Strawberry production (*Fragaria* × *ananassa* Duchesne ex Rozier) in coconut fiber slabs under greenhouse, a teaching tool

E. Cedillo[a], L.P. Martínez, P. Castro and F.D. Contreras

Licenciatura en Planificación para el Desarrollo Agropecuario, Facultad de Estudios Superiores Aragón, Universidad Nacional Autónoma de México, Mexico.

Abstract

Strawberry production in Mexico has been increasing in recent years. In 2018, 13,562 ha were harvested in Mexico, while in 2010 only 6,273 ha were harvested. It means that in a period of 8 years, there has been an increase of more than 100%. The main producing state is Michoacán with more than 76% of the cultivated area in Mexico. The majority of strawberry is cultivated in the open field and a small area in tunnels of low technology. Strawberry production under greenhouse conditions is still very scarce in Mexico and there is little information about it. The Center of Productive Practices of the Faculty of Higher Studies Aragon of the National Autonomous University of Mexico, is a learning and knowledge space of protected agriculture for students of the Bachelor of Planning for Agricultural Development. In the period from August 2017 to March 2018, 'Festival' strawberry was grown under greenhouse conditions in coconut fiber slabs. The objective of doing this was for students to learn about strawberry production and management, but also to participate in the planning, design and implementation of this type of projects to support farmers once they graduate. However, water quality is not the most appropriate in the study area, as it has a high concentration of salts and bicarbonates. Coconut fiber slabs of 100×15×12 cm with a capacity of 18 L were used, with a separation between plants of 20 cm and between slabs of 15 cm. Drip tape irrigation and a modified Steiner nutrient solution were used. The students experienced, observed and learned to carry out the strawberry crop management practices. Under a constructivist approach, students learned by doing, it means that they participated in the whole productive process.

Keywords: subtrate, nutritive solution, crop, protected agriculture, slabs

INTRODUCTION

Strawberry is one of the horticultural crops with the highest growth in the cultivated and harvested area in Mexico within the last 8 years (Table 1). In 2010, 6,273 ha were harvested; for 2015 10,073 ha were harvested; for 2018, 13,562 ha were harvested, approximately in an increase of more than 100% with respect to 2010 (SIAP, 2019).

This expansion is due to a reassessment of its nutritional properties and new cultivation technologies that contribute to obtaining higher yields per unit area and higher quality and food safe products.

The strawberry fruit is appreciated for its shape, color, flavor and aroma and; it can be consumed directly, in yogurt and desserts. In addition, it is widely valued for its nutritional properties since it is a fruit very rich in antioxidants, fiber and minerals (magnesium, manganese, potassium), which provides flavonoids and vitamins (C, B2, B3, folic acid) and is low in sugars and calories, so they fit well in most diets. Approximately 90% of strawberries are water, and around 7% are carbohydrates (fructose, glucose and xylitol) (Valero et al., 2018).

[a]E-mail: ecedillo130766@hotmail.com

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Table 1. Strawberry production in Mexico 2010-2018. Source: http://www.siap.gob.mx.

Year	Harvested area (ha)	Production (t)
2010	6,273.91	226,614.71
2011	6,978.40	228,899.59
2012	8,663.80	360,426.45
2013	8,496.85	379, 463.88
2014	9,965.85	458,971.63
2015	10,073.46	392,625.19
2016	11,090.93	468,248.48
2017	13,849.78	658,435.89
2018	13,652.16	653,639.24

Greenhouse strawberry production in coconut (*Cocos nucifera*) fiber slabs is considered friendly to the environment because strawberry can be produced with less water while higher yield and quality is obtained (Martínez et al., 2017). Moreover, the use of agrochemicals decreases notably and soil is not compacted, as occurs in conventional agriculture (Cedillo et al., 2019). With good handling, coconut fiber slabs can be used for several cycles. Also, where the soil conditions are not ideal, coconut fiber can be a good substitute and can be adapted to many cultivation systems. For example, raised beds from the ground can be used to prevent the strawberry fruits from coming into contact with the ground to avoid contamination by bacteria and fungi. Different types of water can also be used but the important thing is to have a chemical analysis of it to offer adequate nutrition to the crop and avoid the presence of biological contaminants in it.

Strawberry is a crop that adapts very well to many types of climates. However, it prefers temperate climates and the harvest is more suitable in the winter months (November-February in Mexico). Its vegetative parts are resistant to cold. The optimal values for proper fruiting are around 15-20°C.

The majority of the strawberry is cultivated to open field, and just a small surface is cultivated in tunnels of low technology. For that reason, the strawberry cultivated under greenhouse conditions is still very scarce in Mexico and there is little information about it. This is the reason why; the Center for Productive Practices of the Aragón School of Higher Studies of the National Autonomous University of Mexico is committed to helping solve the problems that afflict strawberry producers in Mexico through the training of students in bachelor's degree for Agricultural Development. With this aim in mind, the Center of Productive Practices provides a space for learning protected agriculture. During the period between August 2017 to March 2018, 'Festival' strawberry was grown under greenhouse conditions in coconut fiber slabs in order to train students in the management of the strawberry production system. This way students are able to participate in the planning, design and implementation of this type of projects to support strawberry producers once they graduate.

MATERIALS AND METHODS

Students participated in the social service program called "Protected Horticulture" from the Career in Planning for Agricultural Development of the Faculty of Higher Studies Aragón of the National Autonomous University of Mexico. The social service program is a strategy of the educational institution to reinforce theoretical knowledge with practice and brings students closer to the cultivation of vegetables and flowers during the entire cycle of the production process.

