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Effects of early and late sowing on the profitability of cucumber (*Cucumis sativus* L.) production

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ABSTRACT

Objective: To analyze how early and late sowing can improve the income of cucumber producers in the state of Michoacán, Mexico.

Design/Methodology/Approach: Monthly income, production cost, profit, and benefit-cost ratio were calculated in three sowing scenarios: middle, early, and late.

Results: In an early sowing scenario, the income and profit of the producers increase by 10.2 and 9.2 million pesos, respectively, compared to the middle sowing scenario. Likewise, in a late sowing scenario, producer income and profits increase by 29.2 and 20.0 million pesos, regarding the middle sowing scenario.

Study Limitations/Implications: The negative effects on vegetable prices of temporary excess supply prove the need to plan the surface that will be used for early and late sowing, as well as to create a regulatory body that plans the cucumber sowing area.

Findings/Conclusions: Sowing cucumber and other vegetables in early or late dates is recommended, since better production planning will increase the producers' income and profit.

Keywords: cucumber, early sowing, late sowing, planning.

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INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the main vegetables exported by Mexico to the global market. For example, in 2020 Mexico was the largest exporter of cucumbers of the Americas, with 809,000 tons (FAO, 2020). Michoacán is the fourth largest cucumber producer in the country, behind the states of Sinaloa, Sonora, and Morelos (SIAP, 2021). In 2021, it accounted for 17.1% of the domestic market (Martínez-Mendoza, 2021). The cucumbers produced in Michoacán are destined for the domestic market (SADER, 2018). In 2020, Michoacán produced 64,900 tons of cucumber. This was an atypical year, in terms of harvest and commercialization, since this was the lowest volume for the 2016-2020 period, when the production reached >95,000 tons each year (SIAP, 2022b).

Like most horticultural products, cucumber faces a temporary price volatility problem. The fall in prices is a consequence of several factors, including the seasonality of production (Martínez-Jiménez and García-Salazar, 2020). Since cucumber production depends on biological and climatic conditions, it is concentrated in certain months. On the one hand, the largest cucumber harvest was obtained in January 2020, with 12,000 tons (SIAP, 2022a) and the producer price was the lowest of the year, with 3,500 pesos per ton (SIAP, 2022b). In conclusion, the decrease in income negatively impacts the producers.

On the other hand, volatility implies that cucumbers are more expensive in some months, as a consequence of the scarcity of the product. For example, the producer price reached $6,500 pesos per ton in April, a month in which barely 3,000 tons were produced (Table 1). In this sense, high cucumber prices have a negative effect on the consumer.

Another factor that explains the fall in cucumber prices is that most vegetables are perishable, which makes their storage impossible. Unlike grains, vegetables cannot be stored and, if they are consumed fresh, it must be shortly after they have been harvested. A third factor is the atomization of cucumber production. In the case of Michoacán, 970 agricultural producers are focused on this activity, which determines a high geographic dispersion and low price-negotiation power.

The inverse relationship between production and price accentuates the problem. The production cost of cucumber can reach $105,000 mexican pesos per ha (Ramírez Abarca *et al.*, 2021), while an average yield of 13.9 tons per ha was obtained in Michoacán (SIAP, 2021). The previous data indicate that the cost can reach $7,600 pesos per ha —higher than the price in some harvest months.

The seasonal fall in prices caused by excess supply is a phenomenon that has been recorded in many countries. Since 1937, the USA has addressed the problem through a marketing order policy, which focuses on the organization of the vegetable and fruit markets, through the supervision and regulation of trade agreements (AMS, 2022).

In Canada, the government pays a compensation to the producers, if the market price of their product does not reach the target; in exchange, farmers agree to refrain from sowing when the market is saturated (Colomé, 2010).

Currently, Mexico lacks a similar policy. In the 1990s, the excessive supply of horticultural products and the price volatility in Mexico were addressed by the Confederación Nacional de Productores de Hortalizas (CNPH), which analyzed the most important vegetables, as well as the future needs of the global market (Ramírez-Barraza *et al.*, 2015).

