broader leaves and smaller seeds. Reports on the cultivation of *C. proliferus* var. *canariae* (Kuntze, 1891; Ceballos and Ortuño, 1951; Lid, 1967) in Gran Canaria do not fully agree with our field observations. Some populations of Gran Canaria white escobón were seen under semi-cultivated conditions in the northeast of the island. None of the local people we met said that these plants had been planted, although this variety was observed within fenced, cultivated sites and was used widely as a fodder tree, mainly to feed sheep. Farmers pruned it so that the plants developed into small trees, and sheep can only graze the lowest branches.

Typical tagasaste was also found in northeastern Gran Canaria, but under cultivation. Local farmers confirmed that the tagasaste had been planted. Some semi-cultivated plants that farmers called 'escobón mulato' were found within this area. They seemed to be hybrids of tagasaste and white escobón. The leaf hairiness and flowering time of these plants was intermediate between those of tagasaste and white escobón. Farmers rated 'escobón mulato' a poorer forage than either tagasaste or white escobón and described it as very bitter. In this area tagasaste is regarded as a better fodder legume than white escobón.

Wild, dense, white escobón scrub was very often observed in the zone and it is suggested that it arose spontaneously as a result of the destruction of the laurel wood that covered this area until the last century. This form of escobón was frequently found colonizing disturbed areas and abandoned, cultivated fields.

(7) Escobón of El Hierro

This is the rarest morphological form of the *C. proliferus* complex. This plant is found on the cliffs of the heath belt of El Golfo (El Hierro). Its leaves are broadly obovate, hairy and silver in colour. It has large seeds, most of them with a width/length ratio almost equal to one.

***In situ* conservation**

Populations of typical and white tagasaste are conserved within La Caldera de Taburiente National Park (El Paso district, La Palma) and the Unesco Biosphere Reserve of Los Tilos y El Canal (Los Sauces district, La Palma). Populations of typical escobón are conserved in the National Parks of Garajonay (La Gomera) and Las Cañadas del Teide (Tenerife). The local Nature Reserve of Los Tiles de Moya (Gran Canaria) harbours populations of white escobón of Gran Canaria. However it was found that populations conserved within all these reserves are often grazed by animals and widely used by small farmers of the area. Once the projected network of Canary Islands nature

reserves is established, the most important wild populations of the *C. proliferus* complex will be conserved. The most rare morphological types of this complex (El Hierro escobón, Tenerife white escobón and wild typical tagasaste) will also be included within several of the nature reserves of this network.

Prospects for future collecting

The six populations listed below were identified late in September 1989, but it was not possible to collect seeds:

- two populations of white escobón of Tenerife from El Batán (Anaga Ridge) and the laurel wood of La Victoria de Acentejo district;
- two populations of frost-resistant white tagasaste from Pico de La Nieve and the pine forest of Garafía district in La Palma;
- a population of apparently drought-tolerant southern Gran Canaria escobón found in Tasartico region; and
- a population of El Hierro escobón found in the western extreme of El Golfo.

Acknowledgements

We are grateful to the International Board for Plant Genetic Resources for financial support. Thanks are due to Mr J.F. Perez for the transport facilities provided. We wish to thank Mr A. Palomares-Martínez of the Instituto para la Conservación de la Naturaleza and Mr R.L. Cáceres of the Heredamiento de las Haciendas de Argual y Tazacorte for their help in collecting in the La Caldera de Taburiente National Park, La Palma. The authors would also like to express their gratitude to Mr P.O. Machín for his assistance during collecting in La Palma, La Gomera and Tenerife.

References

Anon. 1891. Tagasaste. Kew Garden Bull. of Miscellaneous Info. 1891:239-244.

Anon. 1975. Estudio científico de los recursos del agua en las Islas Canarias (SPA/60/515). Provincia de Santa Cruz de Tenerife. Láminas. Ministerio de Obras Públicas y Unesco, Madrid.

Backer, C.A. and Bakhuizen, R.C. 1963. Flora of Java, Vol. 1. Noordhoff, Groningen.

Braun-Blanquet, J. 1932. Plant Sociology. Hafner, New York and London.

Ceballos, L. and Ortuño, F. 1951. Estudio sobre la vegetación y la flora de las Canarias Occidentales. Instituto Forestal de Investigaciones y Experiencias, Madrid.

Date, R.A. and Halliday, J. 1979. Collection of strains of *Rhizobium*. *In* Mott, G.O. and Jimenez, A. (eds.). *Handbook for the collection, preservation and characterization of tropical forage germplasm resources*. Centro Internacional de Agricultura Tropical, Cali, Colombia.

Hawkes, J.G. 1980. Crop Genetic Resources. Field Collection Manual. International Board for Plant Genetic Resources, Rome and European Association for Research on Plant Breeding, Wageningen (Netherlands).

Hawkes, J.G. 1983. The Diversity of Crop Plants. Harvard University Press, Cambridge and London.

Kuntze, O. 1891. Revisio Generum Plantarum Vol. 1. Arthur Felix, Leipzig.

Lid, J. 1967. Contributions to the flora of the Canary Islands. Universistetsforlaget, Oslo.

Marshall, D.R. and Brown, A.D.H. 1983. Theory of forage collection. *In* McIvor, J.G. and Bray, R.A. (eds.). *Genetic resources of forage plants*. Commonwealth Science and Industrial Research Organization, East Melbourne.

Milne-Redhead, E. and Polhill, R.M. 1971. Tribe 11. Genisteae. *In* Milne-Redhead, E. and Polhill, R.M. (eds.). *Flora of tropical east Africa*. Crown Agents, London.

Muntz, P.A. 1968. Supplement to California Flora. University of California Press, Berkeley and Los Angeles.

Neal, M.C. 1965. In gardens of Hawaii. Special publication no. 50. Bishop Museum Press, Honolulu, Hawaii.

Orpen, J.M. 1907. Notes. Agric. J. Cape of Good Hope 31:2-6.

Pereira-Coutinho, A.X. 1913. Uma Flora de Portugal. Ailland Alves, Paris and Lisbon.

Pérez de Paz, P.L., Arco, M. del, Acebes, J.R. and Wildpret, W. 1986. Leguminosas forrajeras de Canarias. Cabildo Insular de Tenerife, Santa Cruz de Tenerife.

Pitard, J. and Proust, L. 1908. Les Iles Canaries. Flore de l'archipel. Paul Klincksieck, Paris.

Quezel, P. 1987. Dicotyledonae Rosales: Leguminosae. *In* Maire, R. (ed.). *Flore de l'Afrique du nord* Vol. 14. Lechevalier, Paris.

Rivas-Martínez, S. 1987. Memoria del mapa de series de vegetación de España 1:400,000. Instituto para la Conservación de la Naturaleza, Madrid.

Webb, C.J. and Shand, J.E. 1985. Reproductive biology of tree lucerne (*Chamaecytisus palmensis*, Leguminosae). N.Z. J. Bot. 23:597-606.

Wood, M. 1989. Tagasaste in La Palma. Cultivation and utilization. Farm Fodder Trees Australia, Victoria, Australia.

Woodfield, D.R. and Forde, M.B. 1987. Genetic variability within tagasaste. Proc. N.Z. Grassl. Ass. 48:103-108.

Résumé

Ressources génétiques de légumineuses fourragères tagasaste et escobón (Chamaecytisus proliferus *(L. fil.) Link* sensu lato) *dans les îles Canaries*

Du germoplasme de 184 populations cultivées, semi-cultivées et sauvages de *Chamaecytisus proliferus* (L. fil.) Link (Fabaceae: Genisteae) a été collecté dans le îles de El Hierro, La Palma, La Gomera, Ténérife et Grande Canarie (îles Canaries) entre juin et août 1989. Des spécimens d'herbier, des échantillons de sol et des nodules avec *Rhizobium* ont également été prélevés pour la plupart des populations. L'écologie du tagasaste et de l'escobón est décrite. Les graines sont conservées au Centro de Conservacion de Recursos Fitogenéticos, Apartado 1045, 28800, Alcalá de Henares, Madrid, Espagne.

Resumen

Recursos fitogenéticos de las leguminosas forrajeras tagasaste y escobón (Chamaecytisus proliferus *(L. fil.) Link* sensu lato) *en las Islas Canarias*

Germoplasma de 184 poblaciones cultivadas, semicultivadas y silvestres de *Chamaecytisus proliferus* (L. fil.) Link (Fabaceae: Genisteae) se colectó en las islas de El Hierro, La Palma, La Gomera, Tenerife y Gran Canaria (Islas Canarias) durante los meses de Junio y Agosto de 1989. También se colectaron pliegos de herbario, muestras de suelo y nódulos de *Rhizobium*. Se describe la ecología de tagasaste y escobón. Semillas de esta colección se encuentran conservadas en el Centro de Conservación de Recursos Fitogenéticos, Apartado 1045, 28800, Alcalá de Henares, Madrid, España.

Nouvelles prospections de luzerne (*Medicago sativa* L.) au Maroc

A. Birouk[1], M. El Haddioui[1] et A. Hilali[2]

Introduction

Le Conseil International des Ressources Phytogénétiques (IBPGR) a souligné l'urgence de la collecte des populations de *Medicago sativa* dans les zones méditerranéennes et les régions arides adjacentes (IBPGR, 1985a). Cette décision a été dictée par le potentiel agronomique élevé de ces populations (production de matière sèche, tolérance à la salinité, etc.) et l'accentuation de l'érosion génétique (Ellis Davies, 1984).

