EVALUATION, REGENERATION AND ENHANCED DATABASE MANAGEMENT OF UNIQUE RESOURCES FROM MESOAMERICA

Progress Report
(April 1998 - December 1998)

Presented to

United States Department of Agriculture
(USDA)

By

The Plant Genetic Resources Unit
Tropical Agriculture Research and Higher Education Center
(CATIE)

Turrialba, Costa Rica
March, 1999

Reporting Institution:
The Plant Genetic Resources Unit
Tropical Agriculture Research and Higher Education Center (CATIE)
CATIE 7170, Turrialba, Costa Rica

Principal Investigators:
Dr. Elkin Bustamante, Carlos Astorga

Project Title:
Evaluation, Regeneration and Enhanced Database Management of Unique Resources from Meso-America

Grant No.: FG-CR-104
Project No.: CS-ARS-3

Starting date: January 1997

Scheduled duration: Three years

Period covered:
April 1998 - December 1998

Cooperating Scientists:
Dr. Marikis N. Alvarez, CATIE Regional Representative, Belize
Dr. R. J. Schnell, Tropical and Subtropical Fruit Crops Research Geneticist, USDA, ARS
Dr. Edwin L. Civerolo, Research Leader Crops Pathology and Geneticist, USDA, ARS
Dr. Michiel Hoogendijk, Associated Scientific, IPGRI, American Regional Office

SUMMARY

The activities of the Genetics Resources Unit involve conservation, characterization and documentation of germplasm to obtain a better understanding of the current or potential value of the conserved collections.

The project activities are oriented to reestablish the facilities necessary to manage germplasm and to continue the germplasm characterization process for pepper and squash at CATIE, as well as documenting the information generated in a convenient, internationally compatible system.

During the second year of the project, 10 *Capsicum* and 109 *Cucurbita* accessions were characterized. The project collaborated in the characterization of 31 *Pachyrhizus tuberosus* accessions and developing propagation techniques for *Pouteria sapota* as part of two thesis projects. Inventories of the germplasm stored in the long and the short term were performed, recording the available seed weight per accession.

The transfer of the database continues, and the passport information is available in the pc-GRIN system. The conserved germplasm inventory is being up-dated and the germplasm characterization data from previous years are being standardized in order to transfer them to this system.

The results of the characterization of the *Capsicum* and *Cucurbita* germplasm will be analyzed and subsequently published in the coming months and will be incorporated in the documentation system.

Evaluation, Regeneration and Enhanced Database Management of Unique Resources from Meso-America

1. Introduction

The project during 1998 focussed on four key activities: a) finalizing the characterization of the *Capsicum spp.* species collection (10 accessions); b) giving continuity to the evaluation of the *Cucurbita spp.* collection (105 accessions); c) continuing with the transfer of the Genetic Resources Data Base to the pc-GRIN system; and d) finishing the infrastructure needed to develop the germplasm management activities.

In addition to the activities planned for the report period, the inventory was carried out on the germplasm stored in the short (5°C and 35% RH) and long term (-17°C and 0% RH). The inventory consisted of recording the available seed weight to give priority to the accessions with a low quantity of seeds and proceed with the regeneration of the respective germplasm.

Two thesis projects were carried out with masters' students, which consisted of characterizing the *Pachyrhizus tuberosus* collection and developing propagation techniques for *Pouteria sapota*. These activities improved the valuation of the genetic resources to make them available to the users.

The object of this report is to present the activities carried out and the progress made during this period, and to outline the actions to be undertaken during the third year of the project.

2. Experimental Procedure

2.1. Soil characteristics and meteorological data

In Table 1 in Appendix 1 the soil analysis results for the areas used for germplasm characterization and regeneration are presented. According to the critical levels presented by Bertsch (1987), the pH is considered low and was similar in the 5 soils analyzed (pH 5.0), the phosphorus levels were also low; the potassium levels were low in soils C and D and medium in soils A, B, and E. The best soils in so far as nitrogen content, organic material and cationic exchange capability (soils C and D) were selected for the pepper and squash plantings. A small plot of pepper accessions was planted in soil B. Soils A and E were selected to plant the regenerate two species (*Solanum, tephrosia* and *Lycopersicon*). One group of squash accessions was planted between the rows in a young peach palm (*Bactris gasipaes*) plantation, but no soil analysis was performed here.

Figures 1 and 2 in Appendix 1 show an average of the climate characteristics at CATIE since 1942 (precipitation), 1959 (temperature and relative humidity) and 1965 (solar radiation). These figures compared these values with to the prevalent conditions in 1998. The minimum and mean temperatures in 1998 did not differ significantly from the average general temperatures but the maximum temperature showed a great difference, being higher in all 12 months of 1998. The solar radiation was relatively lower during almost all of 1998 in comparison with the general average (1965-1998). One of the most important characteristics for crop development is precipitation, which during 1998 varied from the general average although the annual totals were practically the same (2684mm and 2636mm respectively). In general, the first months of the year are dry therefore, planting was planned to start in May. The first months of 1998 were particularly dry (see Figure 2 Appendix 1); however, during June and July and from October to December, the precipitation was high. Due to the high rate of precipitation in

July, it was necessary to improve the drainage in the squash plantation. The relative humidity in 1998 was higher all year compared to the general average (1959-1998) except during the month of January. This lower relative humidity was directly related to the low precipitation during those first months of the year.

2.2. Characterization of pepper

In an established 1997 field plantation the characterization of 10 pepper accessions was continued throughout 1998.

The planting distance between rows or mounds was 1.5 meters with 1 meter between plants, for a planting density of 6667 plants per hectare. The distance between plots was 2 meters. The number of plants per accession varied from 5 to 8 according to germination and the seed availability in the original sample.

During the field evaluation, some pepper plants within the same accession were observed to have different characteristics. For this reason these plants or groups of plants were evaluated independently and were identified with the original accession number plus a capital letter as a suffix.

The list of descriptors for *Capsicum spp.* published by IPGRI, AVRDC and CATIE (1995) was used as a basis for the characterization. The pungency of the fruit was classified in 5 stages from sweet to very hot as determined by the organoleptic fruit test.

The pepper data were analyzed with the SAS system, using the cluster procedure. The taxonomic similarity, between each pair of accessions, was done through the distance of Gower (1967).

3. Results and discussion

3.1. Characterization of pepper

The characteristics most commonly used in the field to separate or classify the plants within the 25 accessions that showed a "mixture", were form and size of fruit, and to a lesser degree leaf color and size, and corolla color (see Figure 1). Sixteen of these accessions formed 2 groups of different plants, 8 formed 3 groups, and 1 accession formed 4 groups (see Table 1). The total of the plants obtained by subdividing the accessions is called sub-accessions. On hundred and thirty-three materials were obtained or derived from a total of 97 characterized accessions.

Table 2 shows the 14 countries of source of the 133 pepper accessions and sub-accessions evaluated. Sixty-seven percent of the accessions belong to Costa Rica, Guatemala and Mexico and the other 33% to the remaining 11 countries.

The countries that had the most variation within the 25 accessions were Guatemala and Mexico. Twenty-five sub-accessions originated from 9 accessions from Guatemala (53%) and 15 sub-accessions originated from 6 Mexican accessions (37.5%). This shows some degree of variation in the materials coming from these countries. In the case of Costa Rica, 5 accessions (15.6%) were divided into 11 sub-accessions.

