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Short Research Article

Sustainable Management of Wild Chili (*Capsicum annuum* L. var. glabriusculum) as an Alternative from Production to the Northeast of Mexico

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Abstract

Mexico offers a wide range of cultivated varieties of chills, as well as wild chilies. This are considered as the ancestors of peppers *Capsicum annuum*, which are grown worldwide. In northeastern Mexico this wild chili is strongly rooted in its cuisine. Though this wild chili has high potential for production, the main problem is associated with the difficulty of seed germination for field production. A protocol of germination of piquin chili has been development with good germination. The increasing demand of the wild chili in the Northeast of Mexico and in the international markets, it has become necessary to find an alternative to *in situ* conservation and production in a sustainable way *ex situ* in its natural habitat in the Northeast of Mexico. The prices of this wild chili prices in northeastern Mexico in the market depend largely on prevailing climatic conditions in each season. Therefore, research efforts are undertaken in the development of technology for the management of wild chili production as a sustainable alternative for rural population. On the basis of the information generated on the sustainable management of the resource wild chili by the rural farmers, few technological packages have been developed through courses and workshops which are transferred to the farmers involved in the value chain of the wild chili of northeastern Mexico. Thereby, it has been possible for the effective management of the wild chili agro-forestry system as an alternative sustainable productivity (ecologically, economic, socially and technically viable) in the northeast of Mexico.

1. Introduction

Mexico offers a wide range of cultivated varieties of chili peppers, as well as wild chili. Chile piquin is considered the ancestors and wild relatives closest to the chili peppers *Capsicum annuum*, cultivated around the world. Both the human societies and the crops that feed them have co-evolved; thereby the crops have contributed to the evolution of human societies. The man is mainly dependent on the plants for food, In fact, the farming and the domestication, was not the result of an event, or an idea, discovery, or an invention, but is the product of a long adaptive process that took place for thousands of years (Perez, 2009, Pozo and Ramirez, 2003). The genus *Capsicum* is of American origin, a tropical species belonging the family Solanaceae which includes tomatoes, tobacco and potatoes among others. Its centre of origin seems to be in the region that includes the north of Argentina, Bolivia, and the south centre of Brazil. Mexico is considered as the center of origin of species with high potential agri-food, thereby offering a wide range of varieties and types of chilies grown, as well as a large number of wild chili. In addition Mexico posses a great genetic diversity and ability to domesticate, this contains the types and varieties of chili with greater surface area, cultivated, greater production, greater consumption and marketing in the world (Hernandez et al., 1999).

The use of chili dates back from ancient times, primarily as a condiment, but it is also an important source of vitamin C, in addition to various uses by different American cultures (Long-Solis, 1986). *Capsicum annuum* var. *annuum* is the variety most widely known and of greater economic

importance for its global distribution (Pickersgill, 1969). It is likely that Chile improved significantly its productive system through the best management practices adopted for soil and propagation, irrigation, advanced technology, and different method of planting up to the conventional system, thereby, making it highly competitive with the rest of the crops of the region (Kirnak, 2003). Its nutritional value, medicinal, cultural exchange, as a tribute, its production, industrialization and trade at various times, their types and its dissemination throughout the world have been documented (Laborde and Well, 1982; Long-Solis, 1986).

In Mexico, *C. annuum*, is found in all the States of the Republic under n a wide variety of conditions, grown in undisturbed places, pastures and in backyards (Loaiza et al., 1989),. It is rarely found on the top of the place 1000 meters above sea level; though there are records it grows up to 1100 m of altitude in Queretaro and 1300 m of altitude in Coahuila (Laborde and Well, 1982, Hernandez et al., 1999). Moreover, it is described as widely disseminated species with its distribution throughout the coastal zone of the country.

Currently, in the Northeast of Mexico this wild species is strongly rooted in its typical gastronomy. Its marketing comes mainly from collectors of wild populations, thereby causing gradual deterioration of the ecosystem as well as the natural banks of germplasm, coupled with the difficulty of seed germination.

