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Phaseolus Genetic Resources Grown in Campeche, Mexico

Fermín Orona-Castro[1], Rogelio Lépiz-Ildelfonso[2], Juan Medina-Mendez[1], Mónica Guadalupe Lozano-Contreras[3], Mirna Hernández Pérez[1]

[1]Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP), Campo Experimental Edzná, Km 15.5 Carretera Campeche-Tixmucuy, Campeche, México
[2]Universidad de Guadalajara, Guadalajara, México
[3]Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP), Campo Experimental Mocochá, Km 25 Carretera Mérida-Motul, Yucatán, México
Email: orona.fermin@inifap.gob.mx

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Abstract

The protein intake of the population in the Yucatan Peninsula is based upon the different forms of beans naturally developed. The different ecotypes of creole beans that are grown traditionally have been displaced by improved varieties, thereby turning into a risk of losing a valuable source of germ-plasma. The present study is aimed to identify, collect and preserve several bean species genetic resources grown in Campeche, Mexico, in addition to the development of an identification card with the main phenotypic characteristics and yield components. A total of 33 different samples were collected from nine different municipalities statewide; out of those, 15 were *Phaseolus vulgaris* and 18 *Phaseolus lunatus*. The collected samples diversity is reflected in the range of growth habits from the bush to the indeterminate climbing species, being these the most representative with about 29 samples, many of those because of the way the planting is carried out, which is traditionally performed in association with the cultivation of corn. Early samples were identified in this diversity with their cycle ranging from 60 to 120 days after emergence. Samples of *Phaseolus lunatus* with 1.35 to 2.86 t/ha yield potential were also obtained.

Keywords

Creole Beans, Collect, Preserv, Genetic Variability

1. Introduction

The bean has had a rather long traditional consumption dating all the way back to pre-Hispanic times, presenting

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a wide diversity for both wild and cultivated varieties [1]. Along the Yucatan peninsula, protein diet is based on beans naturally grown since the pre-Columbian era, differing in size (medium, small and large), shape (flat, round and kidney-shaped), plus color (white, black, brown, yellow, cream, purple, etc.). They represent valuable genetic resources with a high potential for the security of the regional food intake, providing a relevant contribution to reduce poverty due to their nutritional resource availability in underserved rural areas [2] [3].

Different bean varieties are cultivated along the state of Campeche; however, it is threatened the conservation of seeds. Due to changes in land use by livestock, use of agrochemicals, genetic erosion, population explosion, disaster, fire and release of improved varieties have resulted in the reduction of the genetic base and the gradual disappearance of native crops or wild [4].

When we lose the genetic diversity of a species and only a few copies of collection, the work of thousands of years of evolution is lost [5], as in the case of populations of wild beans (*Phaseolus vulgaris* L.) which are used by incipiently humans, nowadays. Many of those are tolerant to stress-inducing environments; moreover, their nutritional characteristics and quality may be exceptional, representing an untapped resource, thus [6].

The project "Food legumes inventory and conservation grown in the state of Campeche" was carried out with looking forward to maintaining the different bean varieties grown along the state of Campeche, throughout a plan aimed to encourage both the collecting and preservation of different edible bean variants, in several diverse species that are quite relevant for human nutrition. Consequently, the study was aimed to 1) characterize the germ-plasm richness, abundance and distribution of the *Phaseolus* wild and cultivated bean species; 2) develop passport identification with phenotypic characteristics and yield components; 3) preserve the genetic resources of several bean species grown in Campeche, Mexico.

2. Materials and Methods

2.1. Collections

Samples were collected between 2011 (10 samples were *lunatus* and 8 *vulgaris*) and 2012 (8 samples *lunatus* and 7 *vulgaris*). The town and municipality of collection were determined based upon several interviews with producers, looking forward to identify and trace the collection route were wild beans were traditionally grown in the state of Campeche, performing collections in the nine municipalities of Hecelchacán, Hopelchén, Tenabo, Campeche, Champotón, Calakmul, Escárcega, Candelaria and Carmen, plus along 39 towns (**Figure 1**).

2.2. Establishment and Crop Handling

All of the collected samples were established on the field in the town of San Antonio Cayal, located in the Campeche municipality (19˚45'08.14"N and 90˚09'51.84"W, ASNM 31 m); these were sown in plots of six rows and six meters long; the planting distance between rows was 80 cm, plus 10 cm in between plants; a 50 kg density of seed per hectare was used. The cultivation conditions were under temporary planting, having August 24th, 2012 set as the cultivation date. The harvesting took place at the beginning of November for the early samples, coming to an end in the same year by December 29th with the late genotypes. The type of soil in this region is Luvisols known as K'ankab (classification according to the Mayan), red soils with high clay content but with permeable drainage [7].