The accessions and sub-accessions grouping was done through the method of hierarchic grouping of Ward (1963), using the distance matrix calculated by the Gower method (1967) that combine qualitative and quantitative characters. The Ward methodology has been used by Lopez (1991), Márquez (1992) and Tapia (1998) for the grouping of 106 clones of *Ipomoea batata*, 40 accessions of *Pachyrhizus erosus* and 31 accessions of *P. tuberosus*, respectively. According to Ward (1963) this method get together those two individuals or groups which union produce a minimum or increase in the total sum of the error square between groups.

The results obtained are shown in Tables 3 and 4. The 133 materials analyzed form ten groups.

Table 3 shows the averages per group of the quantitative characteristics selected as discriminates. The average seed diameter is one of the characteristics that showed the least variation among the groups varying from 2.9 mm (group 4) to 4.4 mm (group 3). The length of the sample fruit shows a marked difference among the various groups with an average of anywhere from 1.6 cm (group 4) to 9.7 cm (group3). In the case of the number of seeds per fruit, the biggest difference was found between group 4 (20.5 seeds) and group 2 (171.5 seeds). Taking these averages into consideration, it is possible to identify clear differences among the groups analyzed.

The majority of the subdivisions per accession stayed in the same group. In the following accessions: 16067 (Costa Rica), 16268, 11277 (Guatemala) and 8062 (Mexico), the sub-accessions are distributed in distinct groups that show the variation within these accessions (see Table 4).

A χ^2 test was conducted to verify if the groupings are affected by the country of origin and by species. Both tests proved significant. The distribution of the Costa Rican accessions and sub-accessions was concentrated in groups 3, 5, and 6 (78.9%), the Mexican materials in groups 4, 7, and 8 (84%), the Guatemalan materials in groups 6 and 7 (66.7%), the Peruvian accessions and sub-accessions in groups 1, 9, and 10 (83%) and the 5 accessions from Russia remained in group 3, confirming the relationship between the origin and the procedure with the groupings obtained (see Table 4). This also gives an indication of the variety that exists among countries or places of origin and the need to have sufficient genetic representation of materials coming from different regions.

Pungency is an important characteristic in the selection of the materials for the market because there is an important demand for both spicy hot and sweet materials. Sweet types characterize groups 2 and 3 since the majority is *Capsicum annuum*. *The C. chinense* fruits are known for being very spicy hot, and this was proven in the study, because the majority of the accessions in this species had very high pungency ratings (value 9). Ten out of eleven *C. annuum* individuals in group 4 are also characterized as spicy hot (pungency 7) or very spicy hot (pungency 9).

Groups 5 and 6 are characterized by presenting the majority of the accessions and sub-accessions of the *C. frutescens* species. These results prove the tendency of grouping by species, however, the 12 materials of *C. chinense* were distributed among 5 groups showing variation in this species (see Table 4). Some genotypes were not identified to the species level because they are named for genus only (*Capsicum spp.*). The majorities were found in groups 7 and 8 (57.6%).

The discriminate value of the qualitative characteristics is determined through the χ^2 test. Of the 46 characteristics analyzed, 32 were found to have high significance (1%), 4 with 5% significance and only 10 insignificant. The qualitative characteristics selected as being the most significant include: pubescence of the hypocotyl, position of the flower, color of the corolla, color of the corolla's mark, color of the filament, the form of the fruit, the form of the fruit with the pedicel, and pungency of the fruit. The discriminate value of quantitative characteristics is determined through the Engels "D" index (1983), using the group measurements from multiple Duncan comparisons. The main characteristics chosen as discriminates are: length of mature leaf, days of flowering, length of corolla, length of filament, thickness of the fruit wall, number of seeds per fruit and seed diameter.

3.2. Squash characterization

With regards to the squash crop, 125 accessions were planted in 1998 in three planting dates. During the field growth period, some plants died or did not produce fruit; therefore, the total of the characterized accessions is generally lower than the number of accessions planted initially. Due to germination and field problems 16 (12.8%) died. For this reason, only 109 accessions were evaluated; however, this information has not been incorporated in the database. Table 5 shows the percent of field germination in each accession and identifies the accessions that presented problems. For example, the seeds in accession 9325 germinated in one hundred per cent but none of the plants survived because of vigor problems.

Information on 51 accessions, evaluated in 1997, was incorporated to the database and later it was statistically analyzed.

The characteristics that were most commonly used in the field to classify plants within accessions were fruit form, size and color (Figure 2). One hundred fourteen materials were obtained from the 51 accessions analyzed. Thirty-six accessions had variations: 16 accessions formed 2 groups of different plants, 15 formed 3 groups, 4 formed 4 groups and accession 15050 formed 6 sub-accessions. Differences were not found inside of 15 accessions (29.4%). This result illustrates the variety that exists within the accessions as a product of the allogamous reproduction characteristic of this species.

Table 6 shows the average values of the quantitative characteristics of the fruit and seeds of 114 accessions and sub-accessions evaluated to date. The characteristics of weight and fruit length showed the highest degree of variation with variation coefficients (VC) of 59.4% and 49%, respectively. Looking at the minimum and maximum values it can be seen that there are small fruits averaging at 327g, and large fruits averaging at more than 6 kg. It is important to note that these are the averages based on 10 fruits evaluated per accession, since fruits weighing more than 12 kg were found. The characteristics of seed length, width, and thickness showed lower degrees of variation with coefficients of 8.4%, 9.7% and 12.1%, respectively. This indicates that they are relatively uniform characteristics within the accessions. No complete statistical analysis has been conducted of all the information, owing to the fact that part of the genetic materials are still being evaluated in the field and the information collected is being entered into the data bases.

3.3. Characterization of jicama (*Pachyrhizus tuberosus* (LAM.) SPRENG)

Cesar Tapia did this work, as part of his masters thesis study at CATIE. The summary of his thesis is presented in Appendix 2. The objective was to evaluate the genetic diversity of the collection of *P. tuberosus* through the morphological and molecular characterization of 31 accessions.

The collections were classified in 4 groups: "ashipas" (groups 1 and 4), "chuines" (group 2) and jicamas (group 3) identifying among the groups, and the accessions within groups, ten qualitative characteristics and 7 quantitative characteristics with higher discriminate power. The form and type of the lobe of the leaf foliole, color of the root flesh, growth habits, days to flowering and days to physiological maturity are the most useful characteristics to be used in an initial description. For the molecular characterization, RAPD markers were used and the variation in the collection was determined through a distance matrix, dendograms, and bootstrap and canonic discriminate analysis. Ten primers were identified, showing 32 polimorphisms. Seven

of these "primers" were most useful in distinguishing among the groups, finding duplicates and errors and characterizing individuals.

3.4. Evaluation of zapote (*Pouteria sapota* JACQ.) propagation methods

This study was developed as part of CATIE master thesis research of Susana Lobato. The objective was to design techniques for propagation alternatives to conserve, multiply and utilize *Pouteria sapota* genetic resources.

Grafting was favored by controlled greenhouse conditions. The lateral overlaying technique resulted in the highest yield percentages. Only the 10800-2 genotype showed positive results with the stake planting technique. Using *in vitro* cultivation techniques, the difficulty multiplying fuelwood species was confirmed, nevertheless the material basis for disinfecting and deoxidization remains and may be of interest in future experiments.

The summary of this thesis work is included in Appendix 2.

