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The vegetable garden in soilless protected agriculture, an alternative for family farming

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Abstract

The vegetable garden in soilless protected agriculture is a production model that can be an option to support low-income families. The National Autonomous University of Mexico, through the Aragón School of Higher Studies and the Degree in Planning for Agricultural Development, proposes the implementation of vegetable gardens to grow a diversity of species under protected agriculture by small-scale farmers who work at a family level. The aims of adopting this technology by small-scale farmers will be for instance the production of quality food, the creation of permanent sources of employment and getting an additional income in the productive unit, and at the same time making a sustainable use of natural resources such as water and the environment. This production model can be used in urban, peri-urban and rural areas. The vegetable garden project in protected agriculture without soil, was developed at the Center for Productive Practices of the Faculty of Higher Studies Aragón from 2019 to 2021. A 134-m² tunnel-type greenhouse was used with six beds with volcanic rock substrate and irrigation by drip. Six different horticultural species were grown: cucumber, jalapeño pepper, poblano pepper, spinach, lettuce, and radish. A modified Steiner nutrient solution was prepared for plant fertilization. A record was kept of the yield m⁻² of each of the species and the sale income. The results obtained show that this is an excellent alternative for obtaining fresh high-quality food by small farmers, a source of income and self-employment for their families and local people, and a wise use of the natural resources. The vegetable garden is an option to improve the productivity of family farming in Mexico.

Keywords: protected agriculture, family farming, soilless cultivation

INTRODUCTION

Globally, family farming is responsible for managing farmland and producing most food (FAO, 2014). The Food and Agriculture Organization (FAO) states that “family farming is necessary to guarantee food security, care and protection of the natural environment, end poverty, undernourishment and malnutrition”.

Family farming, also known as family farm, is defined as “a mode of agricultural, forestry, fishing, livestock and aquaculture production that is managed and operated by a family. It is predominantly dependent on family labor, including men and women. The family and the farm are linked, evolve together and combine economic, environmental, social and cultural functions” (FAO, 2014).

In the world, family farming is so diverse in size, access to market, technological level, access to financial resources, as well as culturally diverse depending on the region, even within the same country. Each farm makes use of natural resources in a different way, which combines activities like agriculture, livestock, fishing and the collection of forest products. Therefore, the public policies implemented by each government must take into account all these aspects.

Moreover, given the growing need to produce more healthy food, as well as the serious deterioration of the soil, which must be addressed both nationally and globally (SEMARNAT, 2009), it is important to propose alternatives to help family farming, which is the main

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producer of food, to improve their income, promote the employment of family labor and take care of the environment.

The vegetable garden under protected agriculture is an activity that can be developed by farming systems. Protected agriculture is a production system that uses metal structures and plastic covers to protect crops against wind, rain and pests. Greenhouses are used for that purpose, since they provide the highest level of protection and control. In Mexico, a garden is generally associated with the cultivation of fruit trees. However, this concept is also used for the cultivation of various vegetables in a small space near a family home. To differentiate and delimit it, the proposed system will be called horticultural garden, because it includes vegetables. On the other hand, protected agriculture is a production technique that has grown considerably in Mexico. Recently, in the year 2000, 700 ha were cultivated and by 2017 more than 25,000 ha have been reported (Bastida, 2017). Generally, protected agriculture in Mexico has used shade nets and greenhouses dedicated to monocultures such as tomato, cucumber and bell pepper. Most protected agriculture professionals in Mexico agree that for a production unit using this technology to be profitable, it must start with at least 1.0 ha, which implies a large investment and access to large markets.

As in the rest of the world, Mexican farmers work in small family units but they have little or no access to finance and new technologies. Family farming can also be found in the cities or near them, and it is known as urban and peri-urban agriculture. This is carried out on the limits of the cities or within them, and it includes several agricultural, livestock and forestry activities which provide ecological services to the community (Martínez, 2020). Taking into consideration this situation, the National Autonomous University of Mexico, through the Faculty of Higher Studies of Aragón and the Degree in Planning for Agricultural development proposes the implementation of small vegetable gardens including a diversity of species to be cultivated with protected agriculture by small farmers at a family level. The idea is to encourage the adoption of this technology to produce quality food, create permanent sources of employment and an additional income to the productive unit, by making a sustainable use of the natural resources such as water and the environment. Protected agriculture offers several advantages, for instance by using protection structures crops are isolated and protected against adverse climatic effects, the damage of pests and diseases. Cultivation under protected agriculture can be done on soil or using some substrate. For our project, because it was carried out in a city, the quality of the soil was not good, so substrate was chosen. However, to make this feasible, government support is required to finance the installation of the protection structures which can have a high initial cost. Moreover, the government needs to provide training and technical assistance to farmers.

