

Evaluation of information on genetic resources activities of some legumes in Ghana

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ABSTRACT

Genetic resources information on acquisition, characterization, evaluation, documentation, and distribution of 13 legumes under conservation at the Plant Genetic Resources Centre, Bunso, were reviewed as a genetic resources support component for effective management of the germplasm for crop improvement. Comparatively, in all the 13 legumes examined, detailed acquisition information on the accessions in geographical location, edaphic and climatic factors, ethno-botany, and agronomy have been documented. Out of the 13 legumes, cowpea, groundnut, African yam bean, and French beans had characterization and preliminary evaluation information (qualitative and quantitative) on their vegetative, reproductive, yield and its components. Diversity in the accessions were assessed statistically. Accessions with the maximum and minimum parameters have been indicated. The legume accessions are being conserved at 5-7 per cent moisture content and -18 °C in deep freezers, and are being maintained as active as well as base collections for distribution, storage, and regeneration. Materials mostly distributed to users are cowpea, groundnut, bambara groundnut and lima bean with passport data. The implications of the information on effective use for crop improvement are discussed.

RÉSUMÉ

ABOAGYE, L. M.: *Evaluation d'information sur les activités des ressources génétiques de quelques légumineuses au Ghana.* Information des ressources génétiques relatif à l'acquisition, la caractérisation, l'évaluation, la distribution et la documentation de treize légumineuses sous la conservation au Centre des Ressources Génétiques de Plante était révisée comme un élément de soutien des ressources génétiques, pour la gestion efficace du germoplasme pour l'amélioration de culture. Comparativement, dans toutes les treize légumineuses étudiées, l'information détaillée d'acquisition des accessions relativement à la situation géographique, édaphique, climatique, ethno-botanique et agronomie ont été documentés. Sur les treize légumineuses, dolique, arachide, dolique tubéreux d'Afrique, et haricot vert avaient d'information de caractérisation et d'évaluation préliminaire (qualitative et quantitative) sur végétatif, reproducteur, rendement et ses constituants. Diversité en les accessions étaient évaluées utilisant les statistiques simples notamment la moyenne, variation, écart type, coefficient de variation et index de diversité de Shannon. Les accessions ayant les valeurs maximum et minimum ont été indiquées. Les accessions des légumineuses sont conservées à 5-7 % de contenu d'humidité et -18 °C dans les congélateurs et étant maintenu comme collections actives ainsi que collections de base pour distribution, stockage et régénération. Matières le plus souvent distribuées aux utilisateurs sont dolique, arachide, voandzou et haricot de lima avec les données de passeport. Les implications de l'information sur l'utilisation efficace pour l'amélioration de culture sont discutées.

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Introduction

In developing countries which have the bulk of the world's plant genetic resources (PGR) (Arunachalam, 2000), information management in recently established PGR institutes needs a constant review of documented information to

map out strategies for sustainable PGR management. Proper documentation of PGR activities is indispensable for the ultimate and efficient use of PGR. Periodic evaluation of information on acquisition, characterization, evaluation, documentation, and distribution is of

utmost importance, since the use of materials and traits varies with time. Furthermore, evaluation of the PGR activities would help in the planning of future acquisitions, maintaining a reasonable number of accessions through identifying duplicates, the development of core collections (Brown, 1989), and in the location of sites where duplicate materials are kept.

Formats for acquisition, characterization, evaluation, and further evaluation have been described as the minimum information that the accession must have to adequately describe or manage the accessions and standard conservation practices (Genebank Standards, 1994). Invariably, not all the recommended practices are being followed in PGR management, especially in developing countries, due to lack of logistics and qualified personnel.

Few genetic resources information generated have been evaluated. These include the use of rice germplasm at the International Rice Research Institute (Loresto, Guevarra & Jackson, 2000), the PGR activities in 10 crops in China (Gao *et al.*, 2000), and the ideas for developing legume genetic resources by Vavilov (Kurlovich *et al.*, 2000).

In Ghana, legumes play an important role in agriculture and several accessions are under conservation. The objective of this paper is to evaluate the documented PGR information on 13 legumes in an attempt to identify and improve upon some practices that may be hindering the effective use of the legume PGR, so as to enhance the use of the legume genetic resources for crop improvement.