3.5. Germination Tests

Under controlled temperature and humidity conditions, 184 pepper accessions were evaluated (see Table 7). The lowest germination percentage was 9% in accession 10006, while 36 accessions germinated less than 50% and 133 showed germination levels lower than 85%. Considering the fact that the initial germination is 100% in general, sample regeneration should be considered when germination is less than 85% according to the standards published by FAO/IPGRI (1994). Germination was higher than 85% in 51 accessions (27%).

3.6. Regenerated Species

The species that were regenerated during this period were *Solanum topiro* (1 accession), *Tephrosia* (1 accession) and *Lycopersicon esculentum* (7 accessions).

3.7. Inventory

During this period, the inventory of the available seed weight per accession was up-dated for the majority of species stored in the cold rooms (orthodox seeds). This information is being transferred to the pc-GRIN database.

3.8. Data Base

The documentation work has continued with the introduction of the passport data, characterization information and germplasm inventory. From August 24-28 the documentation assistant participated in a course on pc-GRIN carried out in CIAT, Cali, Colombia. The course was designed to train participants to manage the GRIN software.

From October 26 to November 6 and from December 14 to December 18, Michiel Hoogendijk (IPGRI/CIAT) helped install the pc-GRIN to initiate and establish the plant genetics resource data base. The first task was to up-date the taxonomy data and the introductory germplasm books that contain the passport data for all the accessions at CATIE. Later this information was transferred to pc-GRIN. Part of the information is being entered directly since several problems have been encountered transferring the database completely. Currently, information is being prepared on pepper characterization and the inventory of the cold room collections to be introduced into the GRIN system at a later date.

3.9. Technical support

Dr. Raymond Schnell reviewed the activities carried out by the project during his visit in December 15-17. The analysis included the progress made on the facilities to manage and conserve the germplasm; the results obtained from the germplasm characterization and the collaboration with the IPGRI[1] (Office for the Americas) to transfer the Database to the pc-GRIN system. Dr. Schnell expressed his satisfaction with the work being done. He also commented on the possibility of preparing two articles on the characterization information collected (*Capsicum* and *Cucurbita*) to be published in a journal of genetic resources in 1999. Proposed development activities for the next period were put forth as well as the need to extend the project period until March 2000, due to the initial delay (March 1997). But this extension would not imply an increase in the budget requirements. Dr. Schnell promised to deliver the proposal to USDA, and he suggested it will not be difficult to have it approved.

Dr. Schnell expressed that the project is developing within the framework of its objectives and has achieved significant results in reinitiating the Plant Genetics Resources Unit activities.

4. Conclusions

4.1. The statistical analysis carried out on peppers allowed for the formation of 10 groups with 133 materials studied. The main characteristics that distinguish the groups were determined.
4.2. Field variation was evident in 36 out of 51 squash accessions generating a total of 114 materials evaluated. The characteristics of weight and fruit length showed the highest levels of variation. Less variation within accessions were found in seed length, width and thickness.
4.3. The characterization studies illustrate the variation present in these germplasm collections and present the possibilities for a preliminary selection of the genotypes with adequate characteristics for commercial production or for improvement programs.
4.4. The information in the introduction books that contain the passport data have been successfully transferred to the pc-GRIN system.
4.5. Economic contribution of the project has allowed for a marked improvement in the infrastructure, laboratory equipment and supplies.

5. Future work plans

5.1. Continue the characterization of 120 accessions of *Cucurbita moschata*.
5.2. Germplasm viability tests (short and long term)
5.3. Regenerate 25 tomato (*Lycopersicon spp.*) accessions
5.4. Prepare a scientific article on *Capsicum* characteristics.
5.5. Up-date the pepper and squash data bases in pc-GRIN.
5.6. Data analysis and publication.

6. Literature cited

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7. List of scientists

Antonio Mora, Investigator CATIE
Rodolfo Sánchez, Technical Assistant CATIE
Luis Chaves, Documentation Assistant CATIE
Dr. Marikis N. Alvarez, CATIE Regional Representative, Belize
Dr. R. J. Schnell, Tropical and Subtropical Fruit Crops Research Geneticist, USDA, ARS
Dr. Edwin L. Civerolo, Research Leader Crops Pathology and Geneticist, USDA, ARS
Dr. Michiel Hoogendijk, Associate Scientist, IPGRI, American Regional Office

8. Publications

No publications so far.

9. Graduate students

M.Sc. Susana Lobato
M.Sc. Cesar Tapia

Figure 1. Shapes and sizes of pepper fruit

Figure 2. Shapes and sizes of squash fruit

Table 1. Accessions containing groups of plants with different agronomic traits and divided in sub-accessions

Number of groups	Accessions divided in sub-accessions	Number by group
2	Costa Rica: 10948, 14376, 16067 y 20426 México: 8061, 8062 y 10077 Guatemala: 11277, 11391 y 16518 Perú: 5347 y 7208 Honduras: 10995 Ecuador: 16211 Nicaragua: 20013	15
3	Guatemala: 6134, 8054, 11568, 12358 y 16268 México: 8053, 8063 y 18800 Costa Rica: 13972	9
4	Guatemala: 8057	1
	Total	**25**

Table 2. Source by country of accessions and sub-accessions of *Capsicum* spp. evaluated in 1998

Country	Accessions	Sub-accessions*	Total	Percentage
Costa Rica	27	11 (5)	38	33.0
Guatemala	8	25 (9)	33	17.6
Mexico	10	15 (6)	25	16.5
Peru	8	4 (2)	12	10.3
Russia	5		5	5.1
Ethiopia	4		5	4.1
Honduras	2	2 (1)	4	3.1
United States	2		2	2.1
Nicaragua	1	2 (1)	3	2.1
Ecuador	1	2 (1)	3	2.1
Spain	1		1	1.0
El Salvador	1		1	1.0
Syria	1		1	1.0
Cuba	1	1	1	1.0
Total	**97**	**62 (25)**	**133**	**100**

*Number between parenthesis indicates the original accessions divided in sub-accessions

Table 3: Averages per group of the discriminate quantitative characteristics for the 133 accessions and sub-accessions of *Capsicum* spp. evaluated in 1998

Characteristics	Groups									
	1	2	3	4	5	6	7	8	9	10
No. of accessions and sub-accessions	9	6	17	11	19	24	21	12	7	7
Length of the mature leaf (cm)	5.3	7.2	6.9	3.3	5.6	4.8	4.6	4.6	4.8	7.1
Days to flowering	108.1	115.2	84.8	125.4	143.7	127.0	95.8	91.2	121.6	116.7
Length of corolla (mm)	8.1	9.6	11.0	4.8	6.9	7.9	9.3	9.3	7.6	8.4
Length of filament (mm)	1.7	2.8	3.4	3.2	1.5	4.3	4.7	5.6	2.0	2.9
Length of fruit (cm)	5.5	6.9	9.7	1.6	3.7	4.1	6.5	6.7	4.0	7.1
Thickness of fruit wall (mm)	1.6	3.1	4.0	0.9	1.4	2.0	2.5	2.2	1.6	2.0
No. of seeds per fruit	72.5	171.5	139.6	20.5	30.2	33.1	81.4	79.8	44.2	97.0
Seed diameter (mm)	3.5	3.8	4.4	2.9	3.5	3.5	3.9	4.0	3.6	4.1

Table 4. Grouping of accessions, sub-accessions, species, source by country and place and pungency of the materials from the *Capsicum* collection evaluated