MATERIALS AND METHODS

A horticultural garden project in protected agriculture without soil was developed in the Center for Productive Practices of the Faculty of Higher Studies Aragón from 2019 to 2021. For its implementation the students from the "Protected Horticulture" social service program of the Career in Planning for Agricultural Development of the Faculty of Higher Studies Aragón of the National Autonomous University of Mexico participated. The Social Service Program is a strategy of the educational institution to reinforce theoretical knowledge with practice. It has the purpose to bring students closer to the cultivation of vegetables and flowers throughout the cycle of the production process. Students carry out greenhouse cleaning activities, install the irrigation system and the planting beds, as well as carrying out the cultivation tasks, keeping the information record and supporting the students of lower grades when they visit the greenhouses. Additionally, along with the professor in charge, they propose agricultural development alternatives that can be implemented by farmers to benefit family farming.

For the horticultural garden, a tunnel-type greenhouse of 134 m² was used, with a height of 6 m at the top, a plastic cover with 85% light transmission and anti-aphid mesh on the sides and front. The greenhouse has a recirculation and air extraction system with an automated fogging system to control high temperatures during the day. The cost of the greenhouse and the equipment are high and this can be a limiting factor for the adoption of

this technology by small-scale farmers. Six beds were built with volcanic rock substrate and drip irrigation by strip, with drippers every 0.1 m. In each bed, a horticultural species was grown, like cucumber (*Cucumis sativus* L.), jalapeño pepper (*Capsicum annuum* L. var. *annuum*), poblano pepper (*Capsicum annuum* L. var. *annuum* 'Chile Poblano'), spinach (*Spinacea oleracea* L.), lettuce (*Lactuca sativa* L.) and radish (*Raphanus sativus* L.). A modified Steiner nutrient solution was prepared for the fertilization of the plants. A record was kept of the yield m^{-2} of each of the species and of the income obtained from their sale. Each planting bed was 10 m long by 0.82 m wide and 0.3 m deep to have a cultivated area of 8.2 m^2 . For the cultivation of cucumber, lettuce, jalapeño and poblano peppers an indirect planting system was used. First, the seeds were germinated in a nursery and then, they were transplanted to the tezontle beds. For the radish and spinach, direct sowing was done on the planting bed. All the activities related to crop management and record keeping were carried out by the students of the social service program and coordinated by the professor in charge of the project.

RESULTS AND DISCUSSION

The results obtained from the horticultural garden project are described in this paragraph. Firstly, it is worth to mention that the species produced in the greenhouse were evaluated individually, taking into consideration the time from plating or transplanting to harvest, total yield per cycle and the number of cycles that can be established in a year. On the other hand, the selling price kg^{-1} or unit^{-1} and the total income obtained from each species per crop cycle and a sum of the income for the entire production unit were also considered. Additionally, for the crop cycle the time elapsed from sowing to the last day of harvest was considered too. For the cultivation of spinach, the leaves were cut and sold in bags of 200 g (units). In the case of radishes, the sale was made in bunches (group of 10 radishes with an average weight of 532 g), and a head of lettuce has an average weight of 450 g piece^{-1} . For the selling price, the final price was calculated without intermediaries, and the vegetables were sold directly to the consumers at a fair price. Generally, the price paid by intermediaries is 60% lower than that paid by final consumers. For example: a lettuce that costs \$ 30 to the final consumer, the intermediary only pays \$ 18 to the producer.

As can be observed in Table 1, the vegetables that offer the highest income are cucumber, spinach, jalapeño pepper and poblano pepper. However, these species have very long growing cycles, with the exception of the spinach, which means that it takes much longer to produce them and get an income than lettuce, spinach and radish.

Table 1. Results of the production and sale of six vegetables in the horticultural garden of 134 m^2 (prices are in Mexican pesos \$).