Dans le cadre du programme 'Ressources Génétiques et Sélection de la Luzerne au Maroc', des prospections de populations locales ont été réalisées dès 1981-82, suivies des évaluations agronomiques et de l'analyse génétique du matériel collecté (Birouk, 1982, n.d.; Birouk et Dattee, 1989; Birouk *et al.*, 1989). A la lumière des résultats acquis, de nouvelles prospections de luzerne locale ont été effectuées en 1985-86 à travers diverses régions du pays, dans le but d'enrichir la collection existante.

Objectifs et méthodologies des nouvelles prospections

Ceux-ci varient selon que ces régions ont ou non été déjà explorées (Tableau 1).

Régions précédemment explorées

Dans ce cas, les objectifs visent l'approvisionnement en matériel de départ susceptible de présenter un potentiel prometteur pour un ou plusieurs critères de sélection. Dans la région de Demnate, des agriculteurs identifiés en 1981-82 ont été à nouveau visités. Dans les régions présahariennes, les objectifs d'approvisionnement pour la sélection sont combinés, dans certains cas, à la sauvegarde des populations, menacées par la persistence de la sécheresse.

En accord avec plusieurs auteurs (Marshall et Brown, 1983; Burton et Ellis Davies, 1984), les techniques d'échantillonnage ont été améliorées en tenant compte de:

- la nature des caractères recherchés,
- l'étendue de la variabilité observée dans les évaluations antérieures,
- la répartition de la variabilité entre niveaux hiérarchisés intra- et interpopulations ou intra- et interrégions.

Ces trois facteurs ont permis de déterminer *a priori* le nombre et la taille des échantillons à prélever dans chaque région, et de mieux planifier les prospections. Ainsi, dans la localité de Demnate par exemple, dont les luzernes sont assez homogènes pour les caractères agronomiques, et riches en allèles rares localisés (Birouk et Dattee, 1989; Birouk *et al.*, 1989), un faible nombre d'échantillons ont été recherchés avec toutefois une grande quantité de semences par échantillon.

Parallèlement à la récolte de graines, des collectes de souches de *Rhizobium meliloti* (nodosités et échantillons de sols) ont été effectuées selon la technique de Date et Halliday (1979). Ces prélèvements ont concerné principalement les zones où les problèmes de salinisation des sols et des eaux se posent avec acuité, entraînant l'abandon des terrains dans certains cas. Dans le cas des légumineuses fourragères, la constitution de collections de ressources génétiques de *Rhizobium* est importante, surtout dans le cas de conditions particulières de sol (IBPGR, 1985a). Il existe en effet des arguments en faveur d'une spécificité entre la plante hôte et la souche de *Rhizobium*, témoignant d'une coévolution parallèle des légumineuses et des souches de *Rhizobium* associées (Mathison, 1983). Obaton (1974) avait trouvé des différences entre souches de *R. meliloti* pour leur efficience et leur compétivité. Mytton *et al.* (1984) ont mis en évidence l'importance et la limite de la sélection, en absence de conditions de stress, des meilleurs combinaisons entre des cultivars de luzerne et des souches de *R. meliloti*.

Région prospectée pour la première fois

Il s'agit du bassin de la Moulouya, situé dans le Maroc Oriental. Les luzernes de cette région sont locales et multipliées traditionnellement par les paysans. Elles sont cependant moins réputées que celles des autres régions précédemment étudiées, et pourraient provenir d'échanges avec la vallée du Ziz (Birouk, n.d.). La sécheresse qui sévit dans le bassin haut et moyen de la Moulouya depuis plusieurs années réduit progressivement les zones de culture, en particulier la luzerne, qui est concentrée sur les points d'eau. Une réduction de 60% des superficies emblavées en luzerne y a été enregistrée durant les six dernières années (Anon., 1986).

Les luzernes de cette région ont fait l'objet d'une collecte systématique en vue de leur préservation.

Caractéristiques pédoclimatiques des régions prospectées

La caractérisation du milieu dans les collectes d'espèces fourragères, spontanées ou cultivées, est très importante (Reid et Strickland, 1983; IBPGR, 1985a).

[1] Institut Agronomique et Vétérinaire Hassan II, Département d'Agronomie et d'Amélioration des Plantes, Rabat, Maroc
[2] Institut Agronomique et Vétérinaire Hassan II, Département des Sciences du Sol, Rabat, Maroc

Tableau 1. Régions et objectifs des prospections

Région	Objectif	Nombre d'échantillons recherchés par région	Taille de l'échantillon	Observations
Amont vallée du Ziz-Haut Atlas	Recherche de populations résistantes au froid, à bonne persistance	Elevé	Faible	Résistance au froid et longévité des populations de l'Atlas et de l'aval de la vallée du Ziz (Région de Rich). Variabilité interpopulation - élevée
Aval des vallées désertiques (Ziz et Dra)	Recherche de populations non dormantes, tolérantes à la salinité. Collecte de nodosités de *Rhizobium*	Elevé	Faible	Les populations de l'aval sont les moins dormantes. La sécheresse est persistante, la collecte vise aussi la sauvegarde
Oasis isolées	Recherche de populations productives, non dormantes, tolérantes à la salinité. Prélèvement de *Rhizobium*	Faible	Elevée	Un écotype de l'oasis isolée de Tazzarine s'est révélé être à haute productivité hivernale et totale. Retour pour confirmation et approvisionnement
Vallée du Dadès	Recherche de population tolérantes à la salinité. Prélèvement de *Rhizobium*	Elevé	Faible	Longue sécheresse et accentuation de la salinisation des eaux et des sols. Variation inter-population importante
Demnate	Recherche de populations non dormantes, productives	Faible	Elevée	Homogénéité relative des caractères agronomiques. Singularisation pour les caractères enzymatiques et présence d'allèles rares localisés
Moulouya	Collecte systématique de populations locales	Elevé	Elevée	Régression alarmante de la culture de la luzerne sous l'effet de la sécheresse. Disparition ou pénurie de semences locales

Seul le bassin de la Moulouya sera décrit ici, puisque les autres régions l'ont été dans les précédents rapports (Birouk, 1982, n.d.).

Toutes les études écogéographiques distinguent deux sous-régions dans la zone prospectée du bassin de la Moulouya (Tableau 2 et Ionesco, 1965). Cette région est caractérisée par un climat aride dont la continentalité augmente du Nord au Sud, permettant de distinguer la zone de Taourirt et la zone de Missour-Outat Oulad El Haj. Certains auteurs ont effectué des études fréquentielles pour prévoir les risques de sécheresse dans le bassin de la Moulouya (Donadieu, 1977). La zone de Missour-Outat est la plus exposée aux risques de sécheresse prolongée; entre 1968 et 1980, cinq années sur douze ont été des années sèches, et la sécheresse actuelle sévit depuis plus de huit ans.

Dans la zone prospectée, la luzerne est exploitée essentiellement au printemps et en été avec en moyenne six coupes par an (4 à 10 coupes). Les luzernières ont un âge moyen de 4,5 ans (3 à 10 ans). La luzerne est utilisée largement sous forme de foin durant la période hivernale d'agnelage et de lactation. Le foin de luzerne participe pour 20% dans la répartition des unités fourragères de complémentation des ovins élevés sur parcours (Eres, 1972; cité par Donadieu, 1977).

Aucune technique particulière d'entretien ou de culture n'a été relevée dans cette région, dont les luzernes sont moyennement hautes avec un collet

Tableau 2. Caractéristiques du milieu dans la nouvelle zone prospectée
Donées climatiques sur des séries de 40 ans. P - Pluviométrie annuelle; N - Nombre de jours de pluie/an; M - Moyenne des maxima du mois le plus chaud (°C); m - Moyenne des minima du mois le plus froid (°C); F_1 - Fréquence des années sèches et très sèches ($X > 7$); F_2 - Fréquence des années humides ($X < 2$) avec X = nombre de mois/an dont la pluviométrie est < médiane.

	Moyenne Moulouya (Taourirt)	Haute Moulouya (Outat - Missour)
Latitude	34°-34°48′ Nord	32°45′-33°30′ Nord
Longitude	2°-2°45′ Ouest	3°-3°28′ Ouest
Altitude	300-450 m Nord-Sud	500-800 m Nord-Sud
Climat	Aride à hiver tempéré et étés chauds P ≃ 220 mm M = 36,7; m = 4,9 N ≃ 50 F_1 = 25%, F_2 = 13%	Aride à hiver froid et étés chauds P ≃ 190 mm Outat: M = 37,2; m = −1 Missour: M = 41; m = −0,1 N ≃ 35 F_1 = 39%, F_2 = 10%
Sols	Limono-sableux Calcaires	Limono-sableux Caillouteux

Tableau 3. Repartition des échantillons collectés par sous-région

Région	Sous-région	Nombre d'échantillons collectés de graines	Dénomination	Echantillons de nodosités	Echantillons de sol
Ziz (amont) Haut-Atlas		14	S1-S14		
Aval des vallées désertiques	Ziz-Tafilalet	23	S15-S37	18	18
	Dra	5	S39-S43	10	9
Oasis isolée	Tazzarine	2	S44-S45		
Vallée du Dadès		1	S38	7	7
Moulouya	Taourirt	11	T1-T11		
	Outat-Missour	32	01-032		
Demnate		2	Dem 5-Dem 6	2	2

profond, et présentent des symptômes de maladies fongiques *(Pseudopeziza medicaginis)*.