Group	Accession or Sub-accession	*Capsicum* Species	Country	Place	Pungency*
1	15389	annuum	Ethiopia	Addis Abeba	7
1	16432	annuum	Spain	Malaga	7
1	18060	annuum	Mexico	Oaxaca	7
1	18631	annuum	Peru	Arequipa	7
1	15403	sp.	Ethiopia	Addis Abeba	7
1	5347A	annuum	Peru	Lima	5
1	5347B	annuum	Peru	Lima	5
1	15392	annuum	Ethiopia	Addis Abeba	7
1	15238	frutescens	Costa Rica	Alajuela	7
2	20292	annuum	Costa Rica	Cartago	0
2	**20293**	**annuum**	**Costa Rica**	**Cartago**	**0**
2	**18757**	**annuum**	**Costa Rica**	**Alajuela**	**0**
2	**20436**	**annuum**	**Costa Rica**	**Cartago**	**0**
2	**10886**	**sp.**	**Honduras**	**Comayagua**	**0**
2	15393	sp.	Ethiopia	Addis Abeba	5
3	19260	annuum	Russia	Moldova	0
3	19262	annuum	Russia	Moldova	0
3	18764	sp.	Mexico	Mexico	0
3	18766	sp.	Mexico	Mexico	3
3	19263	annuum	Russia	Vniissok	3
3	19264	annuum	Russia	Volgograd	5
3	20353	sp.	Costa Rica	Cartago	5
3	20426A	annuum	Costa Rica	Cartago	3
3	20266	annuum	Costa Rica	Cartago	0
3	20462	annuum	Costa Rica	Cartago	0
3	20339	sp.	Costa Rica	Cartago	0
3	5489	chinense	Peru	Lima	5
3	20338	sp.	Costa Rica	Cartago	0
3	12908	annuum	United States	California	0
3	8062A	sp.	Mexico	Oaxaca	9
3	20426B	annuum	Costa Rica	Cartago	0
3	19259	annuum	Russia	Moldova	0
4	18808	annuum	Mexico	Mexico	7
4	**18812**	**annuum**	**Mexico**	**Mexico**	**7**
4	**18798**	**annuum**	**Mexico**	**Mexico**	**7**
4	**18811**	**annuum**	**Mexico**	**Mexico**	**7**
4	**11277A**	**sp.**	**Guatemala**	**Chiquimula**	**7**
4	**18816**	**annuum**	**Mexico**	**Mexico**	**7**
4	**18805**	**annuum**	**Mexico**	**Mexico**	**9**
4	**10652**	**annuum**	**Guatemala**	**Zacapa**	**9**
4	**16512**	**annuum**	**Guatemala**	**Retalhuleu**	**7**
4	**18814**	**annuum**	**Mexico**	**Mexico**	**7**
4	16283	annuum	Guatemala	Guatemala	7
5	20013B	frutescens	Nicaragua	Boaco	7
5	20298	frutescens	Costa Rica	Cartago	7
5	13327	frutescens	Costa Rica	Limón	7
5	20012	frutescens	Nicaragua	Boaco	7
5	16211A	frutescens	Ecuador		7

* 0=Sweet 3=Mild 5=Medium 7=Hot 9=Very hot

...Table 4 continued

Group	Accession or Sub-accession	*Capsicum* Species	Country	Place	Pungency
5	16211B	frutescens	Ecuador		7
5	20013A	frutescens	Nicaragua	Boaco	7
5	16518A	frutescens	Guatemala	Suchitepequez	7
5	16518B	frutescens	Guatemala	Suchitepequez	9
5	14376A	annuum	Costa Rica	Limón	5
5	14376B	annuum	Costa Rica	Limón	7
5	20264	frutescens	Costa Rica	Cartago	5
5	20268	frutescens	Costa Rica	Cartago	7
5	15245	frutescens	Costa Rica	Alajuela	7
5	20027	frutescens	Costa Rica	Cartago	7
5	20299	frutescens	Costa Rica	Cartago	5
5	16067A	chinense	Costa Rica	San José	7
5	18758	frutescens	Costa Rica	Alajuela	7
5	17750	chinense	Syria	Tartous	9
6	11391A	frutescens	Guatemala	Izabal	7
6	**11391B**	**chinense**	**Guatemala**	**Izabal**	**7**
6	**10947**	**frutescens**	**Costa Rica**		**7**
6	**13328**	**frutescens**	**Costa Rica**	**Limón**	**7**
6	**11747**	**frutescens**	**Costa Rica**	**San José**	**7**
6	**8058**	**sp.**	**Guatemala**	**Salomá**	**7**
6	**10948A**	**frutescens**	**Costa Rica**	**Juan Viñas**	**7**
6	**10995B**	**frutescens**	**Honduras**	**Comayagua**	**7**
6	**6134A**	**frutescens**	**Guatemala**	**Suchitepequez**	**7**
6	**6134B**	**frutescens**	**Guatemala**	**Suchitepequez**	**7**
6	**12910**	**chinense**	**Costa Rica**	**Limón**	**9**
6	**13972A**	**chinense**	**Costa Rica**	**Cartago**	**9**
6	**13972B**	**frutescens**	**Costa Rica**	**Cartago**	**7**
6	**6134C**	**frutescens**	**Guatemala**	**Suchitepequez**	**7**
6	**13215**	**frutescens**	**Costa Rica**	**Puntarenas**	**0**
6	**8060**	**sp.**	**Guatemala**	**Alta Verapaz**	**7**
6	**12118**	**frutescens**	**Honduras**	**Comayagua**	**7**
6	**13972C**	**frutescens**	**Costa Rica**	**Cartago**	**7**
6	**12911**	**frutescens**	**Costa Rica**	**Limón**	**7**
6	**10948B**	**frutescens**	**Costa Rica**		**7**
6	**11277B**	**frutescens**	**Guatemala**	**Chiquimula**	**5**
6	**10995A**	**frutescens**	**Honduras**	**Comayagua**	**7**
6	**11742**	**frutescens**	**Costa Rica**	**San José**	**7**
6	11401	chinense	Guatemala	El peten	9
7	11635	sp.	Guatemala	El Peten	7
7	8057A	annuum	Guatemala	Baja Verapaz	7
7	11568B	sp.	Guatemala	El Peten	7
7	11568C	sp.	Guatemala	El Peten	7
7	8057C	annuum	Guatemala	Baja Verapaz	7
7	8063A	sp.	Mexico	Oaxaca	7
7	16268A	annuum	Guatemala	Guatemala	5
7	16268B	annuum	Guatemala	Guatemala	5
7	8057B	sp.	Guatemala	Baja Verapaz	7
7	8061A	annuum	Mexico	Oaxaca	7
7	8061B	annuum	Mexico	Oaxaca	7
7	10077B	annuum	Mexico		7
7	8062B	sp.	Mexico	Oaxaca	7
7	10077A	sp.	Mexico		7