In this respect Maiti et al. (1997) studied seed coat ultrastructure and a method for inducing rapid germination of the wild chili, (*Capsicum annuum* var. *aviculare* D. and E., Solanaceae). The technique involves keeping the seeds of chilepiquin mixed with cowdung for 7 days in refrigerator at 4 °C and put on germination with satisfactory germination percentage. Besides, Cardenas et al. (1997) developed In vitro tissue culture of wild chili, (*Capsicum annuum* var *aviculare* (Dierb.) D'Arcy and Esbaugh): an alternative method for propagation

The demand of the wild chili the Northeast of Mexico and its socio-economic importance as a natural resource with potential for its production has compelled to adopt an alternative strategy for in situ conservation and production in a sustainable way *ex situ.*

The methods to manage the wild chili in Northeastern Mexico are gathered from natural habitats of the green shrubs in medium to high thorny desert scrubland, forests of Mesquite and oak forests, in addition to its cultivation in the greenhouse, and in backyards (Figure 1 and 2). This growth and the productivity of this wild chili in its natural areas are highly dependent on the prevailing ecological conditions. The prices, of the wild chili in northeastern Mexico, in the market depend on the climatic conditions prevailing in each season, and it

Figure H: Metaphase plate with 2n=24 chromosome number

offers a great economic support for the families of the rural environment, and its location. Its high demand and scarcity of production urges the necessity of the development of the technology for the management of the wild chili as sustainable alternative production (Villalon-Mendoza et al., 2014).

In view of the above facts, the present study is to publicize the activities concerning the technical and scientific measures on the transfer a technology package, which would make it possible to consider the management of wild chili (piquin chili) as an alternative sustainable productive (ecologically, economic, socially and technically) for the northeast of Mexico.

2. Materials and Methods

In the present work it is intended to assess the postharvest technology, to establish a protocol of germination of piquin chili and finally the development and transfer of technology for sustainable management of this wild chili in its natural

habitat:

2.1. Protocol for germination

The germination test is conducted for two months after the harvest of seeds. The temperature was 25 °C and the experiment was prolonged for 30 days. Germination was conducted in four replications with 50 seeds in each replication on filter papers and distils water in petri dishes of 90×15 mm^2. Also seeds were put for germination with 0% GA as control. Ramirez-Meraz (2001) mentioned that using AG_3 at a concentration of 5000 ppm for 24 hours, obtained results of germination of seeds from piquin chili of the order of 65% germination. Seeds in petri dishes are placed in a germinator (mark Lumistell ®) in 4 replications of 50 seeds in each; and are imbibed for 24 h with 5,000 ppm of Bio Gibb ® (10% GA); that is 10 g of the product in 200 ml of water.

For determining the level of significance among treatments analysis of variance and test of Tukey ($p \leq 0.05$) were undertaken through a statistical package.

2.2. Post-harvest technology

Observations were made on the growth and post-harvest technology of the wild species. In this aspect it was found that the drying of fruit at the shadow is very heterogeneous ensemble. In relation to this factor, Torres et al. (2013), mention that the best drying method for the fruits of piquin chili is to use stoves dryers, controlling temperature and drying time, which makes it homogenizes the quality of lots of fruits.

2.3. Development of technology and its transfer

In the present work it is intended to develop and transfer the technology and also knowledge for sustainable management of the wild chili, (regionally called "piquin"), which were generated since 1989 by researchers from different universities and national research institutes. This is coordinated by the Forest Science Faculty of the Universidad Autonoma of Nuevo Leon, located in the northeast of Mexico.

With the information gathered through scientific research for the last 25 years, a technological package for sustainable management of this wild chili is developed, and validated. This is transferred to the predictors of wild chili "piquin" in Mexico for its implementation.