Résultats de la collecte

Nonante échantillons de graines, 37 échantillons de nodosités et 36 échantillons de sol ont été récoltés (Tableau 3). Certains réajustements entre la théorie de l'échantillonnage et l'empirisme du terrain ont dû être effectués en fonction notamment de la disponibilité des semences. Peu de succès a été rencontré dans les oasis isolées, à partir desquelles seuls deux échantillons ont été ramenés.

Tous les échantillons de graines et de souches isolées sont conservées selon les conditions standard (IBPGR, 1985b). Un double de la collection est entreposé au Centre International (Magneraud).

Les tests de germination des lots de graines sont satisfaisants pour la plupart, et varient entre 74 et 98%.

Après les tests sérologiques des souches isolées de *R. meliloti,* ces dernières feront l'objet de tests de croissance en conditions salines.

Conclusion

La plupart des objectifs des nouvelles prospections ont été atteints, leur réalisation a pu nous montrer la coopération bénéfique qu'il peut y avoir entre la théorie des prospections et le pragmatisme du terrain.

Références

Anon. 1986. Ministère de l'Agriculture et de la Réforme Agraire du Maroc. Statistiques de la Direction de la Production Végétale.

Birouk, A. 1982. Rapport sur la prospection de luzernes locales au Maroc. Conférence de l'Association de Créateurs de Variétés Fourragères (ACVF) Paris, Dec. 1982.

Birouk, A. N.d. Collecte de populations traditionnelles de luzerne au Maroc: Caractérisation pédoclimatique des régions prospectées et recherche de caractères adaptatifs. Pl. Genet. Resources Newsl. (Accepted)

Birouk, A. et Dattee, Y. 1989. Organisation de la variabilité enzymatique des populations marocaines de luzerne (*Medicago sativa* L.): Structures géniques et génotypiques. Genome 32 (1):120-128.

Birouk, A., Dattee, Y., Sadiki, M. et Roumet, P. 1989. Evaluation agronomique et adaptation des populations marocaines de luzerne (*Medicago sativa* L.). Agronomie 9(4):363-377.

Burton, G.W. et Ellis Davies, W. 1984. Handling germplasm of cross-pollinated forages. *In* Holden, J.H.W. and Williams, J.T. (eds.). *Crop genetic resources: conservation and evaluation.* Allen and Unwin, London, pp. 180-190.

Date, R.A. et Halliday, J. 1979. Collection of strains of *Rhizobium. In* Mott, G.O. (ed.). *Handbook for the collection, preservation and characterisation of tropical forage germplasm resources.* Centro Internacional de Agricultura Tropical, Cali, Colombia, p. 21.

Donadieu, P. 1977. Contribution à une synthèse bioclimatique et phytogéographique au Maroc. I.A.V. Hassan II. Département d'Ecologie et de Pastoralisme.

Ellis Davies, W. 1984. A Plan of Action for Forage Genetic Resources. International Board for Plant Genetic Resources, Rome.

IBPGR. 1985a. Forage for Mediterranean and Adjacent Arid/Semi-Arid Areas. Report of a Working Group 24-26 April, 1985. International Board for Plant Genetic Resources, Rome.

IBPGR. 1985b. Handbook of Seed Technology for Genebanks. Vol. 1. International Board for Plant Genetic Resources, Rome.

Ionesco, T. 1965. Considérations bioclimatiques et phyto-écologiques sur les zones arides du Maroc. Cah. Rech. Agron. Inst. Rech. Agron. 19:1-69.

Marshall, D.R. et Brown, A.H.D. 1983. Theory of forage plant collection. *In* McIvor, J.G. and Bray, R.A. (eds.). *Genetic resources of forage plants.* Commonwealth Scientific and Industrial Research Organization, Melbourne, pp. 135-148.

Mathison, M.J. 1983. Mediterranean and temperate forage legumes. *In* McIvor, J.G. and Bray, R.A. (eds.). *Genetic resources of forage plants.* Commonwealth Scientific and Industrial Research Organization, Melbourne, pp. 63-84.

Mytton, L.R., Brockwell, J. et Gibson, A.H. 1984. The potential for breeding an improved lucerne-*Rhizobium* symbiosis: 1. Assessment of genetic variation. Euphytica 33:401-410.

Obaton, M. 1974. Influence des souches de *R. meliloti* sur le rendement de la luzerne et sa richesse en proteines. A.T.P. luzerne compte rendu 1973-1974. Institut National de la Recherche Agronomique, France.

Reid, R. et Strickland, R.W. 1983. Forage plant collection in practice. *In* McIvor, J.G. and Bray, R.A. (eds.). *Genetic resources of forage plants.* Commonwealth Scientific and Industrial Research Organization, Melbourne, pp. 149-156.

Barley collecting in southern Arabia

Luigi Guarino[1]

Recent efforts by the International Board for Plant Genetic Resources (IBPGR) and the national plant genetic resources programmes of countries in the southern part of the Arabian Peninsula to collect wheat in Oman, Yemen AR, PDR Yemen and Saudi Arabia have been considered in a separate paper. Various other crops have also been intensively collected in the region for the first time in the past few years. This paper deals with the case of barley, *Hordeum vulgare*.

Recent rapid development, coupled with an almost complete lack of collecting in the past, has made the region a high priority for gap-filling collecting of wheat. Very much the same may be said of barley. Though perhaps the threat of genetic erosion from such factors as the influx of high-yielding cultivars is somewhat less in this case, as will be shown, the problem of underrepresentation in collections is if anything more acute.

The barley growing areas of southern Arabia

As with wheat, barley in the southern half of the Arabian Peninsula, southeast of a line from Jiddah to the Straits of Hormuz, is mainly grown in the mountainous regions of the eastern (Oman) and southern (PDR Yemen, Yemen AR and Saudi Arabia) corners.

The eastern mountains

Barley is a minor crop in Oman, not usually used for human consumption except in the Musandam Peninsula in the far north. There and at the higher elevations of the western Hajar Mountains, barley, like wheat, may in favourable years be grown rain-fed during the winter, harvesting usually taking place in mid-March. Elsewhere the crop is irrigated. On the Batinah Plain, between the Hajar Mountains and the Gulf of Oman, barley is exclusively grown in mixture with alfalfa: when it is wanted to establish a new stand of alfalfa, barley may be sown at the same time, to be cut green for fodder once or twice along with the alfalfa. There are no figures for the total area of barley in Oman, but there are some 300 ha of wheat, and barley is certainly not as important a crop. Mean annual temperature in this region varies from 29°C on the coast to 27°C at 500 masl in the lee of the mountains and 17°C at 1700 masl in the rain-fed area.

The southern mountains

The rain-fed terraces of the mountains of the southern corner of Arabia are where most of the barley grown in the region is to be found. The narrow high-altitude (>1500 masl) dryland area stretches for about 1000 km south to north from the northern part of the Lahej and Abyan governorates of PDR Yemen, through the central highland region of Yemen AR and the Aseer Mountains of southwest Saudi Arabia, to Taif. Of perhaps 80-90 000 ha of barley in this area, 15-25% is in Saudi Arabia and 75-85% in Yemen AR, where rainfall is generally higher than further north and more evenly spread through the year. The high-altitude barley area of PDR Yemen is probably less than 500 ha. Figures on areas come from Ceccarelli and Mekni (1985), the Central Statistical Organization (1988), the Department of Economic Studies and Statistics (1988) and the Directorate General of National Statistics (1984).

About half the barley area of the region is in the 300-400 mm zone and most of the rest in the 400-500 mm zone (Ceccarelli and Mekni, 1985). In the southern uplands of Yemen AR, the crop may be sown throughout the year. In the northern uplands of Yemen AR and in Saudi Arabia there are winter and summer sowings. Mean annual temperature is about 18°C at 2200 masl, with occasional winter frosts. Barley is used for human consumption throughout the area, and also as a livestock feed occasionally in Saudi Arabia. The practice of sowing with alfalfa, as in Oman, has been observed in the Aseer Mountains of Saudi Arabia.

Barley is also grown to a very limited extent under irrigation in the mid-altitude (1000-2000 masl) oasis belt in the lee of the southern mountains, for example at Beihan in the Shabwa governorate of PDR Yemen and at Najran in Saudi Arabia. The total area probably does not much exceed 200 ha. Mean annual temperature in this area is about 23°C and frosts are unknown.

Barley germplasm collections in southern Arabia

A recent IBPGR-commissioned assessment of the status of germplasm collections of the mandate crops of the International Centre for Agricultural Research in Dry Areas (ICARDA) in the ICARDA mandate countries (Toll, unpublished) showed clearly how underrepresented the countries of the Arabian Peninsula are in international and national barley germplasm collections: no accessions at all were recorded from Oman, PDR Yemen and Saudi Arabia. As was the case for wheat at that time, Yemen AR was the only country in the region which was reasonably adequately covered, thanks to three missions involving the national genetic resources programme and German Technical Cooperation (1978-9) and IBPGR (two missions in 1980). The results of these expeditions are

[1] IBPGR Plant Collector, Agricultural Research Institute, Ministry of Agriculture and Natural Resources, PO Box 2016, Nicosia, Cyprus

recorded by Wood (1980), Ayad and Croston (unpublished) and Sackville Hamilton (unpublished).