The agricultural practice consisted on preparing the cultivation soil throughout two dragging phases, performing the second by cross; the trenching was then carried out, followed by the drawing of the plot size; the planting was done, afterwards. A basal fertilizer application was performed using ammonium phosphate in dosages of 80 kg per hectare, plus 30 kg of nitrogen per hectare. Both manual and chemical weed control, as well as pest control was performed; furthermore, tutors were also set on site because most of the *Phaseolus* collected were samples sown associated with corn and classified as type IV growth.

The data was recorded in order to differentiate the samples as flowering days, maturity days, grain color, flower color, grains number per pod, grain yield and growth habit; the bean evaluation manual was used for data evaluation [8].

3. Results and Discussion

A total of 33 *Phaseolus* samples were collected; 15 samples were from the *vulgaris* species and 18 were *lunatus*

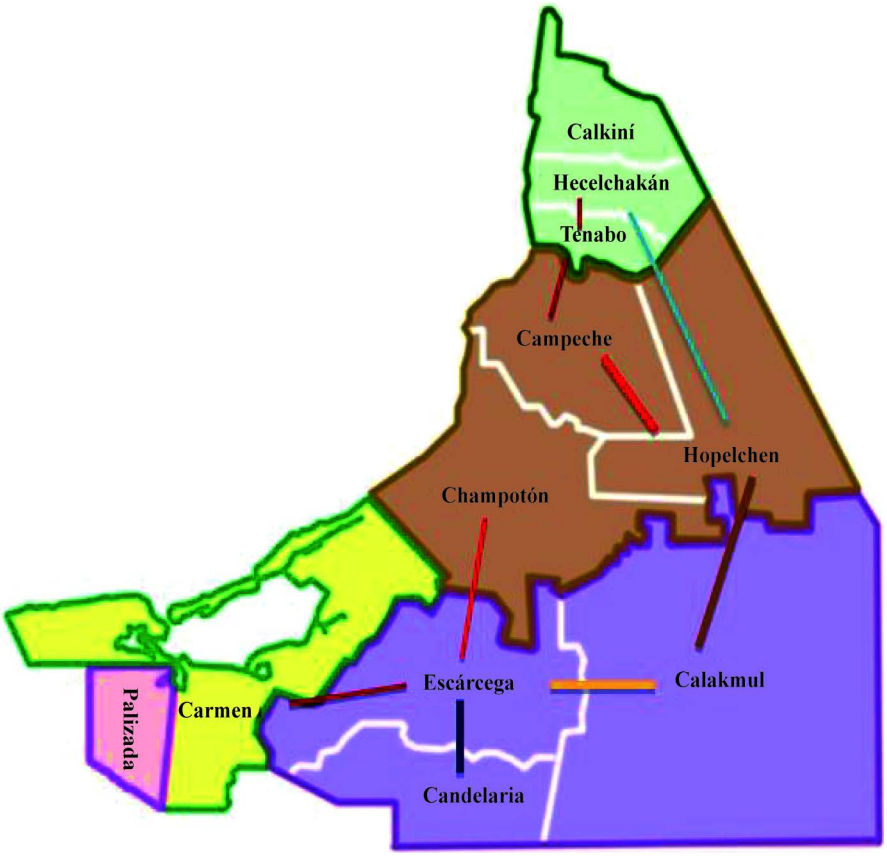

Figure 1. Routes traveled for the collection of wild *Phaseolus* species in the state of Campeche.

(**Table 1**). Four variants of the genotype locally known as the T'zamáa were identified in the sampling collection from the Hecelchacan, Hopelchen and Champotón municipalities (red sheath, purple short sheath and the last being long marbled sheath); the first two plus the last belong to the type IV or beans that require a tutor guide for their proper development (**Figure 2**); two Mejen buul variants were also found at the towns of Chencoh and Iturbide, in the Hopelchen municipality, one of short sheath and another of long. An early *lunatus* (60 days maturity) was found at the town of Dzitnup, in the Hecelchacán municipality; moreover, late *lunatus* samples (132 days maturity) were also found at the town of San Antonio Cayal, in the Campeche municipality.