The sustainable management of the resource of wild chili technology transfer was used to carry out these activities. Therefore, we carry out courses and workshops that support this resource, such as alternative production and improve the standard of living in the rural areas of Northeastern Mexico.

3. Results and Discussion

3.1. Protocol for germination

The piquin chili could not be cultivated in the fields commercially until 1990 for its poor germination less than 1% owing to the presence of hard seed coat and the presence of natural inhibitors. Under natural condition, the dormancy of the seeds eaten by birds are broken after passing though digestive tracts of the birds and the prevailing environmental conditions exposed to the seeds after seed dispersion on the soil. Currently, he is researching continuous ecological strategy, that present this species in their seeds, as is the process of dormancy and its relationship with environmental conditions and development of postharvest handling of their seeds, to increase the germination of the piquin chili were put up his (Guerrero-Velazquez et al., 2014).

In 1989, a protocol was initiated and later established in the Forest Science Faculty, UANL, for inducing the germination of piquin chili. In laboratory, tests were obtained an average of 68% ranging from 56 to 82%, of germination percentage of while the control gave 30%.

The production of the seedlings were undertaken in green house. Sowing is done in plastic trays filled with commercial peat moss. After 85 days of sowing, the seedlings were transplanted in big black plastic bags or in the field under the trees.

The germination of the seed had been an obstacle to the spread of this plant as a crop, under natural condition the fruits are eaten by birds and passed out through the digestive tracts and other environmental conditions thereby causing the breaking of seed dormancy, Aguilar-Rincon et al. (2010). Through the Technology Transfer Centre of Chili of the Forest Science, Faculty of the Universidad Autonoma of Nuevo Leon have been designed three types of productive packages according to the needs of the producer. Within these technological packages are;

3.1. Protocol for germination

It is this investigation study were obtained germination percentages between 60 and 85%, depending on the provenance of the seed. The foregoing confirms Guerrero-Velazquez et al., (2014), who found that the sources of the seeds if affects the germination protocols that must be used to break the dormancy of the seeds of wild chili of Mexico and the United States of America.

3.2. Post-harvest technology

At present, in the Northeast of Mexico this wild chili species is strongly rooted in its typical gastronomy and its cultures, This is because it plays a role in the diet of the inhabitants of the northeastern Mexico in various ways, either by the consumption of the fruit fresh or dried, in salads, sauces, pasta, pickles, moles, drinks, cocktails, etc. The results showed that

74% of the population in the study area consumed this fruit and use this in his home in different forms.

It was found that the fruit of the wild chili is considered a vegetable in home garden and is identified by the inhabitants of the north-east of Mexico. Culturally thereby, becoming a part of the culinary dishes, the characteristics of the region (Villalon et al., 2003). The test results showed that the wild chili was recognized for covetable aroma, its shape, size and characteristic flavor. Garcia et al. 2012, found similar results, noting that consumers of Chile did not detect the origin of the fruit; if production came from wild or cultivated production, by what he concludes that if there is the possibility of domesticating this regional resource.

The fruits were collected at end of autumn in December from wild plants in Linares, Nuevo Leon, located in the northeast of Mexico. It presents semi-arid climate with rainfall in the summer with an average temperature of 21.4 °C and precipitation of 800 mm annually.

The red fruits are collected in a mass scale and dried for 8 days at ambient temperature and in the shade. The seeds were extracted from the dried fruit and washed with water. Dry the seeds are separated from the best quality by selecting by immersion in water, the floating were eliminated.

It is observed that its fruits are small oval of 5 to 7 mm in diameter, which grows lonely with stalks, flowers creamy white in color. During the process of maturation the fruit color changes from green to orange and finally red. Hernandez et al. (1999), reported that the fruits contain an average of 18 seeds $fruit^{-1}$ and very spicy, but its characteristic flavor is very much appreciated by the consumers so that they are ready to pay up to more than 100 times the value of commercial chilies cultivated, as the "Serrano" or jalapeno. On the basis of the literatures surveyed and as well the analysis of markets, it is assessed that in the past few years the interest are increased to grow and use it for medicinal and nutritional properties (Medina, 2003). It was assessed that approximately an average, 3.2 kg of fresh chili makes a kg of dry chili.