Materials and methods

Passport information

A collecting form was used to record the information on the germplasm during collecting expeditions. This included the initials of the collector(s), the collecting number, crop species, date, country, region, district, name of the village or town, precise location in the town or village, altitude, latitude, longitude, type of soil, and topography. Additional information included

precipitation source of sample (field, garden, farm store, market, or an institution), local name, type or race, ethnic group, donor's name, donor's source (own, local, market), cultural practices (rainfed, irrigated, flooded, transplanted), planting and harvesting period, crop association (sole or mixed), and population variability (uniform, low, medium or high). Associated pests and diseases were evaluated.

Characterization and evaluation information

Information available showed that data had been collected on the morphological, reproductive, and vegetative traits in the legumes. The descriptors of the International Plant Genetic Resources Institute (IPGRI) were used, where available, or an improvised one was prepared and used. These included time of planting, date to 50 per cent germination, plant height at specific date, leaf shape, terminal leaflet length and width, leaf pigmentation, number of branches, number of nodes, stem diameter, time to 50 per cent flowering, time to 50 per cent maturity, pod length, pod width, pod thickness, number of locules per pod, number of pods per plant, seed length, seed width, seed thickness, seed pigmentation, and yield per plant. Simple statistical procedures (mean, range, standard deviation and correlation coefficient) were used to describe the materials. Diversity indices used to describe variability were coefficient of variation and the Shannon diversity indices (SDI).

Conservation and distribution information

The seeds of the legumes were bagged, sealed and stored. The package had the name of the species, the collecting number, accession number, date stored, and percent germination. The materials were stored at 3-7 per cent moisture content and -18°C in deep freezers (Genebank Standards, 1994). Materials distributed on request were small samples with passport information and the date requested, date dispatched, name of requestor, institution, number of accessions of the species, and plant quarantine certificate.

Results

Evaluation of passport information

In all the 13 legumes under conservation, comparative detailed information had been documented on geographical location, edaphic and climatic factors, and the agronomy of the accessions.

Evaluation of conservation and use of the legume germplasm

Table 1 shows some genetic resources information on the legume germplasm. Of the 13 legumes, seven are of African origin, three from Asia, and three from the Americas. This shows that some indigenous legumes are being conserved against possible threats of extinction.

All the legume accessions are being conserved as active and basic collections. Generally, the number of seeds per accession stored on most of the accessions was below the recommended number (4 000 in homogenous materials and 12 000 in heterogenous materials), due to limited cold storage space and the greater frequency of distribution compared to regeneration and multiplication. The number under conservation varied from 531 accessions in cowpea to less than 10 accessions in pigeon peas and sword beans. The materials that had been distributed most were cowpea (201 accessions), followed by groundnut (44 accessions). The materials were distributed to users in institutions inside and outside Ghana, accompanied by passport data.

Evaluation of characterization and preliminary evaluation information

Table 2 indicates the characterization and evaluation data of four of the legumes. In groundnut, one qualitative, five vegetative, and two reproductive traits, together with three yield factors and their components, had been characterized and evaluated (Aboagye & Bennett-Lartey, 2001a). In cowpea, one qualitative, six vegetative (Aboagye & Bennett-Lartey, 2001b), and three reproductive traits as well as 11 yield factors and their components had been evaluated.

In African yam bean, four qualitative, four vegetative, and five reproductive traits as well as nine yield factors and their components had been evaluated (Aboagye *et al.*, 2001). In French beans, three qualitative, five vegetative, and two reproductive traits, together with 10 yield factors and their components, had been evaluated (Aboagye, 2002).

Evaluation of statistical analyses used in the evaluation and characterization

Table 3 shows the statistical procedures used in evaluating and characterizing the four legumes. The experiments were replicated in cowpea, African yam bean, and French beans. The range, mean, standard deviation, and coefficient of variation (CV) were used in evaluating diversity in the four legume species. Correlation analyses were applied to varying number of traits in three species: groundnut, 7 traits; cowpea, 5 traits (Aboagye & Bennett-Lartey, 2001a,b); and African yam bean, 12 traits (Aboagye *et al.*, 2001).

The Shannon diversity indices (SDI) were used to elucidate diversity in four traits each in cowpea, African yam bean, and French beans. In groundnuts, ecological diversity in four ecological zones, where they were collected, had been analyzed. Divergent accessions in each trait of the species had been selected.