...Table 4 continued

Group	Accession or Sub-accession	*Capsicum* species	Country	Place	Pungency
7	12358A	sp.	Guatemala	Suchitepequez	7
7	12358C	sp.	Guatemala	Suchitepequez	7
7	8063B	annuum	Mexico	Oaxaca	5
7	8063C	sp.	Mexico	Oaxaca	9
7	8057D	sp.	Guatemala	Baja Verapaz	7
7	12358B	sp.	Guatemala	Suchitepequez	7
7	11568A	annuum	Guatemala	El Peten	0
8	11204	sp.	Guatemala	El Progreso	7
8	**8054A**	**sp.**	**Guatemala**	**Alta Verapaz**	**7**
8	**12909**	**sp.**	**United States**	**California**	**7**
8	**8054C**	**annuum**	**Guatemala**	**Alta Verapaz**	**7**
8	**18800B**	**annuum**	**Mexico**	**Mexico**	**5**
8	**8054B**	**annuum**	**Guatemala**	**Alta Verapaz**	**5**
8	**8053A**	**sp.**	**Mexico**	**Oaxaca**	**9**
8	**8053B**	**sp.**	**Mexico**	**Oaxaca**	**7**
8	**5345**	**annuum**	**Peru**	**Lima**	**7**
8	**18800C**	**annuum**	**Mexico**	**Mexico**	**5**
8	**8053C**	**sp.**	**Mexico**	**Oaxaca**	**5**
8	18800A	sp.	Mexico	Mexico	9
9	16268C	frutescens	Guatemala	Guatemala	7
9	18638	annuum	Peru	Tacna	7
9	18048	frutescens	San Salvador	San Salvador	7
9	20297	annuum	Costa Rica	Cartago	5
9	7208A	chinense	Peru	Lima	7
9	7208B	chinense	Peru	Lima	7
9	11717	sp.	Cuba	Villa Clara	7
10	16067B	sp.	Costa Rica	San José	7
10	**5374**	**chinense**	**Peru**	**Lima**	**7**
10	**19733**	**baccatum**	**Ecuador**	**Esmeraldas**	**5**
10	**20337**	**chinense**	**Costa Rica**	**Cartago**	**9**
10	**5465**	**frutescens**	**Peru**	**Lima**	**7**
10	**5488**	**frutescens**	**Peru**	**Lima**	**3**
10	**5380**	**chinense**	**Peru**	**Lima**	**7**

Table 5. Percentage of germination for each squash accession (*Cucurbita moschata*) planted in the 1998.

Accession	Planting Date	Seed planted	Germination (%)
5982	18/5	15	13.3
7401	18/5	15	26.6
7763	18/5	15	80.0
8001*	18/5	15	0
8002*	18/5	15	0
8006*	18/5	88	0
8009	18/5	15	93.0
9321*	18/5	15	26.6
9325*	18/5	15	100.0
9327	18/5	15	20.0
9379	18/5	15	93.3
9430	18/5	15	73.3
9478	18/5	15	93.3
9815*	18/5	15	86.6
9817*	18/5	15	46.6
10991*	18/5	15	73.3
11642	18/5	15	86.6
11682	18/5	15	73.3
11730	18/5	15	86.6
11779	18/5	15	100.0
11872	18/5	15	20.0
11877	18/5	15	20.0
11883	18/5	15	86.6
11884	18/5	11	90.1
11885*	18/5	113	0
11921	18/5	15	100.0
12009*	18/5	75	0
12024*	18/5	15	26.6
12028*	18/5	15	26.6
12036	18/5	15	80.0
12054	18/5	15	60.0
12078	18/5	15	20.0
12079*	18/5	15	33.3
12088	18/5	15	93.3
12096*	18/5	15	12.3
12099	18/5	15	73.3
12113	18/5	15	33.3
12129	18/5	15	93.3
12130	18/5	15	73.3
12132	18/5	15	60.0
12331	18/5	15	80.0
12444	18/5	15	73.3
12465	18/5	15	100.0
12480	18/5	15	80.0
18846	18/5	15	86.6

...Table 5 continued

Accession	Planting Date	Seed planted	Germination (%)
18868	18/5	15	80.0
18871	18/5	15	26.6
12026*	5/6	81	38.0
18848*	5/6	51	0
18859	5/6	77	22.5
18872	5/6	15	68.5
18923	5/6	15	93.3
5997	22/6	38	94.7
6254	22/6	50	72.0
6259	22/6	50	58.0
6371	22/6	50	92.0
6508	22/6	50	94.0
9284	22/6	50	70.0
9285	22/6	50	88.0
9294	22/6	50	80.0
9316	22/6	50	16.0
9317	22/6	50	82.0
9319	22/6	50	90.0
9320	22/6	50	92.0
9322	22/6	50	86.0
9421	22/6	50	92.0
9619	22/6	50	100.0
10716	22/6	50	26.0
10742	22/6	50	60.0
10743	22/6	50	60.0
10789	22/6	50	4.0
11087	22/6	50	98.0
11543	22/6	50	96.0
11585	22/6	50	80.0
11878	22/6	50	8.0
11919	22/6	50	28.0
19218	22/6	50	66.0
11961	23/6	50	44.0
11992	23/6	50	20.0
11993	23/6	50	22.0
11994	1/7	50	74.0
12011	1/7	50	52.0
12025	1/7	50	70.0
12027	1/7	50	24.0
12029	1/7	50	58.0
12030	16/7	50	54.0
12060	2/10	150	29.0
12061	2/10	228	97.4
12188	2/10	90	17.8
12058	22/10	50	14.0

...Table 5 continued

Accession	Planting Date	Seed planted	Germination (%)
12125	22/10	50	18.0
12148	22/10	50	30.0
12164	22/10	50	16.0
12272	22/10	50	78.0
12317	22/10	50	72.0
12478	22/10	50	16.0
12481	22/10	50	20.0
12488	22/10	50	64.0
12490	22/10	50	34.0
14338	22/10	42	83.3
14351	22/10	17	65.0
14885	22/10	50	38.0
14887	22/10	50	66.0
14889	22/10	50	62.0
14890	22/10	50	70.0
14891	22/10	50	76.0
14892	22/10	50	80.0
14894	22/10	50	88.0
14895	22/10	50	50.0
14896	22/10	50	90.0
14897	22/10	50	86.0
14898	22/10	50	84.0
14900	22/10	50	74.0
14902	22/10	50	88.0
14903	22/10	50	76.0
14904	22/10	50	78.0
20118	22/10	25	24.0
20119	22/10	25	76.0
20120	22/10	25	60.0
20121	22/10	36	30.5
20122	22/10	25	88.0
20123	22/10	25	80.0
20124	22/10	25	64.0
20125	22/10	30	77.0

*These accessions died due to germination and vigor problems

Table 6. Minimum and maximum values, ranges, averages, standard deviation and variation coefficient of the quantitative characteristics of the fruit and the seeds of 114 accessions and sub-accessions of *Cucurbita moschata*.

Characteristics	Minimum	Maximum	Range	Average	Standard Deviation	Variation Coefficient (%)
Weight of the fruit (g)	327.0	6725.3	6398.3	1951.9	1160.0	59.4
Length of the fruit (cm)	6.5	55.0	48.5	22.1	10.8	49.0
Width of the fruit (cm)	8.5	24.2	15.7	14.4	3.4	23.7
Length of the pedicel (cm)	2.0	7.5	5.5	4.4	1.1	25.0
Thickness of the skin (cm)	1.3	6.4	5.1	3.3	0.9	27.4
Thickness of the flesh (cm)	0.9	4.3	3.4	2.0	0.7	35.0
Diameter of the cavity (cm)	5.5	16.3	10.8	9.4	2.2	23.4
Number of seeds per fruit	56	814	758	430.8	162.4	37.7
Length of seed (mm)	12	18.5	6.5	15.4	1.3	8.4
Width of seed (mm)	6.0	10.0	4.0	8.2	0.8	9.7
Thickness of seed (mm)	2.0	4.3	2.3	3.3	0.4	12.1

Table 7. Results of germination of 184 accessions of peppers (*Capsicum* spp.) under controlled temperature and humidity conditions