Besides this, fruit has the possibility of increasing its value added for the inhabitants of the north-east of Mexico. It is one of the types of chili with greater national and international market, in addition to be eaten fresh. In order to increase the storage time and possibility of commercialization and export, this chili can be prepared as pickle, as red sauce, in brine or sold as red dried powder.

The above facts showed the importance of the wild chili in northeastern Mexico, as a natural resource of great socioeconomic relevance for its population, and about 63% of the accessions of the wild are marketed as fresh.

In addition to the findings of other researchers (Rodriguez del Bosque et al., 2003), the present study proved to be feasible that the wild chili during its processes of domestication, enhance its productive system through best management practices for soil and propagation, irrigation more technology and different methods of planting up to the conventional system, thereby making them more competitive.

The marketing of the chili wild in the northeast of Mexico comes mainly from collectors of wild populations, thereby generating a deterioration of the ecosystem and the natural banks of germplasm. This is, coupled with the difficulty that presents the germination of the seed (Medina, 2007).

The demand of the wild chili and its socio-economic importance as a natural resource, primarily in rural areas, make the species with potential for its production, therefore it is necessary to find an alternative to *in situ* conservation and production in a sustainable manner.

The annual market for this product is very large, regional (over 30 t), national (over 50 tons) and internationally (over 60 tons of dry fruit and red), just for its market in the neighboring country United States of America, (called "the nostalgia market)". It has been investigated intensively by different institutions, throwing very valuable information which supports the management of the wild chili as a productive alternative viable economically and ecologically for the Northeast of Mexico, with respect to the possibility of exporting of wild chili (Secretaria de Economia. 2005).

The growth of this wild chili species in natural areas depends entirely on the environmental conditions, such as soil, altitude, rainfall, potential evaporation and temperatures. In this way, the prices of the wild chili in the market, depends on the climatic conditions prevailing in each season (Villalon-Mendoza et al., 2014). This resource represents a great economic support for families in rural areas of northeastern Mexico, which by its location interact with the wild chili. This urges the necessity of the development of cutting edge technology for the management of the wild chili as sustainable alternative production.

3.3. Development the process of transfer of technology

On the basis of the information obtained from the producers of chili and from the conferences organized by Forest Science Faculty, three technologies have been developed and transferred mentioned below, this coincides with the recommended processes and that should be included and followed in the transfer of technologies in the rural environment that mentions (Villalon et al. 2009).

The technology transfer process for the sustainable management of the chili is divided as follows:

3.3.1. Conventional technology

The production of conventional, method using normal agricultural activities of cultivation, including the use of irrigation, agrochemicals, pruning, weeding and integrated control of pests and diseases, in the open air or with the use of mesh 30% shade.

3.3.2. Agroforestry technology

The agroforestry production is using native tree species (comprising the typical green scrub) as the generators of forest shade required for the cultivation of Chili, under an arrangement seeking to have a 30% shade at random. In this case, there may or not necessary to apply agrochemicals and the use of drip irrigation.

3.3.3. Organic technology

The organic production is using any of the two previous arrangements, but without the use of agrochemicals, neither directly nor indirectly.

Producers are looking for typically convention system of agricultural production, and then they go to the agroforestry for its low-cost and make it organic. Although in the region, there are producers who are interested for starting the type of organic production under agroforestry arrangement (Villalon et al., 2007). On the other hand, the income in the rural areas could help to reduce extreme poverty, efforts directed toward improving the power and other aspects that make up the standard of living, as they say Valeo and Valero (2015), it is important to study the protein and calorie intake of the homes to understand the status and the possible improvement or deterioration of poor households in Mexico. Similar findings was reported by Medina et al. 2006.