Crop	Crop cycle (days)	Yield m^{-2}	Total yield	Selling price (\$)	Total income (\$)
Cucumber	180	44.87 kg	368.0 kg	15.0 kg^{-1}	5,520.0
Jalapeño pepper	180	17.9 kg	147.0 kg	20.0 kg^{-1}	2,940.0
Poblano pepper	180	13.35 kg	109.5 kg	20.0 kg^{-1}	2,190.0
Lettuce	90	12.8 pieces	105 pieces	15.0 piece^{-1}	1,575.0
Spinach	60	55.7 units	441 units	10.0 unit^{-1}	4,410.0
Radish	45	17.4 bunches	143.0 bunches	10.0 bunch^{-1}	1,430.0

Our proposal for the family vegetable is to be used throughout the whole year by a family. Considering that the species have different cultivation cycles in a year, there might be from 2 to 8 production cycles (Table 2). In such a way, the following results might be obtained in a year.

Moreover, it is of vital importance to take into consideration the expense to be done in fertilizer and water (Table 3). The cost of the fertilizers was obtained directly from the agricultural input suppliers, and the cost of the water was obtained from CONAGUA (2020). As for the water and fertilizers expenditure, the information records kept during the development of the project provided the necessary data.

Table 2. Projection of cycles per year, yields and annual income of each of the species considered in the horticultural garden of 134 m² (prices are in Mexican pesos \$).

Crop	Cycles year ⁻¹	Yield year ⁻¹	Annual economic income (\$)
Cucumber	2	736.0 kg	11,040.0
Jalapeño pepper	2	294.0 kg	5,880.0
Poblano pepper	2	219.0 kg	4,380.0
Lettuce	4	420.0 pieces	6,300.0
Spinach	6	2,646 units	26,460.0
Radish	8	1,144 bunches	11,440.0
Total			65,500.0

Table 3. Expense of fertilizer and water in the horticultural garden of 134 m² year⁻¹.

	Expense (kg)	Cost (\$ kg ⁻¹)	Total (\$)
Potassium nitrate	46	20	920.0
Nitric acid	86.81	36.3	3,151.2
Calcium nitrate	39.5	28	1,106.0
Phosphoric acid	17.71	117.1	2,073.8
Potassium sulfate	30.22	16	483.5
Magnesium sulfate	36	35	1,260.0
Microelements (complex)	4.5	500	2,250.0
Water	90.0 m ³	22.98 m ³	2,068.2
Total			13,312.7

Labor cost: \$ 4,435.92.

The cost of the labor was calculated based on the average of 10 wages ha⁻¹ day⁻¹, considering that there is an area of 134 m², so the cost is 0.13 wages per day. If the day has 8 h, the farmer will be using an average of 1.0 h day⁻¹, which represents 3 days month⁻¹ and 36 days year⁻¹. For the calculation, the minimum wage for Mexico in 2020 of \$ 123.22 is considered (Secretaría del Trabajo, 2021).

Considering the cost of the fertilizer, water, and the labor cost the family income year⁻¹ in the vegetable garden is \$ 47,751.38.

Taking into consideration that the minimum wage for the year 2020 in Mexico was \$ 123.22 day⁻¹ (Secretaría del Trabajo, 2021), it is possible to claim that a worker can obtain a gross income without considering benefits and Christmas bonus up to \$ 35,487.36. This means that the income obtained from the horticultural garden of 134 m² under protected agriculture is 1.34 times higher than the one earned by an employee working for a week (six days). This information allows us to conclude that in a small horticultural garden, healthy food and an additional income can be obtained in the family unit. Moreover, self-employment is encouraged due to the fact that the agricultural activities can be carried out by family members in their free time.

The production system is friendly to the environment due to the protection that the greenhouse allows, and by having a good management of it, it is possible to reduce the application of agrochemicals to control pests and diseases. Additionally, there is an efficient water management by the proper control of the drip irrigation system. For these projects to be successful, it is important that the government finances the construction of the greenhouses, the acquisition of the irrigation and environmental control equipment, since these are expensive and the farmer could not afford them. On the other hand, it is of vital importance that educational institutions participate in the generation of this type technology, as well as train and support farmers with technical assistance and courses for crop management, irrigation and plant nutrition. Without that support, it is difficult for farmers to achieve acceptable yields to improve their income.

CONCLUSIONS

As a conclusion, the vegetable garden in protected agriculture is a strategy for the development of family farming. This can take place in small spaces and can be used in rural, urban and peri-urban areas. It allows obtaining fresh and healthy food, promotes family integration, self-employment and it is friendly to the environment. By cultivating different species of vegetables in the horticultural garden, it is possible to have a greater diversity of food and offer several products to the same buyer.

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