Toll listed the mountainous areas of the Arabian Peninsula as priority 1 regions for wheat collecting and priority 2 regions for barley collecting, after some areas of North Africa. Since then, these areas have been covered by collaborative missions between the relevant national genetic resources programmes and IBPGR, and both wheat and barley have been extensively collected to fill the obvious gaps that existed. Guarino (unpublished), Guarino and Al-Ghaz (unpublished) and Guarino and Al-Juwaied (unpublished) give details of the collecting carried out in collaboration with, respectively, the Department of Research of the Ministry of Agriculture and Fisheries, Oman; The Department of Research and Extension of the Ministry of Agriculture and Agrarian Reform, PDR Yemen; and the National Agriculture and Water Research Centre of the Ministry of Agriculture and Water, Saudi Arabia.

Table 1. Barley germplasm collected since 1980 and now internationally available

Country	No. of samples collected for each mission						Total
	1980	1980	1987	1988	1989	Other	
Oman			51				51
PDR Yemen				7			7
Saudi Arabia					13	5	18
Yemen AR	77	12				56	145

Table 1 shows the number of barley accessions now available to the international germplasm community from the four countries dealt with here. Note that the 1989 mission to Saudi Arabia covered only the southwestern mountains, in contrast to the other missions, which were country-wide. Other regions of Saudi Arabia remain to be collected.

Variability of barley

Though some work on variability within national collections has been done (e.g. Damania *et al.*, 1985), no comparative characterization or preliminary evaluation studies have yet been carried out on barley germplasm throughout the region. However, as in the case of wheat in southern Arabia, the number of traditionally recognized local varieties in different areas can give a limited, preliminary indication of variability within the crop.

In Oman, barley is usually simply called 'shayir', the standard Arabic word for the crop. Only two of over 100 farmers visited in 1987 recognized and grew distinct local varieties to which they referred using different names. At Dariz in the Dhahirah region, 'Magdula' and 'Nassasi' are grown, and were collected, in addition to 'standard' shayir. At Al-Juwaeif in the Jau region, the varieties 'El-Alia' and 'Jasima' were collected. All barley grown in Oman is six-rowed.

Ayad and Croston (unpublished) record collecting five distinctly named two-rowed hulled types in Yemen AR ('Aswad', 'Balaidi', 'Bokur', 'Safeh' and 'Saglah') and one two-rowed naked type ('Habeeb', grown in the Yarim area only). They also record that a six-rowed type is apparently grown in the Rada area, but could not be found. It should be pointed out that 'Balaidi' may simply mean 'local' or 'of this place' and may be used to refer to very different things in different places. No local names for barley varieties were recorded in PDR Yemen by the 1988 mission, but Mu'allem (1988) lists four local two-rowed varieties: 'Bokur', 'Bothinah', 'Khatrin' and 'Marboua'a'.

Discussions with local farmers in the mountainous southwest of Saudi Arabia suggest that two main types of barley are recognized there, both two-rowed, 'Bokur' and 'Ghiad'. They are distinguished morphologically mainly on the basis of grain size, but there are also agronomic differences, only the small-seeded type ('Ghiad') being grown in summer in the area.

It is probably safe to suggest that up to about ten main morphological types of barley, most of them two-rowed, are grown in the mountains of the southwestern corner of the Arabian Peninsula. The name 'Bokur' is recorded throughout this area, but experimental work is needed to determine whether samples labelled with this name, or for that matter labelled 'Balaidi', actually represent single main morphological and agronomic types, and whether forms given different names in different areas also do. Even in cases where this is so, there will doubtless be considerable cryptic genetic variation between samples of the same name, and its quantification will also need experimental studies. It is to be hoped that now that a reasonably comprehensive collection from the whole region has begun to be assembled, these will soon follow.

Genetic erosion

The area sown to local varieties is decreasing both in absolute terms, as farmers leave the land or turn to cash crops, and as a proportion of the total wheat area, as development in agriculture leads to the influx of high-yielding varieties (HYVs). Though all this is probably true for barley to some extent in some areas, the trend is not nearly so marked and the threat of genetic erosion therefore not nearly so acute at the moment.

Some idea of this may be gained by looking at when barley HYVs were first released, keeping in mind that the first introductions of wheat HYVs in the region go back to the early 1970s. No modern varieties have been released in Oman as yet. In PDR Yemen, 'Bonus' and 'Nabawi' were introduced for their good brewing qualities, but they have not been widely adopted. 'Arafat' and 'Beecher' were released in Yemen AR in

1986, the first such introductions. In Saudi Arabia, commercial barley projects, growing cultivars like 'Gusto', started in the mid-1980s: they are concentrated in the northern part of the country, which has not traditionally been an important barley-growing area.

No doubt, this situation will soon change. However, we may be reasonably certain that recent barley collecting in southern Arabia, in contrast to the case of wheat, has sampled variability that has probably decreased little in the past few decades. It is interesting to note that though Wood (op. cit.) suggested that naked barley was no longer grown in Yemen AR, this was subsequently collected by Ayad and Croston.

References

Ceccarelli, S. and Mekni, M.S. 1985. Barley breeding for areas receiving less than 250 mm annual rainfall. Rachis 4:3-9.

Central Statistical Organization. 1988. Summary of the Final Results for the First Agricultural Census, 1985. Aden, PDR Yemen.

Damania, A.B., Jackson, M.T. and Porceddu, E. 1985. Variation in wheat and barley landraces from Nepal and Yemen AR. Z. Planzennuchtg. 94:13-24.

Department of Economic Studies and Statistics. 1988. Agricultural Statistical Yearbook, 1986/87. Riyadh, Saudi Arabia.

Directorate General of National Statistics. 1984. Statistical Yearbook, 1983. Muscat, Oman.

Mu'allem, A.S. 1988. Genetic resources of cereal crops in PDR Yemen. 2. Barley, millet and maize. FAO/IBPGR Pl. Genet. Resources Newsl. 72:32-33.

Wood, D. 1980. Collecting in Yemen Arab Republic. FAO/IBPGR Pl. Genet. Resources Newsl. 40:23-26.

Date palm genebank in the Kingdom of Saudi Arabia

Abdullah Saleh Al-Ghamdi[1]

Introduction

In 1977-1978 there were 11 million palm trees in Saudi Arabia with a total production of 411 000 tonnes/year (anon., 1978). Hussain and El-Zeid (1978) have reported the existence of 400 cultivars in Saudi Arabia alone, distributed in more than seven major date growing regions. Differences within the same cultivars were noticed when grown in different regions (Asif *et al.*, 1983).

Most of the current cultivars originated from chance seedlings that produced acceptable fruit quality. Also, a multitude of unnamed cultivars occur since each seedling may be considered a potential cultivar due to the high degree of heterozygosity in the dioecious date palm (anon., 1914).

Date germplasm is threatened by pests, diseases, genetic erosion, bud mutation, environmental hazards, population pressure and poor management.

Implementation and organization of the genebank

Numerous date palm cultivars are represented as a few specimens in collections or grown in limited geographical areas (IBPGR, 1986). The first date palm repository was established in 1977 in Indio, California as a part of the United States Department of Agriculture germplasm conservation programme. The date palm genebank at the Date Palm Research Center (DPRC), King Faisal University (KFU) was established in 1982, containing national and international sections and a new section for date palm produced through tissue culture.

Cultivars were also imported from the USA and Iraq. Cultivars produced through tissue culture technique were imported from the USA, France and England.

For documentation and evaluation of date palm genebank data, information and observations were recorded on monthly, quarterly, and yearly bases. The data and information were recorded before date palm offshoots planting, during vegetative growth, flowering and fruiting stage.

In 1982, 510 date palm offshoots belonging to 31 cultivars were collected from seven major date-palm-growing regions: Al-Madina, Besha, Al-Ahsa, Al-Quatif, Najran, Al-Gassem and Al-Jof.

In 1984, 213 date palm offshoots of 15 cultivars were imported from the USA, most originally old world. 145 date palm offshoots belonging to 11 cultivars were imported from Iraq in 1985. A tissue culture section with over 20 cultivars has also been set up. The maintenance of the large living collections requires large inputs of land and labour, and is beset by many problems, such as space considerations associated with the need to conserve an adequate sample of wide genetic variation.