3.4. Regional situation

Seeds usually are selected in the region for the establishment of the productive area; in addition the producers carry out its mass selection of the best individuals from his plantation to harvest for good harvest. Economically, the system of agroforestry production turns out to be a production system for the first cycle of cultivation (10 months). It recovers the investment made and the economic gains are obtained attractive. One of the main problems observed is the difficulty of obtaining labor. At the time of the harvest, an average of seven collectors are normally required to carry out in the year, starting the first in the months of May and June which fetch the best prices in the market. The other problem facing during the cultivation of this species is the occasional damage caused by viruses transmitted by the whitefly (*Trialeurodesvaporariorum*), The above coincides with what was found by Medina-Matrinez (2007).

3.5. Actions executed for the transfer of technology on sustainable management

Courses and workshops are conducted on transfer of technology for the sustainable management of the wild chili: during the period from 2010 and up to date in 2014 in various states of Mexico (Nuevo Leon, Tamaulipas, Veracruz y Coahuila).

The participants interested producers, were found, both from the private sector, as "ejidatarios" (producers in rural areas who have a land tenure in a way communal) and communities, marketers, processors etc, and were highly appreciated by the participants/providers of technical services professional, exporters of the product field, students, suppliers, teachers of technical schools, collectors and authorities of the federal and municipal levels. In this course managed to convene stakeholders in the States of Tamaulipas, Nuevo Leon, Durango, San Luis Potosi, and Aguascalientes, Mexico. In addition was attended by 15 speakers of different institutions in the northeast of Mexico, who participated as instructors in the course and enriched the analyses and discussions of the issues. Should be noted that 43% of participants were of the female gender, what comes to highlight the importance of the culture of piquin chili for women entrepreneurs of north-eastern Mexico.

On the implementation of that kind of events that promote bonding and diffusion of the University with the society, fulfilling this with one of the tasks proposed by the same University of bonding transferring the technology generated through its research activities. The courses lasted for 16 hours, in two days, consisting of 15 issues, a workshop of financial management for producers of piquin chili in their productive activities, as well as the display of 8 posters on the sustainable management of the piquin chili also thus transfer technology to producers to take advantage of times of relaxation of those attending the event. The topics covered were the following topics: The conference contained various themes about: Handling and processing of seeds of piquin chili, Piquin chili of quality plant production techniques, Sustainable management of the culture of piquin chili in field under different production systems, Main friendly products with the environment and the human being for the control of pests and diseases of piquin chili, Management of mycorrhizal fungi to increase productivity in the cultivation of piquin chili, Techniques of fertilization as a productive strategy, where it was to learn the techniques of fertilization, Considerations for organic production certification of production of piquin chili, as this topic of great interest to producers, Post-harvest of piquin chili, quality and marketing, Sustainable control techniques of wildlife in plantations of piquin chili presented, Legal standards of management and production of piquin chili, Effect of capsaicin as part of the quality of piquin chili,Methodology of drying of the piquin

chili fruit for its conservation, Management of quality and organoleptic characteristics of the piquin chili, Alternative uses of piquin chili topic, Use of the piquin chili in regional cuisine culinary activities and its use in culinary activities and a workshop about the financial management. The workshop was conducted for piquin chili producers in their productive activities.

During the development of the course is generated constant interest of participants. The courses were the gastronomical samples which served food with all the participants, where it was the course, time which also served to interact in an interactive way between producers, researchers, buyers, processors, exporters and public in general. For this purpose, also was with areas for business, masses which were used by those interested in establishing negotiations.

4. Conclusion

This research carried out a package systems have been developed for sustainable agroforestry production of "piquinchili" with very good results, using the native vegetation as forestry component of the system. The technology transfer activities showed an impact in the studio area to increase the number of producers of chili in a 27% and the areas sown in a 74%.

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