No.	Accession	Germination (%)	No.	Accession	Germination (%)
1	10006	9	47	9037	55
2	7801	11	48	10815	57
3	9927	17	49	6145	57
4	10628	19	50	7811	58
5	10793	19	51	8052	58
6	8388	20	52	9221	58
7	10950	23	53	9910	58
8	10945	27	54	8055	59
9	8205	27	55	9923	59
10	8386	27	56	10761	60
11	7246	29	57	7310	60
12	9934	30	58	7796	60
13	9924	32	59	7257	62
14	10015	34	60	8597	62
15	7810	34	61	10005	63
16	10871	35	62	7204	63
17	8390	37	63	7345	63
18	8394	37	64	9835	63
19	9926	37	65	9836	63
20	10003	38	66	9049	64
21	10760	39	67	7237	65
22	9832	39	68	5345	66
23	9830	40	69	7208	66
24	9935	41	70	9782	66
25	6143	43	71	9906	66
26	10014	45	72	7320	67
27	9839	45	73	9164	67
28	10951	46	74	10914	68
29	1608	46	75	7290	68
30	7258	47	76	9204	68
31	9829	47	77	9226	68
32	10792	49	78	10630	69
33	7218	49	79	10917	69
34	9936	49	80	10916	70
35	10909	50	81	9840	70
36	8534	50	82	6134	71
37	10757	51	83	8051	71
38	10946	51	84	9040	71
39	7301	52	85	9806	71
40	7803	52	86	10004	72
41	8387	52	87	7818	72
42	9909	52	88	9140	72
43	9937	53	89	9921	72
44	10730	54	90	8994	73
45	10862	55	91	10013	74
46	8248	55	92	7300	74

...Table 7 continued

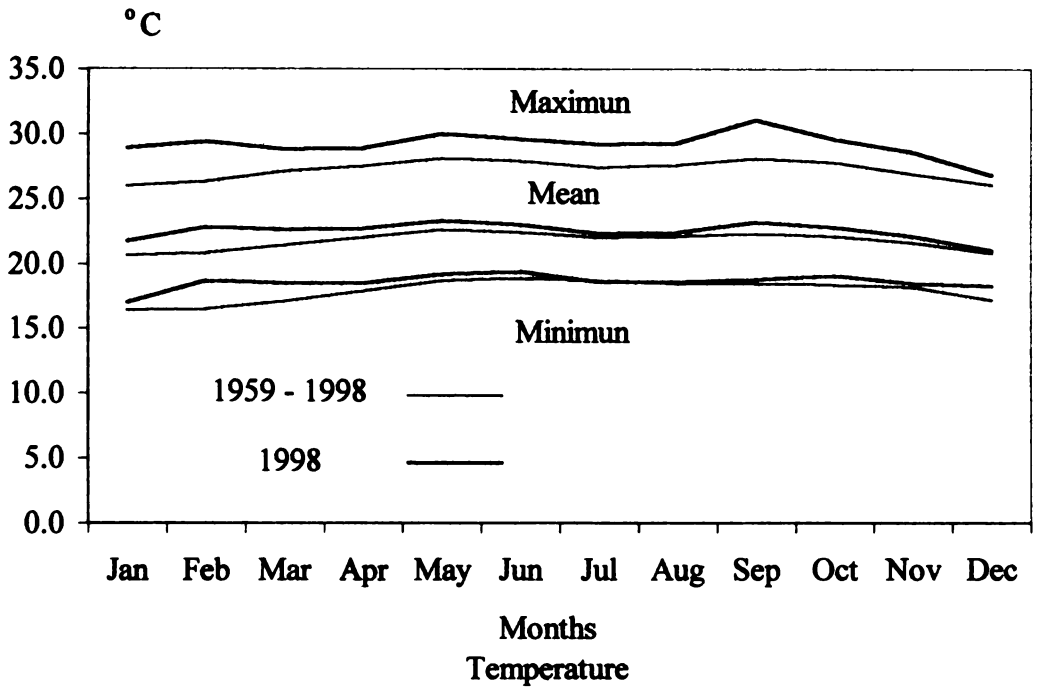
No.	Accession	Germination (%)	No.	Accession	Germination (%)
93	8054	74	139	9803	85
94	9200	74	140	9807	85
95	9833	74	141	6131	86
96	7279	75	142	8048	86
97	7287	75	143	9110	86
98	9043	75	144	9779	86
99	7815	76	145	9834	86
100	9831	76	146	6126	87
101	9873	76	147	6586	87
102	10948	77	148	7201	87
103	6135	77	149	8395	87
104	7253	78	150	9159	87
105	8060	78	151	9170	87
106	8289	78	152	9781	87
107	9838	78	153	9902	87
108	9925	78	154	6146	88
109	6147	79	155	7798	88
110	7809	79	156	7800	88
111	7816	79	157	7802	88
112	9096	79	158	9115	90
113	9801	79	159	9139	90
114	9916	79	160	9186	90
115	6136	80	161	9190	90
116	7813	80	162	9805	90
117	7819	80	163	6642	91
118	9097	80	164	7202	91
119	9157	80	165	7209	91
120	8057	81	166	7214	91
121	9135	81	167	8995	91
122	9778	81	168	6630	92
123	7807	82	169	7203	92
124	8058	82	170	9095	92
125	9841	82	171	9122	92
126	8064	83	172	9183	92
127	8999	83	173	9892	92
128	9103	83	174	7133	93
129	9917	83	175	7417	93
130	6587	84	176	9053	93
131	7210	84	177	10077	94
132	8396	84	178	8093	94
133	9776	84	179	9131	94
134	10666	85	180	9913	94
135	10749	85	181	9922	95
136	6132	85	182	8053	96
137	9123	85	183	9038	96
138	9777	85	184	9079	96

APPENDIX 1

Table 1. Soil analysis in areas used for characterization and multiplication of the pepper and squash accessions

Parameter	Soil A	Soil B	Soil C	Soil D	Soil E
Sample depth (cm)	30	30	30	20	20
pH water	5.0	5.0	5.0	5.14	5.19
Extractible acidity (cmol(+)/l)	0.89	0.35	0.58	0.77	0.86
Ca (cmol(+)/l)	1.55	1.80	1.34	1.65	1.89
Mg (cmol(+)/l)	0.44	0.44	0.21	0.59	0.76
K (cmol(+)/l)	0.27	0.24	0.18	0.19	0.26
P (mg/l)	7.55	9.35	5.76	10.8	8.1
Cu (mg/l)	4.75	5.06	4.64	6.69	8.03
Zn (mg/l)	0.75	0.80	0.52	1.11	1.37
Mn (mg/l)	12.07	9.46	5.15	7.88	18.22
Organic Matter (%)	8.30	9.76	12.19	9.89	9.92
N (%)	0.39	0.47	0.56	0.49	0.45
C.I.C.* (cmol(+)/l)	35.51	38.42	45.27	41.43	39.02
Ca (cmol(+)/l)	2.10	2.30	2.00	1.55	1.88
Mg (cmol(+)/l)	0.53	0.58	0.33	0.58	0.80
K (cmol(+)/l)	0.54	0.49	0.39	0.41	0.52
Na (cmol(+)/l)	0.02	0.05	0.03	0.07	0.11
Texture	Clay loam	Clay loam	Clay loam	Clay loam	Clay loam