3.1. Genotype Geographical Distribution

The largest number of *Phaseolus* genotypes were located in the Campeche municipality (21 genotypes), followed by the Champotón and Hecelchacán with 4 genotypes, respectively. The lowest number of genotypes was located in the municipalities of Hopelchén (2), Tenabo (1) and Escárcega (1) (**Figure 3**). It is noteworthy that in the municipalities that were not reported in **Figure 3** (Tenabo, Calakmul, Candelaria and Carmen), the *Phaseolus* collection was performed; nevertheless, similarities among the *Phaseolus* species collected per town were determined during the evaluation of the field. The evaluation of the collected genetic variability was performed based upon the expression of the different morphological characteristics in each accession related to the plant, flower, sheath and grain vegetative growth. These characteristics were repeated in several accessions.

The *lunatus* species is recognized by the Mayan farmers as ib, ibes or lime bean; the cultivation of this bean in the region has played a key role in the diet of the Mayan culture, being the fourth most important crop for the traditional Mayan agriculture in the Yucatan peninsula [9]-[12]. Consequently, it is understood that many of the collected samples during harvesting belong to the *lunatus* species (**Figure 4**), being the Campeche municipality where the largest sample of this species were found (12 collections), compared to the *vulgaris* species (9 collections).

Table 1. Origin, common name and characteristics of 33 bean populations collected in the state of Campeche during 2011 and 2012.

Col.	Located	Common name	Beans color	Days to flowering	Days to maturity	Weight of 500 seeds (g)	Production cycle
C1	Campeche	T'zamáa red sheath	Black	40	113	98.94	*Intermediate
C2	Hopelchén	Cole buul	Black	38	115	103.38	Intermediate
C3	Hecelchacán	Mejen ib	Red	30	70	127.44	Short
C4	Hecelchacán	Ibes white	White	50	132	132.22	Intermediate
C5	Hopelchén	Ibes munition	White	42	112	142.62	Intermediate
C6	Hecelchacán	Zot chet buul	Black	35	80	112.5	Long
C7	Campeche	Bush black beans	Black	42	118	75.03	Intermediate
C8	Campeche	Colored green beans	Red	49	132	89.04	Intermediate
C9	Champotón	Red creole beans	Red	47	129	110.47	Long
C10	Champotón	Mejen buul	Black	32	73	145.16	Short
C11	Champotón	Rod bean red sheath	Red	43	120	129.95	Intermediate
C12	Campeche	T'zamáa green sheath	Black	41	113	141.32	Intermediate
C13	Campeche	T'zamáa Bush long sheath	Black	35	85	131.5	Intermediate
C14	Campeche	T'zamáa marbled sheath	Black	42	115	120.89	Intermediate
C15	Campeche	Ibes pinto creole	Pinto	45	110	193.31	Long
C16	Hecelchacán	Ibes white plane	White	45	115	139.31	Long
C17	Campeche	Charro beans	Red	35	102	282.17	Intermediate
C18	Campeche	Ibes cream plane	Cream	43	113	136.97	Intermediate
C19	Campeche	Ibes dark purple	Dark purple	41	119	175.99	Intermediate
C20	Campeche	Ibes light red	Red	35	95	136.76	Intermediate
C21	Campeche	Ibes light purple	Light purple	35	95	167.21	Long
C22	Escárcega	Ibes black plane	Black	42	112	177.67	Long
C23	Campeche	Creole Bush beans	Black	30	73	87.07	Intermediate
C24	Tenabo	Ibes pink	Pink	30	90	132.62	Long
C25	Campeche	Ibes light pink	Pink	45	115	140.21	Long
C26	Campeche	Ibes cream-black pinto	Cream-Black Pinto	45	115	149.87	Intermediate
C27	Campeche	Ibes white-black pinto	White-Black Pinto	42	112	170.0	Intermediate
C28	Campeche	Ibes black	Black	42	112	159.86	Long
C29	Campeche	Ibes fucsia	Fuscia	30	90	133.86	Intermediate
C30	Campeche	Ibes cream-black marbled	Cream-Black marbled	43	113	165.28	Intermediate
C31	Kesté	Bean pigeon paw	Red	48	131	45.18	Long
C32	Campeche	Ibes cream-pink pinto	Cream-Pink Pinto	45	118	141.45	Long
C33	Campeche	Red beans	Red	45	118	85.38	Intermediate

*Production cycle times: Short (60 - 90 days), Intermediate (91 - 120 days), Long (121 - 150 days)