Learning by doing was the teaching method used to guide students to learn by being directly involved in the strawberry productive process under greenhouse conditions. This "is a method by which students make the most of their education through active participation. In the process, the learner took ownership of own learning" (Fikru, 2020).

As mentioned above, the students with the supervision of the teacher carried out the cleaning activities of the greenhouses, installed the irrigation system and the planting beds,

as well as carried out the cultivation tasks, kept the information record and supported their partner students of lower grades when they visited the greenhouses. During the activities, students had the teacher's support but also their peers', this way they were able to construct their own learning through experiences and observations made in the greenhouse. According to constructivism, learning is an active process which is socially constructed. This is "an approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner" (Elliott et al., 2000).

A tunnel-type greenhouse with a 6.6 m-wide by 24 m-long zenith ventilation, a zenith height of 6 m, a plastic cover with a light transmission of 85% and anti-aphid mesh on the sides and front was used (Figure 1). The greenhouse also has an air recirculation system and an automated fogging system to control high temperatures during the day.

Figure 1. Tunnel-type greenhouse where the work was carried out, the planting beds and the students' work are shown.

Planting beds raised from the ground to a 1 m-height were used, with 3 rows of 100×15×12 cm coconut fiber slabs, with 8 holes per slab in a three-bolillo planting frame (this term refers to a transplant in equilateral triangle shape) at a distance between plants of 13 cm and between rows of slabs of 15 cm. A drip irrigation system was installed with a strip with emitters every 10 cm. 15% drainage was managed with an open system. The preparation of the nutritive solution was carried out in a 2500-L tank with a ½ HP pump, a mesh filter and an irrigation timer. The nutrient solution was made directly and manually in the 2500-L tank, handling an electrical conductivity of 2.0 mS cm^{-1}.

'Festival' strawberry was used, which is one of the leading cultivars in Mexico, due to the fact that it produces abundant fruit of excellent quality, both for fresh consumption and for processing. It is a short photoperiod plant with early production that is consistent and uniform. It is a great producer of stolons and performance. Moreover, it produces bright red strawberry with a conical shape, firm texture and excellent flavor. The fruit maintains a medium to large size throughout production. It is susceptible to fruit anthracnose (*Colletotrichum acutatum*), crown rot (*Colletotrichum gloeosporodies*) and bacteria (Sistema Producto Fresa, 2012).

The strawberry plants were transplanted on August 30, 2017, the harvest started 60 days after the transplant and ended 5 months later. The plants ware produced by the company "PLANANASA" located in Guanajuato, Mexico. The fruit was harvested twice a week. Old leaves were pruned every 15 days and defective or poorly pollinated fruits were removed every 10 days. Pollination was done manually and daily when, the students moved the strawberry plants.

A modified Steiner nutrient solution was used, due to the fact that the water in the

region is very high in salts, chlorides and bicarbonates (Table 2).

Table 2. Nutritive solution used in strawberry.

Nutritive solution	NO_3^-	$H_2PO_4^-$	SO_4^-	HCO_3^-	K^+	Ca^{2+}	Mg^{2+}
Calculated formula (meq L^{-1})	12	1	7	1	7	8	5
Water analysis (meq L^{-1})	0.05	0.02	0.9	5.8	0.79	4.14	3.62
Applied nutritive solution (meq L^{-1})	11.95	0.98	6.1	-4.8	6.21	3-86	1.38

RESULTS AND DISCUSSION

Learning by doing has been an effective way to consolidate knowledge and put it into practice, due to the fact that the students were involved actively in the whole productive process. The facilities where the strawberries were grown are in the Valley of Mexico, a highly populated urban region, where most of the students have no link with the agricultural sector. For that reason, the participating students showed great interest in learning about production technology and the possibilities of using substrates and greenhouses in urban areas with reduced spaces, the efficiency in the use of water through the use of the drip irrigation system, and the consumption potential of strawberries in the study area. All the production was commercialized between the members of the university community, which was something that generated a lot of interest among the students to continue producing strawberries.

A group of six graduates of the degree in Planning for Agricultural Development, which have an interdisciplinary training in economic, social, planning and productive aspects were directly involved in this program. As a result, they had the opportunity to put into practice all the knowledge previously acquired in the classroom. Because they were in charge of carrying out all the practical activities like the following: transplantation, pruning, preparation of nutritive solutions, phytosanitary control, pollination, harvesting and registration of information, but also keeping a record of them, and evaluating the results obtained at the end. The teacher only acted as a tutor and advisor for these activities, making the necessary supervision.

The students experienced, observed and learned how to carry out the management practices of the strawberry crop. The results from the productive point of view were not very high, there was an average yield of 20 t ha^{-1}, but the learning acquired by the students was the most important outcome as part of their training. Because, in optimal management conditions it is possible to obtain until 70 t ha^{-1} (INTAGRI, s/a).

Additionally, the graduate students mentioned before supported with guided visits to other students still in the training-process and had an active participation as helpers in the delivery of a course regarding Vegetable Management Under Greenhouse Conditions. Also, they helped with the teaching of the following subjects: Agricultural Production, Management of Technological Packages, Agrosystems and Agricultural Systems of the Bachelor in Planning for Agricultural Development, where about 100 students were trained.

CONCLUSIONS

The production of strawberries in coconut fiber slabs under greenhouse conditions is a suitable alternative to learn to cultivate under protected agriculture in agricultural teaching institutions. It allows students to learn directly about the management and care of the crop, which is something that in the future will help them to generate new technological alternatives for Mexican producers.

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