Table 1. Date palm cultivars of Saudi origin

Ser. no.	Region	Cultivars	No. of offshoots
1	Al-Hassa	Shahal	23
2		Rezeiz	21
3		Mijnaz	19
4		Khlas	16
5		Shaishi	20
6		Ghur	18
7		Tanageeb	24
8		Hilali	26
Total			167
9	Al-Madina	S. Yanbu	23
10		Rabea'a	20
11		Helwa	27
12		Safawi	22
13		Ruthana	22
14		Shalabi	20
Total			134
15	Besha	Shukul	10
16		Barni	6
17		Gassb	11
18		Sefri	27
Total			54
19	Najran	Barni	4
20		Seghah	13
21		Bayadh	5
22		Mawakel	9
23		Rutab	8
Total			39
24	Al-Quatif	Khnazi	20
25		Bkerah	21
Total			41
26	Al-Gassem	Om-Alkhsh	5
27		Ruthana	5
28		Dnanah	2
29		Shagra	44
30		Om-Alhamam	4
Total			60
31	Al-Jof	Helwa	9
32		Hsseneah	6
Total			15
TOTAL (all regions)			510

[1] Date Palm Research Center, King Faisal University, PO Box 400, Al-Ahsa 31982, Saudi Arabia

Table 2. Date palm cultivars of American origin

Ser. no.	Cultivars	No. of offshoots
1	Dari	21
2	D. Noor	27
3	Halawi	20
4	Hilali	30
5	Khadrawy	12
6	Madjool	5
7	Thory	24
8	Zahdi	13
9	Peggyann	6
10	Khasab	8
11	Honey	23
12	Khalas	3
13	Sayeedi	7
14	Minacker	9
15	Hayyani	5
Total		213

Table 3. Date palm cultivars of Iraqi origin

Ser. no.	Cultivars	No. of offshoots
1	Ashrasy	11
2	A. Omran	15
3	Barbin	11
4	Barhi	8
5	Barem	15
6	Dubini	10
7	Khadrawy	16
8	Khastawy	10
9	Maktomi	15
10	Tabarzal	15
11	Zahidi	19
Total		145

Table 4. Number of tissue cultures

Ser. no.	Cultivars	No. of cultures
USA cultivars - International Plant Research Institute (IPRI)		
1	Madjool	32
2	Deglet Noor	18
Total		50
British cultivars		
A - Date Palm Development Co., Twyford		
1	Madjool	15
2	Deglet Noor	9
3	Jrivs	14
4	Fard	13
5	Barhi	10
Total		61
B - Unilever		
1	Fahal	20
2	Barhi	9
3	Lulu	20
4	Nagal	19
5	Khasab	5
6	Khnazi	25
Total		98
French cultivars - French Research Group on the Date Palm (FRGP)		
1	Madjool	5
2	Boufegos	10
3	Bouskri	4
4	Boustami	8
5	Thory	10
6	Zahdi	9
7	Fard	10
8	Helwa	5
9	Khadi	5
Total		66
Saudi Arabian cultivars - Date Palm Research Center, King Faisal University		
1	Khasab	2
2	Ghur	4
3	Om-Rhem	1
Total		7

References

Anon. 1914. Origin of the date palm. J. Hered. 5:498-508.

Anon. 1978. Current sample survey, Ball. Agric. Statistic. Div., Ministry of Agriculture and Water, Riyadh, Saudi Arabia. (In Arabic)

Asif, M.I., Al-Tahir, O.A. and Al-Kahtani, M.S. 1983. Interregional and inter-cultivar variations in dates grown in the Kingdom of Saudi Arabia. Proc. 1st Symp. Date Palm, Al-Ahsa, Saudi Arabia.

Hussain, F. and El-Zeid, A. 1978. Studies on physical and chemical characteristics of date varieties of Saudi Arabia. Ministry of Agriculture and Water, Riyadh, Saudi Arabia. (In Arabic)

IBPGR. 1986. Genetic resources of tropical and subtropical fruits and nuts. International Board for Plant Genetic Resources, Rome, pp. 78-83.

Collecting wild species in Dhofar, Southern Region of the Sultanate of Oman

Luigi Guarino[1]

During September and October 1988, this mission collected wild species, mainly forage grasses and legumes, in the Dhofar area of the Southern Region of the Sultanate of Oman, following up and completing work begun the previous year, when crops were collected throughout the Sultanate.

Dhofar is a relatively mesic area in the otherwise generally very arid context of the Southern Region, and of the southern part of the Arabian Peninsula as a whole. It has a unique flora, which has developed in isolation for hundreds of thousands of years and which supports a large livestock population, including, unusually for the region, considerable numbers of cattle.

Lately, as the traditional transhumant way of life has begun to lapse, serious environmental degradation has occurred, which has doubtless included genetic erosion of important forage species, and perhaps local extinctions. This International Board for Plant Genetic Resources (IBPGR) collecting project should be seen in the context of considerable efforts by various agencies, both national and international, to halt such degradation and reverse the process. A new Department of Range Management and Forestry of the Ministry of Agriculture and Fisheries, for example, has recently been set up in the Southern Region as a Food and Agriculture Organization/United Nations Development Programme project.

The collecting area

The Southern Region of the Sultanate of Oman occupies about a third of the total area of the country, amounting to some 117 000 km^2 between longitudes 52 and 57°E and latitudes 20 and 17°N. The southern seaboard and its fringing arc of mountains, collectively known as Dhofar, cover only about 18 000 km^2 of this, or about 15%, but support 90% of all the livestock of the region and a similar percentage of the total human population of 111 000 (Planning Committee for Development and Environment in the Southern Region, 1987). This is because, unlike the flat, low-lying hinterland of the Southern Region, the mountains of Dhofar are able to derive a benefit from the moisture-bearing winds of the summer monsoon, and are therefore a heavily vegetated 'island' surrounded by desert, a sort of natural oasis of forest and grassland where it has been possible for a relatively intensive transhumant pastoralism to develop.

Though rainfall as measured by standard rain gauges is usually 200-400 mm during the two months of the monsoon in the Dhofar mountains, mist traps suggest that five times as much moisture might be available as occult precipitation condensing on vegetation only 1 m tall (Stanley-Price *et al.*, 1985). Salalah, the regional capital on the coastal plain, receives about 100-150 mm of rainfall, and very little occult precipitation. Thumrait, in the rain-shadow of the mountains, receives less than 50 mm, and no occult precipitation.

The coincidence of topography and weather systems that obtains in Dhofar is unique in Arabia, as is the assemblage of species it supports. To some extent, this may be seen as a relict: the Dhofar mountains, like the island of Socotra to an even greater extent, have acted as a refugium for the descendants of the relatively mesic circum-Tethyan Tertiary flora. The strongest phytogeographic affinities are with tropical northeast Africa, though there are also elements from the Indian subcontinent and south Iran (Miller *et al.*, 1988).

Germplasm collecting

Collecting was carried out at 43 sites, concentrating on J. Qara, which has the largest extent of grassland, but extending to J. Qamar, which is the best forested, and the Salalah Plain.

The soils of collecting sites on the Salalah Plain tended to be low-fertility alkaline clay loams and silt loams of alluvial origin. On the plateau there were reddish cracking clays of neutral reaction, 50 cm deep on average. According to work by the Department of Research, these plateau soils tend to be low in zinc and manganese.

Some 130 samples were taken, representing about 40 species. A duplicate of each sample has been deposited with the Department of Research in Salalah. A list of species collected, with the numbers of separate samples of each, is provided in Table 1. Most of the species collected are legumes and grasses. Three woody species in other families were also collected. Particular attention was paid to species known to be of importance as food for livestock either in Dhofar itself or elsewhere, and to species related to such plants.

Some of the more interesting species collected are described below.

Leguminosae

Acacia gerrardii Benth.

A smallish tree of tropical Africa and Arabia, in Dhofar this species is found on the dry side of the summit plateaux, mostly on deeper soils. Its foliage and pods are heavily browsed both on the tree and, once fallen, on the ground.

[1] IBPGR Plant Collector, Agricultural Research Institute, Ministry of Agriculture and Natural Resources, PO Box 2016, Nicosia, Cyprus

Table 1. Species collected in Dhofar, 1988

Species	No. of samples
Leguminosae	
Acacia etbaica	1
A. gerrardii	2
A. laeta	1
A. nilotica	1
A. tortilis	1
Alysicarpus glumaceus	2
Delonix elata	1
Indigofera coerulea	1
I. phillipsiae	1
Rhynchosia minima	3
Vigna radiata	2
Gramineae	
Acrachne racemosa	3
Apluda mutica	2
Aristida adscensionis	1
Arthraxon hispidus	2
A. lanceolatus	2
Arthraxon sp.	1
Brachiaria eruciformis	3
B. lata	1
Cenchrus pennisetiformis	14
C. setigerus	7
Cymbopogon schoenanthus	1
Dactyloctenium aegyptium	8
D. aristatum	11
D. scindicum	6
Dicanthium foveolatum	4
Digitaria ciliaris	4
D. nodosa	2
D. stricta	2
Echinochloa colona	1
Eragrostis barrelieri	1
E. ciliaris	3
Eustachys paspaloides	1
Leptothrium senegalense	2
Panicum atrosanguineum	3
Setaria intermedia	2
S. pumila	1
S. pumila?	8
Tetrachaete elionuroides	2
Tetrapogon tenellus	6
Tragus berteronianus	4
Others	
Anogeissus dhofarica	4
Blepharis dhofarensis	1
Dodonaea angustifolia	1

Acacia laeta R.Br. ex Benth.

A shrub or small tree of the Sahel and southwest Arabia, it is on the edge of its range in Dhofar, where it is found in dry, north-draining wadis. Leaves and pods are browsed by livestock in the Sahel, and it also produces gum, like *A. senegal,* which is similar. It is taxonomically close to *A. mellifera,* the foliage of which is reported to be very high in protein in the Sahel and readily eaten by goats both while on the tree and after it falls. Leaves are said to start emerging in the middle of the dry season in Africa.