*C.I.C. = Cationic Exchange Capability



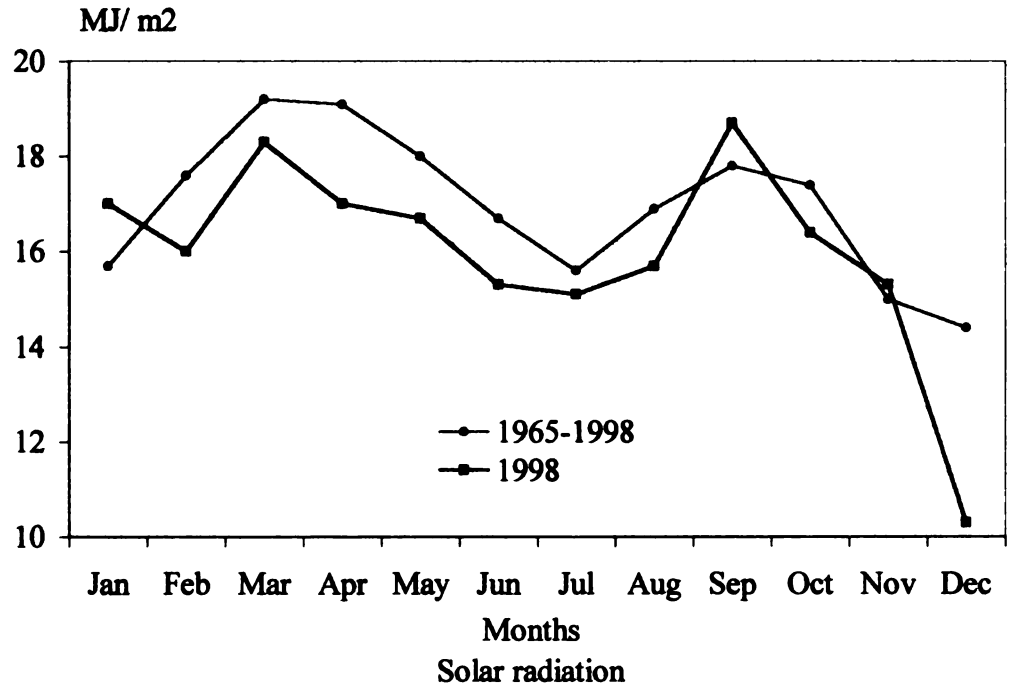


Figure 1. Temperature and solar radiation recorded at CATIE, Turrialba. Costa Rica.

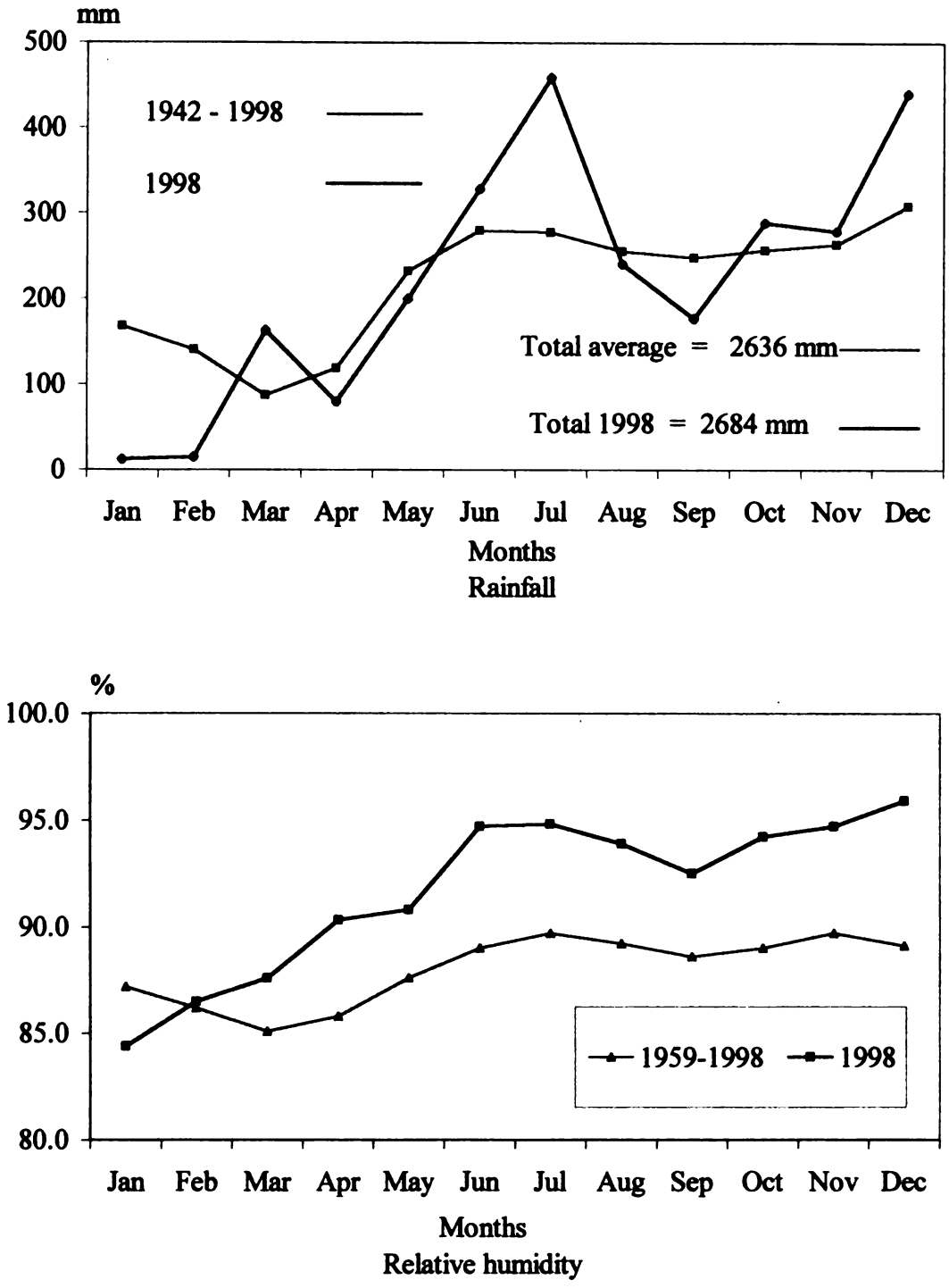


Figure 2. Total monthly rainfall and relative humidity average recorded at CATIE, Turrialba. Costa Rica.

APPENDIX 2

TAPIA, C.G. 1998. Morphologic and molecular characterization of the genetic diversity of CATIE's collection of *Pachyrhizus tuberosus* (LAM.) SPRENG. Thesis Mag. Sci., CATIE. Turrialba, Costa Rica. 157p.

SUMMARY

P. tuberosus commonly called yam bean (jicama), like *P. erosus*, the most widely distributed species of its kind; is a native leguminous tuber from South America. It is considered as a promising crop due to its high potential for producing biomass for human and animal consumption. Its yields are exceptional, up to 150 tons per hectare and it contains 3 to 5 times more proteins than other roots like cassava or sweet potato. It fixes nitrogen and moreover it contains high levels of "rotenona", a natural insecticide, that is an interesting option for use in organic agriculture as pest control.