Discussion

Documentation of information on genetic resources is a vital component for effective use of the materials under conservation in gene banks. Such information must be readily available to enable users select materials of interest. Information gathered during collecting expeditions and documented as passport data, is the most basic exploitation, management, and utilization data at the gene bank. The available passport information is in detail, in the area of agronomy, geographic and edaphic factors, as compared to other plant genetic resources' activities such as uses and ethno-botany. However, these detailed factors have not been

TABLE I

Genetic Resources Information on 13 Legumes under Conservation

<i>Common name</i>	<i>Botanical name</i>	<i>Origin</i>	<i>No. conserved</i>	<i>No. ** distributed</i>	<i>Type of collection</i>	<i>Available data</i>	<i>Type of documentation</i>
African yam bean	<i>Sphenostylis sternocarpa</i> (Duke, 1981; Porter, 1992)	West Africa	30	None	Active/ Basic	Passport data Characterization Evaluation Distribution (Aboagye <i>et al.</i> , 2001; Amoatey <i>et al.</i> , 2000)	Manual and computerized
Bambara groundnut	<i>Voandzeia subterranea</i> (Smart, 1990)	West Africa	77	8	Active/ Basic	Passport data Distribution (Bennett-Lartey <i>et al.</i> , 1997; Ayensu, 1989; Anchirina & Bennett-Lartey, 1998)	Manual and computerized
Cowpea	<i>Vigna unguiculata</i> (Ng & Marechal, 1985)	Tropical Africa	531	201	Active/ Basic	Passport data Characterization Evaluation Distribution (Aboagye & Bennett-Lartey, 2001b; Bennett-Lartey <i>et al.</i> , 1997)	Manual and computerized
French bean	<i>Phaseolus vulgaris</i> (Gepts <i>et al.</i> , 1986)	New World	30		Active/ Basic	Passport data Characterization Evaluation Distribution (Aboagye, 2002)	Manual and computerized
Groundnut	<i>Arachis hypogaea</i> (Rachie & Roberts, 1974)	South America	99	44	Active/ Basic	Passport data Characterization Evaluation (Aboagye & Bennett-Lartey, 2001a)	Manual and computerized
Jack bean	<i>Canavalia ensiformis</i> (Purseglove, 1977)	Central America and West Indies	12	7	Active/ Basic	Passport data (Adansi, 1974; Adansi & Holloway, 1978; Bennett-Lartey <i>et al.</i> , 1997)	Manual and computerized
Kerstings groundnut	<i>Kerstingiella geocarpa</i> (Purseglove, 1977)	Africa	16	4	Active/ Basic	Passport data	Manual and computerized

TABLE 1 (continued)

<i>Common name</i>	<i>Botanical name</i>	<i>Origin</i>	<i>No. conserved</i>	<i>No. ** distributed</i>	<i>Type of collection</i>	<i>Available data</i>	<i>Type of documentation</i>
Lima bean (Salgado <i>et al.</i> , 1995)	<i>Phaseolus lunatus</i>	Guatemala	44	25	Active/ Basic	Passport data Distribution	Manual and computerized
Pigeon pea (Rachie & Roberts, 1974)	<i>Cajanus cajan</i>	Africa	9	36	Active/ Basic	Passport data Distribution (Adansi, 1974; Adansi & Holloway, 1978) Bennett-Lartey <i>et al.</i> , 1997; Holloway, 1983)	Manual and computerized
Sword bean	<i>Canavalia gladiata</i> (Purseglove, 1977)	Asia Africa	8	12	Active/ Basic	Passport data (Adansi, 1974; Adansi & Holloway, 1978; Holloway, 1983; Bennett-Lartey, 1991)	Manual and computerized
Winged bean	<i>Psophocarpus tetragonolobus</i> (Smart, 1990)	Asia	12	None	Active/ Basic	Passport data Distribution (Adansi, 1974; Adansi & Holloway, 1978; Holloway, 1983)	Manual and computerized
Soybean	<i>Glycine max</i> (Hymowitz & Newell, 1980; Hymowitz & Singh, 1987)	Asia	2	None	Active/ Basic	Passport data Distribution	Manual and computerized
Velvet bean	<i>Mucuna pruriens</i> var <i>utilis</i> (Rachie & Roberts, 1974)	Africa	17	13		Passport data Characterization Evaluation Distribution (Bennett-Lartey, 1991; Bennett-Lartey <i>et al.</i> , 1997; Bennett-Lartey, 1998)	

** Number distributed may be more than number conserved due to the number of times sent to users

given any attention in their use in characterizing and evaluating the legume accessions in on-station trials.