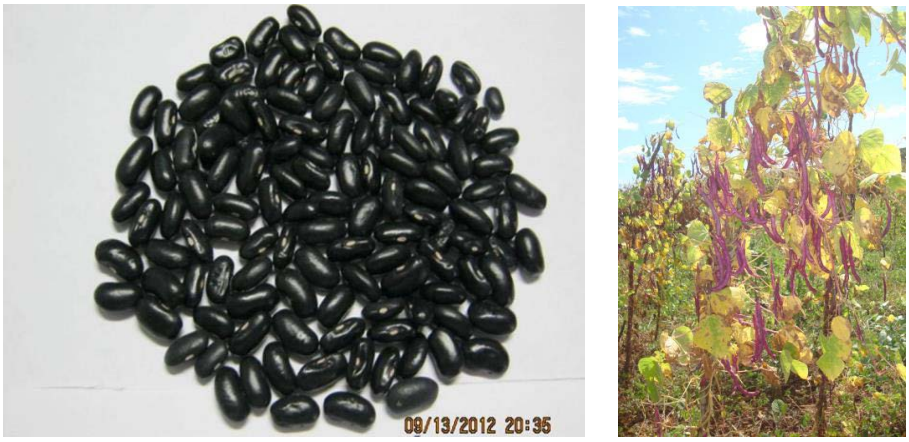

Figure 2. Grain and bean plants native *Phaseolus vulgaris* variety T'zamáa (red sheath) collected in the municipality Campeche.

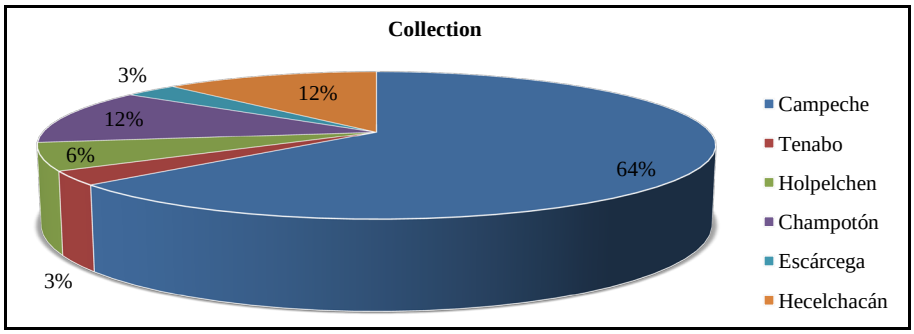

Figure 3. List of collections per municipality in the state of Campeche, Mexico.

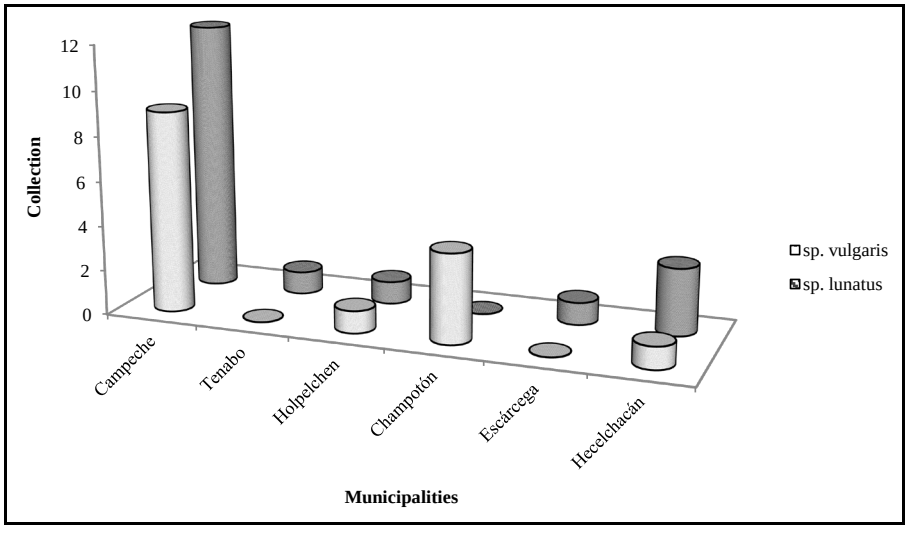

Figure 4. *Phaseolus* species collected by municipalities.

A pretty good idea related with the relevance of genetic resources is provided by such bean diversity among regional farmers, as well as the *in situ* germ-plasma preservation, which keeps being used year after year as part of the family heritage [13]. Features such as flavor, cooking quality, yield stability rather than local adaptability and performance are important attributes that lead farmers to preserve their "wild" varieties, keeping the genetic wealth of their communities [14].

3.2. Collected Genetic Variability Preservation and Usage

An objective of this sample collection was to have the genetic variation revealed in the traditional ecotypes for their future preservation and subsequent improvement. The collected and evaluated samples were sent to the germ-plasma bank based at the National Plant Genetic Resources for Food and Agriculture (SINAREFI), located at the University of Guadalajara in the municipality of Zapopan, Jalisco.