Alysicarpus glumaceus (Vahl) DC

This is an erect or sometimes procumbent annual herb of Arabia and tropical Africa. In Dhofar, it is found, with increasing difficulty, in the deciduous bushland of the escarpment foothills and in the plateau grassland. Also occurring in Dhofar are *A. vaginalis* (L.) DC and *A. longifolius* (Roth.) Wt. & Arn. All have good reputations as forages.

Rhynchosia minima (L.) DC

A pantropical climbing or prostrate perennial herb found in shrubland on the escarpment foothills and in the *Euphorbia balsamifera* zone of the plateau, often within shrubs, and also in the wet escarpment woodland. It is an extremely variable self-pollinating species generally regarded as a good forage, but contributes little nitrogen to the soil. *R. pulverulenta* Stocks is recorded from the Salalah Plain. Sometimes synonymized with *R. minima* var. *memnonia* (Del.) Cooke, it seems to be more drought tolerant than other forms.

Vigna radiata (L.) Wilcz. *sublobata* (Roxb.) Verdc.

This annual climbing herb was collected in tall grassland by a lake and in dense shrubland on the escarpment. It is the wild form of the mung bean, *V. radiata* var. *radiata.* The type collected at the drier site was distinctly smooth-seeded. Several *Vigna* taxa are regarded as important forages in tropical Africa and Asia.

Gramineae

Cenchrus pennisetiformis Hochst. & Steud.

An annual or short-lived perennial growing from east Africa to India in various open communities of semi-deserts and dominant in the wetter coastal plain grasslands of Dhofar. This species is taxonomically close to the taller perennial *C. ciliaris* L., with which it intergrades and which is also recorded from Dhofar. *C. ciliaris* is intermediate between *Cenchrus* and *Pennisetum,* but it is usually placed in the former because of its relationship with *C. pennisetiformis.* Both species are generally regarded as excellent forage.

Cenchrus setigerus Vahl

This clump-forming perennial of subdesert grassland and bushland from east Africa to India is found in Dhofar mainly in the semi-desert grasslands of the coastal plains. It is much esteemed as a forage throughout its range, and widely introduced into other semi-arid regions as fodder and for land reclamation. Though palatable, it is apparently not very productive, though it produces seed quickly. It remains green into the dry season. It may cross with *C. ciliaris* and it resembles some hybrids of *C. pennisetiformis* and *C. biflorus.*

Dactyloctenium aegyptium (L.) Willd.

A loosely tufted to spreading annual, often shortly stoloniferous and mat-forming, sometimes erect, found in weedy situations throughout the tropics and subtropics. It is widely distributed in disturbed areas in Dhofar. Though there are reports of the leaves containing cyanogenic glucosides in certain cases, this is generally said to be one of the best annual grazing grasses in semi-arid areas. It dries out at the beginning of the dry season, but seems to be palatable at all growth stages. Seeds collected from weedy situations are actually sown for fodder in some places in the mountains of northern Oman.

Dactyloctenium aristatum Link

A sprawling, tufted annual, sometimes stoloniferous, of tropical deserts from east Africa to India, it is probably more drought tolerant than *D. aegyptium,* being restricted to the coastal areas in Dhofar. There is little information on its forage potential.

Dactyloctenium scindicum Boiss.

This stoloniferous perennial is found in dry grassland and open bushland from east Africa to India. In Dhofar it grows in the semi-desert grassland and deciduous shrubland of the coastal area and in the dry shrub grassland on the plateau. It is said to be a useful fodder in Africa.

Dicantium foveolatum (Del.) Roberty

A tufted perennial of north and east Africa to India, found in the plateau grassland in Dhofar. The perennial *D. annulatum* (Forssk.) Stapf, which also occurs in Dhofar, is highly regarded as a fodder in the arid areas of India and has been much collected and introduced elsewhere. It is very palatable but of low nutritive value. The annual endemic *D. micranthum* Cope is often dominant in the drier areas of the Salalah Plain. It was not possible to collect either of these species. *D. foveolatum* may be more drought resistant than *D. annulatum,* but is a generally smaller, less leafy plant.

Eustachys paspaloides (Vahl) Lanza & Mattei

This erect perennial occurs from southern Africa to southern Arabia. In Dhofar, it is found as isolated individuals in short-medium plateau grassland, and is conspicuous because still green at the time when the dominant annuals are drying off. It is leafy and well liked by grazing animals in Kenya.

Panicum atrosanguineum A. Rich.

A tufted annual of east Africa, southern Arabia and northwest India, this species occurs in Dhofar in the shrub grasslands of the plateau. It is similar to *P. laetum* Kunth, which is found from Mauritania to Ethiopia in seasonally flooded areas, often in large pure stands, and provides a useful fodder as well as grain for human consumption. *P. antidotale* Retz. is a vigorous perennial also recorded from the plateau areas. It provides good fodder prior to flowering in some regions and is resistant to drought, fire and heavy grazing. *P. turgidum* Forssk., recorded from the desert areas in the rain-shadow of the Dhofar mountains, is a perennial of relatively low palatability but commonly regarded as good camel fodder.

Tetrapogon tenellus (Roxb.) Chiov.

This loosely tufted annual or short-lived perennial is found in tropical Africa and from southwest Asia to India. It is common in Dhofar from the semi-desert grasslands of the coastal plain to the deciduous shrublands of the escarpment foothills. Leafy and possibly perennial, this is probably an important forage resource in the coastal areas of Dhofar. Chemical analyses from Kenya have given good results. The related perennial *T. villosus* Desf., also found in Dhofar, is considered a good forage in the Sudan and Somalia and also gave good composition results; it may be more drought tolerant.

Other families

Anogeissus dhofarica A.J. Scott (Combretaceae)

An endemic deciduous tree up to 12 m tall, sometimes reduced to a shrub by cutting and browsing, this is the commonest tree in the escarpment woodlands. It is an extremely important browse species in Dhofar, particularly for camels, providing fodder at the end of the dry season, when alternatives are few. It comes into leaf just before the beginning of the monsoon. Other *Anogeissus* spp. are also important for browse. There is only one other species in Arabia, *A. bentii* Baker, a large tree endemic to southern Yemen.

Blepharis dhofarensis A.G. Miller (Acanthaceae)

An endemic shrub or small tree found in dense woodland on steep escarpment slopes, this is, with *Ormocarpum dhofarense* Hillc. & Gillett, perhaps the fodder most highly regarded by the local people. The leaves are taken by camels, but the best part of the plant is the green seeds, which are much liked by both camels and goats. Various African species have been reported to be grazed by livestock, particularly camels, but the extent varies. *B. linariifolia* Pers., for example, which occurs in the drier areas of Dhofar, is said to be relished by camels in the Sudan but not liked in Niger.

Recommendations for further collecting work

Though none of the species collected may be said to be in immediate danger of extinction in Dhofar, it is undoubtedly true that the more palatable forage and browse species are declining in abundance. Herbaceous legumes are very rare now in parts of the plateaux and the coastal plains, and though they were perhaps never particularly abundant, they have probably been selectively eaten out of large areas of grassland. Particular attention should be paid to *Alysicarpus, Desmodium, Rhynchosia, Vatovaea* and *Vigna* in future collecting. The root-nodule bacteria *Rhizobium* should also be systematically collected.

Among the forage grasses, *Themeda quadrivalis*, for

example, has also markedly decreased on J. Qara in the past 15 years, though this is not a species usually regarded as being of particularly high palatability. The same has probably also happened to other species, perhaps particularly the perennials of the plateau grasslands and shrub grasslands. It is important that all such declining species, both legumes and grasses, be vigorously collected, for example within enclosures and other protected areas. In the coastal areas, *Sporobolus* is much undercollected, and *Dactyloctenium* and *Cenchrus* are also of interest to the collector.

The forests of Dhofar are its key resources, and for several woody species the general availability of diverse genetic material would be of enormous importance both locally and for forestry work throughout the semi-arid regions. *Anogeissus dhofarica, Acacia* spp. and *Ormocarpum dhofarense* are some of the shrubs and trees with perhaps the most obvious potential. There is evidence that much-used, highly regarded species like *Ormocarpum* and *Blepharis dhofarensis* have declined significantly in abundance in the escarpment forests within living memory, and serious genetic erosion of these interesting endemics has probably already taken place. The *Cadaba* spp. also show signs of overgrazing, and in fact all of the half dozen or so important woody browse species in the Capparaceae should be a high collecting priority.

Among the wild/weedy crop relatives, the most important species for future collecting are *Abelmoschus esculentus* and *A. manihot, Cucumis sativus* and *C. melo, Gossypium stocksii* and *Vigna radiata* var. *sublobata*. It was only possible to collect the last of these on this occasion, and interesting variation was noted. Further collecting should prove of wide interest, as the species is an important forage as well as a relative of the mung bean. Local, cultivated landraces of *C. sativus, V. radiata* and *V. unguiculata* were extensively collected in Dhofar by IBPGR and the Department of Agricultural Research in 1987.

References

Miller, A.G., Morris, M. and Stuart-Smith, S. 1988. Plants of Dhofar. The Office of the Adviser for Conservation of the Environment, Diwan of Royal Court, Muscat.

Planning Committee for Development and Environment in the Southern Region. 1987. Outline Plan for the Southern Region. Vol. 1. Geographic Framework. Technical Secretariat, Salalah.

Stanley-Price, M.R., al-Harthy, A.H. and Whitcombe, R.P. 1985. Fog moisture and its ecological effects in Oman. Arid Lands: Today and Tomorrow.