If the volatility of cucumber prices in Michoacán is a consequence of the seasonality of production, then the problem can be faced by "moving" production over time. Increasing the synchronization of early and late sowing with consumption will prevent temporary excess supply and falling prices.

The aim of early and late sowing would be to increase the producers' income. However, the implementation of these practices poses risks, such as frost or the presence of pests and diseases (Chew Madinaveitia, 2009).

This research sought to analyze the effects that early and late sowing would have on the producers' income and profit. The hypothesis establishes that early and late sowing will improve the income of Michoacán's cucumber producers.

MATERIALS AND METHODS

To achieve the objective, the producers' income, cost, and profit were calculated in different scenarios, considering early and late sowing. Using t as the month in which the production is obtained, the following indicators were determined:

$$ING_t = QPP_t * PP_t \quad (1)$$

$$CP_t = \sum_{i=1}^{I} \left[X_{it} * PI_{it} \right] \quad (2)$$

$$G_t = ING_t - CP_t \quad (3)$$

$$GU_t = \frac{G_t}{QPP_t} \quad (4)$$

$$RBC_t = \frac{G_t}{CP_t} \quad (5)$$

Where ING_t is the income for month t; QPP_t is cucumber production for month t; PP_t is the average rural price for month t; CP_t is the production cost for month t; X_{it} is the quantity of input i used for month t; PI_{it} is the price of input i for month t; G_t is the profit for month t; GU_t is the unit profit for month t; and RBC_t is the Benefit-Cost Ratio for month t.

Income (Equation 1) is determined multiplying production by the average rural price. Production costs (Equation 2) are the results of adding the partial costs (quantity of inputs multiplied by the price of each input). The monthly profit (Equation 3) is obtained discounting production costs from income. The unit profit (Equation 4) is determined through the division of the total monthly profit by the monthly production. The Benefit-Cost Ratio per month was established using Equation 5.

To achieve the objective, income and profit were calculated in three scenarios: a) observed sowing in the year of analysis (middle sowing), b) early sowing, and c) late sowings. Cucumber production in Michoacán in 2020 was obtained from SIAP (2022b). The average rural cucumber prices were obtained from the Sistema de Información Agroalimentaria de Consulta (SIAP, 2022b). The cucumber production cost per hectare was calculated using the monthly yield reported in the sowing and harvesting estimates (SIAP, 2021) and the production cost per hectare was obtained from Ramírez Abarca (2021).

The agricultural calendar reported by the Secretaría de Agricultura y Desarrollo Rural (SADER, 2022) was used for this study. According to this calendar, the AW sowing cycle starts on October of one year and ends on March of the following year, while the harvests begin in December of one year and conclude in September of the following year. Meanwhile, the SS sowing cycle occurs from April to September of one year and the harvests from June to March of the following year.

RESULTS AND DISCUSSION

Middle sowings

In 2020, the annual cucumber production in Michoacán was 65,000 tons. The monthly production ranged from 2,300 to 12,000 tons and extreme values were reported in December and January. In conclusion, a market seasonality was observed. The results are shown in Table 1.

The average annual price was $4,457 pesos per ton, although production seasonality impacted price behavior, which fluctuated between $3,476 and $6,460 pesos per ton (Table 1).

The producers' income amounted to $280.9 million pesos and costs reached $287.4 million pesos, resulting in a loss of $6.5 million pesos. Since income depends on the behavior of production and price, a strong variation is observed between the minimum ($9.0 million pesos in December) and the maximum ($41.8 million pesos in January) values. The producers' economic benefit also ranged from $16.4 to $5.7 million pesos between March and September (Table 1). The average monthly Benefit-Cost Ratio (RBC) was 0.98, which indicates that $2 pesos were lost for every $100 pesos invested.

Early sowing

Sowing, particularly during the early stages, optimizes the number of plants harvested, maximizing production, as long as the amount of water, physical barriers, and soil

Table 1. Income and profits from cucumber production in Michoacán, Mexico in 2020. Thousands of tons, pesos per ton, and millions of pesos.