It may, therefore, be necessary to give attention to these factors for the proper interpretation of the results, since they have considerable effect on the results, especially the quantitative traits. With the exception of bambara groundnuts, ethno-

botanical information and use (as food source) have not been reported on legumes (Anchirina & Bennett-Lartey, 1998). These two factors play important and convincing roles for the ultimate acceptance and adoption of the materials, since desirable traits arising from ethno-botanical information from donors could be incorporated into a cultivar in the process of its development.

TABLE 2

Traits Characterized and Evaluated in Groundnut, Cowpea, African Yam Bean, and French Bean Germplasm

<i>Trait</i>	<i>Groundnut^{a)}</i>	<i>Cowpea^{b)}</i>	<i>African yam bean^{c)}</i>	<i>French bean^{d)}</i>
<i>Qualitative</i>				
Growth habit	*	*	*	*
Twining tendency			*	
Hypocotyl length			*	
Plant pigmentation			*	*
Terminal leaflet shape				*
Degree of lodging				*
<i>Vegetative</i>				
No. of branches	*	*	*	*
No. of nodes		*	*	
No. of leaves		*		
Plant height (cm)	*			*
Plant width (cm)	*			
Stem diameter (cm)				*
Leaf length (cm)	*	*	*	*
Leaf width (cm)	*	*	*	*
Hypocotyl length (mm)		*		
<i>Reproductive and yield</i>				
Days to 50 % flowering	*	*	*	*
Days to 50 % first harvest			*	
Days to last harvest			*	
Days to 50 % maturity	*	*	*	*
Flower colour				
Raceme position		*		
No. of pods per peduncle		*	*	
Pod length (cm)		*	*	*
Pod width (cm)		*	*	*
No. of pods/plant				
Pod weight/plant (g)	*	*	*	*
No. of locules per pod		*	*	*
Pod thickness (mm)				*
Pod pigmentation				*
Seed length (mm)		*	*	*
Seed width (mm)		*	*	*
Seed thickness (mm)		*		*
Seed shape		*		
Seed colour				*
100-seed weight (g)		*	*	
Yield / plant (g)	*	*	*	

* indicates traits characterized and evaluated

^{a)} Aboagye & Bennett-Lartey, 2001a; ^{b)} Aboagye & Bennett-Lartey, 2001b; ^{c)} Aboagye *et al.*, 2001; ^{d)} Aboagye, 2002

TABLE 3

Statistical Procedures, Ecological Diversity, and Divergent Types in Four Legume Germplasm under Conservation

<i>Procedure</i>	<i>Groundnut</i> ^{a)}	<i>Cowpea</i> ^{b)}	<i>African yam bean</i> ^{c)}	<i>French bean</i> ^{d)}
Replication	No replication	Replication (3)	Replication (3)	Replication (4)
Range	*	*	*	*
Mean	*	*	*	*
Standard deviation	*	*	*	*
Coefficient of variation	*	*	*	*
Correlation	*(7)	*(5)	*(12)	
Shannon diversity index		*(4)	*(4)	*
Ecological diversity	*(4)			
Divergent type selection	*	*	*	*

* indicates usage; figures in brackets are the numbers used

^{a)}Aboagye & Bennett-Lartey, 2001a; ^{b)}Aboagye & Bennett-Lartey, 2001b; ^{c)}Aboagye *et al.*, 2001; ^{d)}Aboagye, 2001

Examination of the passport information shows that the names of the accessions are related to original source, morphology, maturity, or adaptation to a particular environment. The names of materials relating to the source provide the clue to explore and obtain more information on diversity of the landraces. The information on agro-morphology collected during exploration must be re-examined when the materials are being evaluated on-station to confirm and corroborate the donors' assertion.