Peanut (*Arachis hypogaea* L.) collecting in coastal Peru

D.J. Banks[1]

Some of the peanut shells found in the archaeological records in South America resemble primitive forms of peanuts which are still grown to a limited extent in irrigated valleys near the coast of Peru. These types are referrable to *Arachis hypogaea* L., subspecies *hypogaea* Krap. et Rig., variety *hirsuta* Kohler. In comparison with present cultivars, the *hirsuta* types are exceedingly late, their vines are extensive and they possess long, weak pegs which make harvesting, even by hand, very difficult. Although these peanuts were abundant along coastal Peru, they are now rare because they are being replaced by modern cultivars that are earlier, more productive and more easily managed. Unfortunately, we have not yet adequately characterized these primitive types for all of the useful traits that they may possess.

In 1985, 37 peanut and three *Rhizobium* samples were collected from coastal Peru (Fig. 1). Emphasis was placed on obtaining the primitive *hirsuta* botanical variety (Fig. 2). The variety proved to be exceedingly rare, although it was extensively cultivated in earlier years.

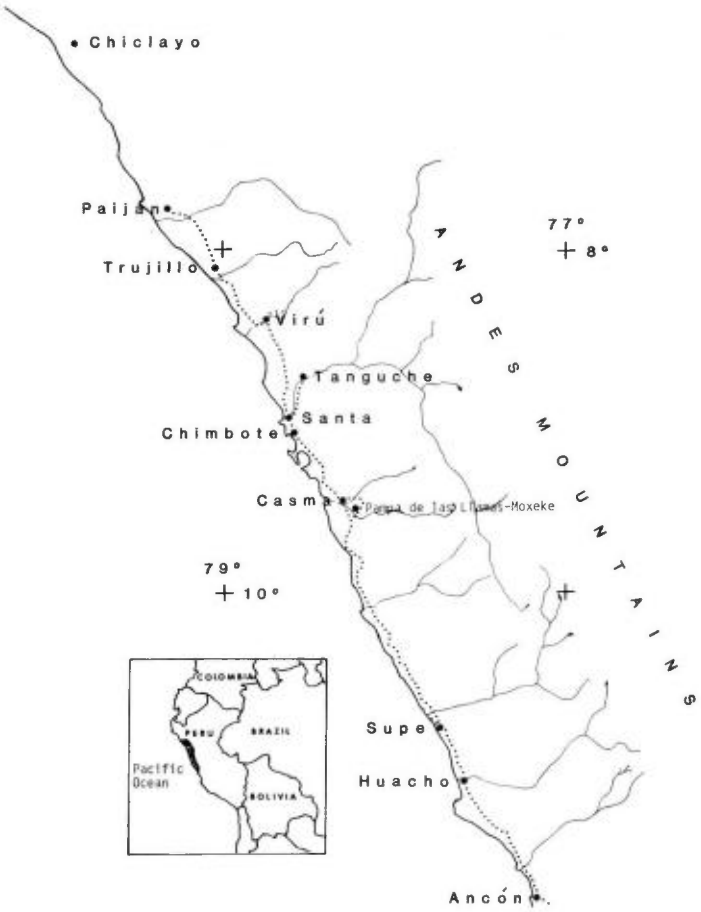


Fig. 1. Peanut collection route (dotted line) along the coast of Peru from Lima to Paiján

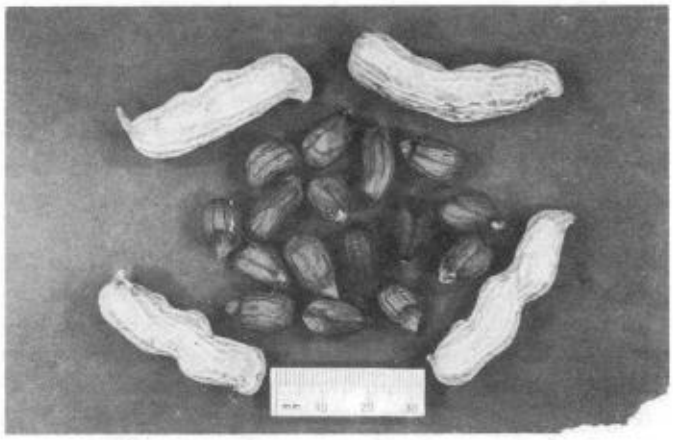


Fig. 2. Pods and seeds of the *hirsuta* peanut

One accession, collected 8 km east of Virú, required about six months to mature, had a semi-prostrate habit and possessed reddish-orange flowers. It was reported to be more drought tolerant than recently introduced cultivars, and is able to remain dormant during dry periods. No samples of wild-type peanuts were found but their existence is a possibility. Because of intensive cropping in the irrigated valleys, few spots remain as refugia for escapes. More thorough searches, especially deep into the mountain valleys toward the west, are warranted. The *Rhizobium* collections are being isolated and studied at North Carolina State University. The peanut collections have been accessed into the US plant germplasm system. They are being characterized at Stillwater, Oklahoma and Stephenville, Texas.

The status of *Arachis hypogaea* L. var. *hirsuta*

The distribution of this variety, the most primitive of all of the cultivars of peanuts known, is extremely limited now. In fact, only five samples of the variety were taken on this trip although we searched extensively for it. Some years ago, the variety was widespread in the river valleys along the coastal area of Peru. However, now it is grown only rarely. Its late maturity coupled with long, weak pegs and dense vegetation cause newer varieties to appear more advantageous. However, the hirsute nature of the stems and leaves suggest drought tolerance. The long peg trait may have potential for escaping invasion by some fungi inhabiting the upper soil strata.

[1] United States Department of Agriculture, ARS, Plant Science Research Laboratory, 1301 N. Western, OK 74075 USA

Collecting alfalfa germplasm in Argentina

S. Ulanovsky[1], M. Elechosa[1], H. Fukuoka[2] and S. Inami[3]

Introduction

The cultivation of alfalfa in Argentina developed from plants of different sources. In the Cuyo region of the country (San Juan and Mendoza provinces), the cultivation of alfalfa originated from germplasm introduced from Chile in the 17th century. Otherwise, the alfalfa fields of the northwest region developed from Peruvian germplasm. In the La Pampa region the alfalfa fields developed from plants from Europe, and the first introductions took place halfway through the 18th century (Itria, 1986). 90% of cultivated alfalfa is located in La Pampa region, on unwatered land, and prevailing utilization is direct grazing. In the northwest region, alfafa is cultivated under irrigation for the production of hay. Most is of the species *Medicago sativa* L. In the material introduced from Peru we find the variety *polia* of that species, and in material from Europe there is a certain amount of the species *Medicago varia* Martyn, a natural hybrid between *M. sativa* L. and *M. falcata* L. (Itria and Tiranti, 1978).

[1] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and Instituto Nacional de Tecnología Agropecuaria (INTA), Unidad de Recursos Genéticos, Centro de Investigaciones de Recursos Naturales, INTA, 1712 Castelar, Argentina
[2] Department of Genetics and Plant Breeding, Faculty of Agriculture, Kyushu Tokai University, Kumamoto, Japan
[3] Aichi-Ken Agricultural Research Center, Aichi-Ken, Japan

Expedition

The collecting trip was performed by a joint Argentine-Japanese mission, between January 18 and February 11, 1989. The institutions that took part were the Instituto Nacional de Tecnología Agropecuaria (INTA), Argentina, through the Programme of Genetic Resources and the Alfalfa Programme, and the National Institute of Agrobiological Resources (NIAR), Japan. 130 seed samples were obtained, most of which represent regional populations that were collected in barns and from fields.

The collecting trip made possible the preservation of valuable material, especially in the northwest provinces, where recently introduced improved varieties are fast replacing local populations that, even though they are less productive, show more persistence and adaptability to the prevailing climatic conditions.

References

Itria, C.D. 1986. El cultivo de la alfalfa en la República Argentina. Colección Científica del INTA, Tomo xiv. Buenos Aires, Argentina, pp. 7-23.

Itria, C.D. y Tiranti, I. 1978. Recursos genéticos de la alfalfa. Cienc. Invest. (B. Aires) 34(3/4/5/6):90-94.

An experimental technique for long-distance transport of evergreen or deciduous cuttings under tropical conditions

James Aronson[1], Gerald Wickens[2] and Elliot Birnbaum[3]

Introduction

Obtaining and transporting germplasm can be a difficult task, particularly in the case of tropical, woody plants which may have tremendous importance to local people but which have never been introduced into cultivation. The germplasm collector can travel great distances, at great expense, only to find that no seeds are available upon arrival. In other cases, a local race or individual plant of interest may already be locally grown, or available in a regional research station. The need may still exist, however, to enlarge the genetic base for purposes of selection and improvement. Even if seeds are available, the need for vegetative propagation material can arise. If seeds are unavailable or unsuitable for any reason, the simplest alternative method of obtaining germplasm from woody plants is to take cuttings. The problem then arises: how to keep the cuttings alive and healthy during transit, especially under tropical conditions?

Traditional methods such as packing wet paper or cloth or vermiculite around the base of cuttings are insufficient to maintain moisture without constant attention, and these methods provide no protection against contamination — a constant threat in the tropics. If cuttings are placed in polyethylene bags to ensure against desiccation, they often rot within a matter of days or even hours. The overland trip back to the cooperating local horticulturist from primary collecting sites in tropical countries may be a matter of several days or even weeks.