Month	Production thousands of tons	Price pesos per ton	Income	Cost	Profits		Benefit-cost ratio
					total	unit	
			millions of pesos		pesos per ton		
January	12.0	3,476	41.8	43.6	−1.72	−143	0.96
February	9.5	4,118	39.3	34.3	5.00	523	1.15
March	7.4	5,351	39.8	56.2	−16.38	−2,201	0.71
April	3.0	6,460	19.5	14.2	5.36	1,774	1.38
May	3.2	5,597	18.2	14.4	3.79	1,168	1.26
June	4.0	4,643	18.3	17.3	1.07	270	1.06
July	4.6	3,689	17.0	19.9	−2.98	−648	0.85
August	4.1	3,775	15.6	18.0	−2.33	−562	0.87
September	5.3	4,028	21.4	15.7	5.69	1,071	1.36
October	6.1	4,656	28.3	27.8	0.56	93	1.02
November	3.3	3,760	12.5	16.1	−3.58	−1,077	0.78
December	2.3	3,936	9.0	10.0	−1.00	−438	0.90
Total	65.0	4,457	280.9	287.4	−6.52	−100	0.98

Source: Table developed by the authors, based on the results of Scenario 1.

nutrients are controlled. Table 2 shows the effect on profit of implementing early sowing. The scenario was based on the same annual cucumber production in Michoacán (65,000 tons), distributed in a different proportion each month. The same average rural price was considered. The results of the scenario are: a) the producers' income increased from $280.9 to $291.0 million Mexican pesos; b) total profit increased from -$6.5 to $2.6 million pesos; c) the profit per ton increased from -$100 to $41 pesos per ton and; d) the benefit-cost ratio increased from 0.98 to 1.01. These changes in production over time can be observed by comparing Table 1 and 2.

Late sowing

Late sowing during the AW cycle is carried out in the months of February and March, which allows producers to adjust harvest times to coincide with the months with highest prices (April and May). Therefore, delaying part of the sowing from January to May, allowed producers to benefit from the higher prices recorded in 2020.

The results obtained with the late sowing scenario are the following: a) income increased from $280.9 to $310.1 million pesos, which represents a 10.4% growth, compared with the base scenario; b) the total profit increased by $20.0 million pesos, from −$6.5 to $13.5 million pesos; and d) the unit profit increased from −$100 to $207 pesos per ton, much higher than the increase observed in the early sowing scenario. The improvement of the benefit-cost ratio amounted to 1.05.

The results obtained in the two scenarios are similar to those obtained by other authors. Espinoza-Arellano (2019) determined that profitability was higher in the early and late sowing of melon of 2016 than in the average sowing. Grijalva Contreras (2011) concludes

Table 2. Income and profit from cucumber production in Michoacán, Mexico in an early sowing scenario. Thousands of tons, pesos per ton, and millions of pesos.

Month	Production thousands (ton)	Price pesos per ton	Income	Cost	Profits		Benefit-cost ratio
					total	unit	
			millions of pesos		pesos per ton		
January	12.0	3,476	41.8	43.6	−1.72	−143	0.96
February	9.5	4,118	39.3	34.3	5.00	523	1.15
March	7.4	5,351	39.8	56.2	−16.38	−2,201	0.71
April	5.4	6,460	35.0	25.4	9.62	1,774	1.38
May	5.0	5,597	28.0	22.2	5.85	1,168	1.26
June	4.2	4,643	19.6	18.5	1.14	270	1.06
July	1.5	3,689	5.7	6.6	−0.99	−648	0.85
August	2.8	3,775	10.4	12.0	−1.55	−562	0.87
September	5.3	4,028	21.4	15.7	5.69	1,071	1.36
October	6.1	4,656	28.3	27.8	0.56	93	1.02
November	3.3	3,760	12.5	16.1	−3.58	−1,077	0.78
December	2.3	3,936	9.0	10.0	−1.00	−438	0.90
Total	65.0	4,457	291.0	288.4	2.64	41	1.01

Source: Table developed by the authors, based on the results of Scenario 2.

Table 3. Income and profit from cucumber production in Michoacán, Mexico in a late sowing scenario. Thousands of tons, pesos per ton, and millions of pesos.