The legume materials under conservation were collected from three principal collecting sources: home garden/field, farm store or market. The degree of purity of the materials varies with the source of collection. Materials collected from the field or home garden are more homogenous than those collected from the market. Variability per species and purity within an accession would be greater when the materials are selected from single variable plants of the species in the field as compared to farm store and markets where mixtures seem probable, and desirable traits cannot be discerned from the seeds. This calls for integrated approach in genetic resources management between curators, scientists, and farmers in collecting germplasm which would

enhance the purity of the materials.

Cumulatively, 36 traits were characterized and evaluated across the four legumes (Table 2). These comprised 11 qualitative and 25 quantitative traits. Although qualitative traits are comparatively easy to measure and interpret, since they are not subject to environmental influence, information on few variates have been reported (Aboagye & Bennett-Lartey, 2001 a & b). The low number that had been characterized would prevent effective use, since users may have to characterize more qualitative traits before using them in their crop development programmes. Thus, as much qualitative information as possible must be included.

Although quantitative traits are subject to environmental influence, with the exception of the African yam bean, none of the experiments were replicated over space and time. Replication of experiment may reduce experimental error when dealing with many accessions, and at times the number of seeds per sample would also hinder replication. Such errors in unreplicated trials could be reduced by adopting the augmented block design, which is the systematic inclusion of standard materials or checks in each block of the experiment to estimate the experimental error. Thus,

some values quantitatively reported may not be the real values, and efforts must be made for replication through space and time or under optimum and controlled conditions.

Nine statistical variables have been used to elucidate the extent of diversity, both quantitatively and qualitatively. Extra caution should be exercised in interpreting the results, especially the quantitative traits. The diversity resulting from the analysis of the qualitative traits is more reliable and could be used to develop core collections. The selection of divergent types in each trait and the correlation between traits may, to some extent, enhance the use of the materials, since some of the materials can be selected and used without re-characterization or re-evaluation, and this would hasten the developmental efforts of the legume germplasm. Of the 13 legumes, only four have been characterized and evaluated.

In Ghana, for production and use, some legumes are termed minor and others major (Klu *et al.*, 2000). The major legumes include cowpea, groundnut and Lima bean; the others are minor (Table 1). This reflects in the number of legumes that had been collected and distributed (Aboagye & Bennett-Lartey, 2000). Factors that may account for the low patronage in the use of the minor legumes include the low number that has been collected, the localized cultivation, and the use of some of the legumes, e.g. African yam bean (Volta Region), bambara groundnut, and kersting's groundnut (savanna areas). Therefore, efforts must be made to collect these minor legumes for conservation, characterization and use, as well as to introduce them to other potential areas for production.

Modern methods have been used to elucidate and enhance the use of crop germplasm. These include randomized amplified polymorphic DNA, isozyme analysis, amplified fragment length polymorphism, and development of core collections of manageable size (Brown, 1989). None of these methods had been used in assessing the genetic diversity of the legume germplasm. Thus, stringent efforts are required for the

logistics to undertake such studies which are more reliable than the agro-morphological characterization, since the basic component, DNA, is relatively stable. Complementation of the two methods would enhance the use of the legume genetic resources under conservation.

Effective and efficient conservation methods have been developed to preserve the legume seeds under review and generally being adopted. However, under resource-poor farmer management of PGR, some indigenous techniques are in use (Anchirina & Bennett-Lartey, 1998). These include putting the seeds in receptacles like bottles, pots, and gourds after being treated with wood ash and extracts from trees (e.g. neem tree) that have insecticidal properties. Knowledge of these indigenous methods must be collected during exploration as part of the passport data, improved upon, adopted, and used alongside the well-known conventional conservation methods. This will offer some alternatives to the over-relied on cold storage system with its attendant problems, especially in developing countries. The development and application of indigenous conservation techniques would also have a significant role in on-farm conservation of plant genetic resources.

Conclusion

The evaluation of information on the legumes has shown that there is the need to add more 'value' to the information on the genetic resources in the area of ethno-botany and use. Although 36 traits have been characterized and evaluated, few legumes have adequate information that can be used immediately, most of them having only passport data. Even if the accessions at hand are few, they must be characterized and evaluated to add some information to the material.

The well-known and widely used legumes are displacing the minor legumes and their extinction is eminent. Therefore, greater efforts are needed to salvage these under-utilized legumes through collection and to exploit their potential for use. Finally, the legumes must be characterized and

evaluated at the molecular level to supplement agro-morphological characterization to enhance their use.

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