The objective of this research was to evaluate the genetic diversity of CATIE's *P. tuberosus* collection in Turrialba, Costa Rica, by through a morphoagronomic and molecular characterization of 31 samples. For the morphologic characterisation, a total of 70 qualitative and quantitative characters were included to design distance matrix between samples. This was used to analyze Ward's hierarchic grouping. The distances between and within groups were analyzed for the characters of greater discriminating value " D "; in addition, the size of the minimum sample was obtained and the genetic variability analyzed. The collection was classified in four main groups: ashipas (groups I and 4), chuines (group 2) and jiquimas (group 3). Ten qualitative characters and seven quantitative characters with greater discriminating power were used to identify groups, and samples within groups. These characters were: the form and type of the lobe of the leafs foliole, color of the root's pulp, growth habits, days to flowering and days to physiological maturity, the most useful characters to be used in an initial description. The minimum sample size for qualitative characters oscillated from 1 to 3 repetitions and for quantitative characters, a minimum sample of 20 to 50, within acceptable limits. The relation length/width of the leaf s main foliole was identified, as were the days to physiological maturity of the pod. The samples with smaller genetic variability for the quantitative characters were the length of the flower, width of the vexillum, relation length/width of the leaf's foliole and the days to physiological maturity.

For the molecular characterization, RAPD markers were used and by means of the distance matrix, dendograms, *"bootstrap"* and canonical discriminate analysis, the variability of the collection was determined. Ten "primers" were identified obtaining 32 polymorphism, being seven "primers" the ones that contributed the most to differentiate between groups, to find duplicates, " label mutations " and to characterize the individuals. In addition, the relationships within both types of characterization were identified by means of correlation based on the distance matrix, which allowed to find out that the best relation in regards to the matrix obtained with molecular markers were with the qualitative characters. The tools used in this research have provided the necessary information to characterize the individuals and, therefore, the future contribution and valuation in the genetic breeding.

LOBATO, S.D. 1998. Development of propagation methods for the conservation of *Pouteria sapota* (Jacq.) Thesis Mag. Scientiae. 1998. Tropical Agricultural Research and Higher Education Center. Turrialba, Costa Rica. 131 p.

SUMMARY

The cultivation of the "sapote" plum, as well as the benefits that it offers for the development and conservation of agrosystems where it is established, confronts two other fundamental problems that limit its development in commercial exploitations in spite of the demand for the fruit in the market and to the ample by-product range that is obtained as a result of its exploitation. These problems are: the lack of effective and efficient methods of propagation that would allow it to obtain a great quantity of plants with homogeneous characteristics; and the conservation and development of clones from promising wild individuals for the development of programs of genetic improvement. The objective of the present investigation is to establish techniques of propagation that may serve as bases for the search of efficient methods for the conservation and multiplication of *Pouteria* materials.

The investigation was carried out using different techniques from vegetative propagation: a) Macropropagation: carried out at the Cabiria Experimental Field, and grafting techniques and rooting of different genotypes from CATIE's collection of sapotaceas. B) Micropropagation: carried out in CATIE's Biotechnology Laboratory, the *in vitro* cultivation techniques of apexes and micrografts were used.

The statistical analysis was carried out by means of analysis of variance and different significant minimums. It applied a design of divided parcels in time and the case of the percentage variable of capture to a factorial design without repetitions, in which the triple interaction was considered to estimate the experimental error.

It was found that grafting was favored by controlled greenhouse conditions, also the technique of lateral plates provided the major percentage of capture.

At the same time, the technique of rooting, although it did not offer the desired results, allowed the identification of a genotype with exploitation potential, since it was the only one that formed an adventitious root and maintained a good percentage of viability and turgidity throughout the experiments. The best results were obtained by using the substrate sand. According to the histology studies, these two techniques are very influenced by the species own physical aspects that limit their answer; among them are fiber bands previous to the cambium and great presence of resinous channels in their bark.

With the use of the *in vitro* cultivation techniques the difficulty to multiply woody species was confirmed; nevertheless, the bases are left in disinfecting material and elimination of oxidation, that can be of interest for future experiments. Regarding micrografts the few results obtained did not allow to obtain many aspects related to the use of this technique for the multiplication and conservation of genotypes of the species, although it was observed from the preliminary results of the possibility of using the methodology of lateral plates for later investigations.

It is recommended to continue with tests of limiting factors such as exogenous as well as endogenous that limit the techniques of propagation by means of grafts and stake rooting for this species, and to continue with the development of a protocol of multiplication and conservation *in* vitro of sapotaceas.

FINANCIAL REPORT

US DEPARTMENT OF AGRICULTURE

OFFICE OF INTERNATIONAL COOPERATION AND DEVELOPMENT

FISCAL REPORT OF GRANTEE UNDER AGRICULTURAL RESEARCH PROGRAM, PUBLIC LAW 480, AS AMENDED

1. FROM *(Name and address of grantee)*	2. Grant No.	3. AMOUNT OF GRANT	
CATIE	FG-CR-104 / CS-ARS-3	$279.000.00	
TROPICAL CROPS AREA	4. Report No.	5. REPORT RERIOD	
7170		FROM	TO
TURRIALBA, COSTA RICA	Second	1-Abr-98	31-Dic-98

6. Project Title

Evaluation, Regeneration and Enhanced Database Management of Unique Genetic Resources from Meso - America

SUMMARY STATUS OF FUNDS	AMOUNT US$
Unused Balance (Report first)	17,545.68
7. Total Grant Funds ***RECEIVED***	83,000.00
8. Total Grant Funds ***SPENT*** Including This Report Period	61,061.12
9. Balance Grant Funds on Hand End of This Report Period (item 8 from item 7)	**39,484.56**
10. Estimated Expenses for Next Period	82,000.00
(EXPLAIN ANY UNUSUAL EXPECTED COSTS BY ATTACHING STATEMENT)	-
PARTI - GRANT FUNDS SPENT DURING THIS PERIOD - RECURRING COSTS	
11. Salaries and Benefits of Project Personnel *(Names and Titles)*	29,742.65
A. Antonio Mora Quiros — Research Assistant	
B. Marvin Sánchez B. — Labor	
D. Luis Alonso Chavez Avila — Labor	
E. Victor M. Araya Garcia — Labor	
F. Juan C. Molina M. — Labor	
12. Travel of Personnel Within Country	499.93
13. Contractual Services ***(ITEMIZE)***	-
14. Supplies and Materials (***EXPLAIN UNUSUAL COST ITEMS BY ATTACHING STATEMENT***)	20,350.03
15. Other Recurring Costs (*Include Items Not Identified Above*)	4,917.50
16. **TOTAL** *(Add Items 11 thru 15)*	**$ 55,510.11**
17. Indirect Costs (*Agreed Allowance or Percentage of Item 16)*	5,551.01
PART II - GRANT FUNDS SPENT DURING THIS PERIOD - NONRECURRING COSTS	
18. Capital Assets Provided Under Grant (*identify Each Item and Attach Copy of Paid Invoice)*	
19. Approved Travel Outside Country (*identify Travelers and Attach Breakdown of Expenses)*	
20. **TOTAL GRANT FUNDS SPENT FOR REPORT PERIOD *(Add Items 16 thru 19)***	**$ 61,061.12**
21. Total Interest Earned on Grant Fund Deposits, if any, from Start of Grant	----------

We certify that amounts reported spent from grant funds are in accordance with the provisions applicable to the above identified grant.

22. SIGNATURE OF PRINCIPAL INVESTIGATOR	23. TETLE	24. DATE
Elkin Bustamante	Tropical Crops Head	03/05/1999
25. SIGNATURE OF OFFICIAL AUTHORIZED TO SIGN FOR GRANTEE	**26. TETLE**	**27. DATE**
Luis Enrique Ortiz	Director Administration and Finances	03/05/1999