Month	Production thousands (ton)	Price pesos per ton	Income	Cost	Profit		Benefit-cost ratio
					total	unit	
			millions of pesos		pesos per ton		
January	4.0	3,476	13.9	14.5	−0.57	−143	0.96
February	4.8	4,118	19.7	17.2	2.50	523	1.15
March	6.5	5,351	34.7	49.0	−14.29	−2,201	0.71
April	9.9	6,460	63.9	46.3	17.54	1,774	1.38
May	9.0	5,597	50.6	40.1	10.56	1,168	1.26
June	5.0	4,643	23.4	22.0	1.36	270	1.06
July	4.6	3,689	17.0	19.9	−2.98	−648	0.85
August	4.1	3,775	15.6	18.0	−2.33	−562	0.87
September	5.3	4,028	21.4	15.7	5.69	1,071	1.36
October	6.1	4,656	28.3	27.8	0.56	93	1.02
November	3.3	3,760	12.5	16.1	−3.58	−1,077	0.78
December	2.3	3,936	9.0	10.0	−1.00	−438	0.90
Total	65.0	4,457	310.1	296.6	13.47	207	1.05

Source: Table developed by the authors, based on the results of Scenario 3.

that, by delaying its sowing, cucumber can be produced from November to May, dates that match the months of 2020 —when the highest producer prices were obtained (March, April, and May).

Although early and late sowings allow producers to face the volatility of cucumber prices, they also imply certain risks. Early AW sowings and harvests —which occur from November to the end of January— offer the producers the possibility of accessing better prices, at the risk of having their plants die from frost (Espinoza-Arellano, 2019). To avoid these and other agricultural risks, Bielinski *et al.* (2010) point out that crop protection during winter is a modern measure. Artificially altering the microclimate changes solar radiation, temperature, wind, humidity, and soil conditions, providing protection against frost and strong winds, extending crop cycles, and promoting precocity (advancement of the harvest).

The drawback of late SS sowing and late AW harvests —which take place in summer and spring, respectively— are high temperatures, that favor the presence of insects, fungi, and viruses (Espinoza-Arellano, 2019). According to Arias and Fuentes (2012), the phytosanitary aspect has a high incidence in cucumber production, especially in late sowing, when fungi, bacteria, viruses, plasmodia, weeds, and insects attack the plant to use it as a means of reproduction or food, potentially damaging and affecting the development of the crop.

Monitoring the crop and establishing integrated pest management (*e.g.*, rotating cucumber with sweet pepper) is an important measure to address this problem. Some diseases caused by microorganisms impact the cucumber's quality of production, damaging the leaves, vascular system, roots, and fruit. Pest and disease management requires a logic of integrity. Phytosanitary control must be considered as a unit of simultaneous protection, which includes the reduction of the environmental impact and the sustainability of the agroecosystem. The implementation of a given measure should contribute to solve another core problem.

Mexican producers must, as in other countries, join a regulatory body to address price variability. Among other functions, the said body would carry out economic studies to determine the optimal production levels that meet domestic and international consumers. In a joint effort with the Mexican Ministry of Agriculture, quotas should be established to avoid temporary excess supply and market saturation.

This organization must include experts and specialized academicians to carry out economic research that promotes the marketing order. The organization will be an agricultural regulatory body that organizes agricultural markets to control the supply of products in periods of abundance. It should also promote technologies such as staged sowing.

CONCLUSIONS

The analysis of the income and costs of cucumber production in Michoacán indicates that seasonality prevents the profitability of the said activity during certain months. Price volatility can be addressed through early and late sowing. Such practices —based on the modification of sowing and harvest times to take advantage of the months in which average rural prices exceed the annual average— allow the farmers to move from a loss situation to a profit situation. In early and late sowing scenarios, the benefit-cost ratio would increase from 0.98 to 1.01 and 1.05. Therefore, producers are advised to choose a late sowing scenario.

The excesses in the temporary supply of cucumber cause the fall in prices and can only be avoided through the organization of the producers. They must jointly plan the level of production and surface that allows them to supply the domestic market and avoid its saturation.

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