Here we describe a low-cost method developed for transporting cuttings long distances and under difficult conditions. It is somewhat complicated, but in our experience justifies the extra effort. Virtually all of the necessary preparations can be made prior to the collecting trip. Our field and nursery data are only preliminary, yet we describe the method in the hope that other collectors will also try it and perhaps improve upon it.

Materials and Methods

The principal material required is one of a variety of superabsorbent (or 'biogel') products available from various commercial firms. We experimented with a variety of products through the courtesy of their manufacturers. For our purposes, we found that those products characterized by quick absorption activity were preferable. However, these products tended to yield a gel with a slurrylike texture — reducing aeration in the area of the cutting bases. Thus perlite granules or styrofoam flakes were added to the slurry to increase aeration.

Ingredients

- superabsorbent powder — 4-6% solution in water
- perlite granules or styrofoam flakes
- rooting powder (0.4-1.5%)
- 1% algacide and fungicide mixed in talc powder
- 1% acaricide mixed in talc
- 0.5% charcoal powder

Additional materials

- paper sacks — about 15 × 7 cm
- polyethylene sacks — about 15 × 5 cm
- rubber bands
- a coolbox
- wound paint or sealing wax (optional)
- bleach (e.g. 3% active chlorine) (optional)

Procedure

Prepare solution of superabsorbent and other ingredients ahead of time. The following quantities are sufficient for preparation of 25 'gel-packs' of 5-15 hardwood cuttings each:

- 20 g superabsorbent powder
- 100 g perlite granules or styrofoam flakes
- 5 g each of 1% fungicide/algacide and acaricide
- 5 g 0.5% charcoal powder
- 5 g rooting hormone

Prior to departure on the field trip, mix ingredients in a bowl or bucket with approximately 400 cc water (0.4 litres) and stir until all water is absorbed. If possible, prepare an equivalent quantity of bleach solution in a separate container.

When a slurry is formed of relatively firm consistency, spoon out approximately 25 cc (0.025 litres) into polyethylene sacks of appropriate size, i.e. about two-thirds as tall as cuttings. Temporarily seal sacks and store tightly in the coolbox until needed.

When cuttings are taken, most or all leaves should be removed. If time permits, a 10-minute soaking in the bleach solution is advised in order to reduce the risk of contamination. Then rinse cuttings with fresh water. If possible, distal ends of cuttings should be coated with a commercial wound paint or other sealant to reduce water loss. Basal ends can be dipped in a rooting hormone powder or solution if desired.

Groups of five to ten or more cuttings are then placed in a polyethylene sack containing aerated

[1] Missouri Botanical Garden, PO Box 299, St Louis, Missouri, 63166-0299 USA
[2] Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB, UK
[3] Negev Jojoba Co., Tel Aviv, Israel

biogel solution (Fig. 1). A rubber band is placed tightly around the upper end of the sack so as to seal the bottom half or two-thirds of the group of cuttings in the sack. The aerated biogel solution should fill approximately half the sack and thoroughly cover the basal portions of all cuttings. The top portion of the cuttings is then covered with an inverted and thoroughly moistened paper sack, held shut at the bottom with an additional rubber band. The result is a finished gel-pack. When all gel-packs are stacked in the coolbox, a moist cloth or towel is spread over them, and the coolbox shut tightly and stored in the coolest part of the vehicle. If possible, blocks of ice or refrigerated cooling bags should be included.

Each morning and evening, the paper sacks covering the gel-packs should be remoistened, preferably with a mist sprayer. Wherever possible, fresh ice should be purchased or the refrigeration units refrozen. If a refrigerator or other cold storage facility is available at long halts, the gel-packs should be stored inside it.

Every day or two, each gel-pack should be checked for contamination by opening each one and smelling the contents. In the event that contamination has occurred, the gel-pack should be opened and affected cuttings pruned or discarded. The remaining cuttings should then be thoroughly washed and repacked into a newly prepared gel-pack.

In the event of a collecting trip lasting a week or more, cuttings should be cleansed and repacked in fresh gel-packs at least twice a week. Upon arrival at the nursery or greenhouse where rooting is to be completed, all surviving cuttings should be carefully washed to remove slurry material. If rooting has clearly not commenced en route, bottoms of cuttings can be pruned slightly, and then redipped in rooting hormone and disinfectants. If necessary, the tops can be recoated with wound paint. The cuttings are then ready to be placed under mist.

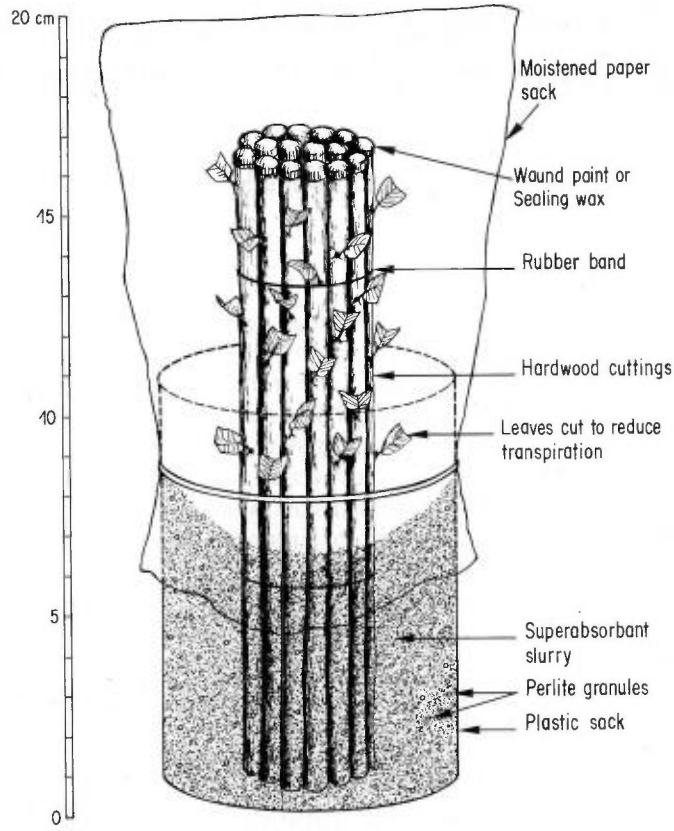


Fig. 1. Plan of a gel-pack

Acknowledgements

The funding of the International Board for Plant Genetic Resources for the collecting trip where this method was first tested is gratefully acknowledged. René Ferris drew the figure. The authors also wish to thank the manufacturers of Agrosoke and Superslurper for samples of their biogel materials. EB is now affiliated with the Jacob Blaustein Institute for Desert Research, Ben-Gurion University of the Negev, Sde Boker Campus, Sde Boker, Israel.

The Editor of the *Plant Genetic Resources Newsletter* will be pleased to consider reports, notes and news from anyone working with plant genetic resources. The Editor reserves the right to edit to meet space limitations.

Please send manuscripts typed double spaced. Where possible, manuscripts should be supplied on IBM- or Macintosh-readable diskettes. Relevant photographs would also be greatly appreciated but only high quality black and white prints rather than colour prints or slides. Colour photographs will be reproduced in black and white, but this is not without a considerable loss of quality.

The Newsletter will also review salient books, scientific papers and other publications.

All contributions should be sent to the Editor, IBPGR, c/o FAO, Via delle Sette Chiese 142, 00145 Rome, Italy.

L'Editeur du *Bulletin des ressources génétiques végétales* serait heureux d'examiner les rapports, notes et nouvelles émanant de quiconque s'occupe de ressources génétiques. L'Editeur se réserve le droit de réduire le texte en cas de manque de place.

Si possible les manuscrits seront fournis sur disquettes compatibles IBM ou Macintosh. Prière d'envoyer les manuscrits dactylographiés en double interligne, accompagnés, le cas échéant, de photographies, de préférence sous forme de bonnes épreuves en noir et blanc plutôt que de tirages en couleurs ou de diapositives. Les photographies en couleurs seront reproduites en noir et blanc, mais avec une nette perte de qualité.

Le Bulletin passera en revue les ouvrages, communications scientifiques et autres publications.

Toutes les communications doivent être adressées à la Rédaction du Bulletin, IBPGR, c/o FAO, Via delle Sette Chiese 142, 00145 Rome, Italie.

El Editor del *Noticiario de Recursos Genéticos Vegetales* considerará con gusto informes, notas y noticias provenientes de aquellas personas que trabajan en recursos genéticos. El editor se reserva el derecho de adaptar los informes según las disponibilidades de espacio.

Cuando sea posible, los manuscritos deberán ser enviados en 'diskettes' compatibles con los sistemas IBM o Macintosh. Les rogamos envíen los trabajos mecanografiados a doble espacio. También apreciaremos el envío de fotografías relacionadas con la materia, que deberán ser de buena calidad, preferiblemente en blanco y negro. Las fotografías en color sólo serán reproducidas en blanco y negro, pero con una apreciable pérdida de calidad.

El Noticiario también hará revisiones de libros, trabajos científicos y otras publicaciones.

Todas las contribuciones deben ser enviadas al Editor, IBPGR , c/o FAO, Via delle Sette Chiese 142, 00145, Roma, Italia.

M/UO225/TRI/1/3.91/5250