3.3. Yield

The yield achieved by the collections that were carried out is shown in **Table 2**, which revealed higher yields than those 615 kg/ha [15] reported in the state of Campeche, having five *lunatus* and three *vulgaris* species standing out. The highest yield took place in the mejen ib, the big flat black ibes and the big white ibes, with 2867, 1327 and 1282 kg/ha, respectively.

The wild varieties potential versus the commercial varieties has been reported by several studies in such regard, mainly concerning yield performance, physical quality and protein content [16] [17]. Additionally, the bean that is both produced and consumed in Mexico comes mainly from native genotypes in lower levels of improved varieties, which have agronomic and quality advantages [18].

The precipitation that took place from the samples planting date (**Figure 5**), to the harvest for seed increase, was 464 mm, if taking into account that the bean water necessity ranges from 600 to 700 mm in 3 or 4 months

Table 2. Yield collections of wild beans in the state of Campeche.

Species	Common name	Yield kg/ha
lunatus	Mejen Ib	2867
	Ibes black plane	1327
	Ibes white	1282
	Ibes munition	1104
	Ibes pinto creole	788
vulgaris	T'zamáa red sheath	953
	T'zamáa green sheath	755
	T'zamáa marbled sheath	943
	Mejen buul	633

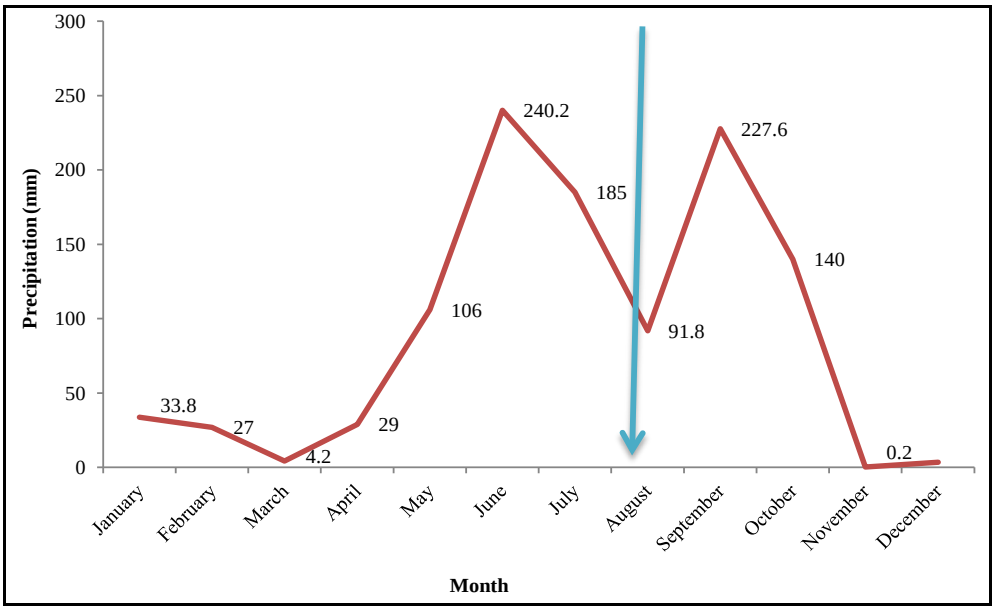

Figure 5. Annual precipitation in the town of Cayal in 2012. The arrow indicates the date of planting material collected for seed increase.

[19], having only 66% of the cultivation requirements covered; nonetheless, nine of the collected samples exceeded the 615 kg/ha yield average statewide (**Table 2**), proving their tolerance ability to extreme weather conditions. As reported by several studies, wild beans are naturally adapted to survive harsh climatic fluctuations until their final germination, under favorable conditions of subsequent cycles, occurs [20]-[22] as observed in the study hereby. The average temperature recorded during the evaluation was 26˚C, maximum was 36˚C and minimum of 18˚C, recorded at the end of the crop cycle.

4. Conclusion

A total of 33 different types of *Phaseolus* species were identified and collected in the state of Campeche, out of which 15 belonged to the *P. vulgaris* species and 18 to *P. lunatus*. The diversity of the collected samples was reflected in the range of growth habits from the bush to the indeterminate climbing species, being the latter the most representative, with about 29 samples, many of those due because of how they were planted, which was a process traditionally performed in association with the cultivation of corn. Early samples were identified in this diversity with a 60 to 120 days fluctuating cycle after emergence; samples with a 1.35 to 2.86 t/ha yield potential were obtained in two *Phaseolus lunatus* samples.

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