

PROFITABILITY TO THE PRODUCER FOR THE CULTIVATION OF AMARANTH IN THE MUNICIPALITY OF CUAPIAXTLA, TLAXCALA

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ABSTRACT

The cultivation of amaranth has been booming in recent years. Given the importance of its nutritional contributions, producers in the municipality of Cuapiaxtla, Tlaxcala produce this plant year after year on their lands, for some years ago. The objective is to know the profitability of amaranth cultivation through the generation of three measures of profit, based on production costs of the activities demanded by amaranth cultivation, using a case study. A cost structure is made (variable and fixed costs); as well as the total value of the production yield, known as Total Production Revenue (TPR), for producers who opt for machinery on rental in two cases, when they apply chemical fertilizers and when they do not apply those, during the production cycle of the amaranth crop; with one hectare of land as reference. Results indicated that the activities carried out during the production of rain fed amaranth crop, for each hectare of cultured land a Net Income of MXN \$ 13,282 pesos is generated to the producer for a yield of 1.5 tons using chemical fertilizers, and a Net Income of MXN \$ 4,750 pesos to the producer for an approximate yield of 1 ton, without using chemical fertilizers. It is concluded that the cultivation of amaranth is profitable; activities that require greater economic contribution are observed with the classification of variable or fixed costs. Three measures of profit help producers to make a decision according to their income and to have an estimation of their profit.

Keywords: net cash income, net income per hectare, net income to the producer.

INTRODUCTION

The *Huatli*, also called amaranth today, has been used since the time of Mesoamerican cultures to the present day. Amaranth is a plant cultivated, domesticated and used in Mexico for more than 7,000 years (Casas *et al.*, 2012 cited in Ayala *et al.*, 2017). This plant had two main uses as Sauer (1993 cited in Iturbide *et al.*, 2012) mentioned; one for human consumption and another for religious use. This led to cultivate amaranth on a large scale, under the intensive system of *Chinampas* that the Aztecs developed in the lacustrine zone of the Valley of Mexico.

After the Conquest of Mexico, the decline of amaranth cultivation began when the Spaniards compared it with the 'bledo' (prostrate pigweed), due to morphological similarities between the two plants. Bledo is a plant with creeping stems, about 30 cm long, dark green triangular leaves and red flowers, very small and in axillary racemes (RAE, 2001). It should be noted that the word bledo in Greek means "insignificant, despicable". The time in which its importance as a crop decreased was "during the Viceroyalty of New

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Spain, due to the suppression of native crops and the planting of crops brought from Europe, which displaced the plant species that were regularly planted by the various ethnic groups that inhabited the current national territory” according to Iturbide *et al.* (2012). But, “Fortunately, the roots in the customs in the villages allowed the consumption of amaranth not to disappear. It has been maintained for centuries due to the action of small farmers who preserved the tradition of its cultivation although on a smaller scale, especially in Morelos, Tlaxcala and Mexico City (Huerta-Ocampo and Barba de la Rosa, 2012)” quoted by Ayala *et al.* (2017). This action kept amaranth alive to this day, those small farmers have passed their cultivation knowledge from generation to generation; in recent years have made domestic agriculture a profitable one, increasing not only social but economic value of amaranth cultivation.

In the municipality of Cuapixtla, Tlaxcala there are mostly small producers, who need to know if growing one to three hectares of amaranth is profitable at the end of the production cycle. Under those conditions it is necessary to assess the profitability of the crop, which in turn requires to know the costs of the amaranth production process. In this way, producers will realize the levels of profit derived from the resources they invest in this crop. The resources used by producers in the municipality of Cuapixtla, Tlaxcala are their own.

Previously, some producers in the municipality of Cuapixtla, Tlaxcala, grew corn and potatoes, but a few years ago they chose to change those crops for amaranth. Therefore, it is important to offer them information so that they can make a decision about producing amaranth or returning to their previous crops. When Tlaxcala positioned itself, in 2015, as the first producer of amaranth nationwide; the producers of Cuapixtla, a municipality of the state of Tlaxcala (Mexico) were even more interested in this crop. However, the growing demand has not been matched by the expected benefits as producers have been affected by factors that directly impact their income, costs and profit.

One of these factors affecting crop producers in the municipality of Cuapixtla, Tlaxcala is the high cost and the required amount of inputs, mainly chemical fertilizers. Another factor that affects the production of amaranth is the scarce labor for cultural work, since wages are required in weed control, harvesting and shelling the grain. It should be noted that Tlaxcala ranks first in the country for sending skilled labor to Canada according to Zempoalteca (2018). At present the young people of the municipality are not familiar with field activities.

On the other hand, there is no consensus among the producers of Cuapixtla, Tlaxcala, regarding the price of grain within the state. This results in producers selling grain at a higher or lower price, regardless of whether they affect other producers in the same area. Some producers do not have their own machinery to carry out agronomic activities within the amaranth crop production system, which forces them to resort to get machinery on rental basis. Also the agro-climatic variables, such as temperature and rainfall, frost or drought affect the yield of the seed. This obviously has an impact on the producer's income. However, despite the aforementioned factors, the growing demand seems to

create an income opportunity for any individual who intends to carry out the production of amaranth in the municipality of Cuapiaxtla, Tlaxcala.

In order to assess the above statement, this research reviews the costs generated by the amaranth production system, which mainly depend on the available technology (machinery rental); labor (daily wages) for cultural work (rental of external laborers); and the cost of fertilizers. All those costs are increased in some cases by the rental of the plot. The objective of this research is to know the profitability of amaranth cultivation through the generation of three measures of profit. Through production costs of the activities demanded by the cultivation of amaranth, through the budget method and the two linear functions of costs and income in a case study, in the municipality of Cuapiaxtla, Tlaxcala. This research also shows the cost structure (variable costs and fixed costs); as well as the income obtained by the producer, which is the Total Production Revenue through the budget method, for producers who opt for the rental of machinery. Two different aspects were considered in the case of producers who apply and do not apply chemical fertilizers during the production cycle of the amaranth crop. This research takes as a reference one hectare for the generation of the three measures of profit.

The hypothesis addressed is that the production system of rain fed amaranth cultivation, in the municipality of Cuapiaxtla, Tlaxcala, is profitable for small producers who own or get lands on rental, labor and machinery, with and without chemical fertilizer.

THEORETICAL BACKGROUND

Through the economics of production, which is responsible as explained by Doll and Orazem (1979), for the study of the economic principles used when making management decisions of a company and considering the economy of production as an instrument of planning. Through two linear production functions of costs and income and the budget method, three measures of profit can be generated for the producer in the area. These render the generation of the three measures of profit referred to in this investigation:

Net Cash Income. According to López (2020) it is the total amount of money that is incorporated into the budget, after discounting expenses related to taxes, commissions or amortizations, in this case private since income belongs to the producer.

Net Income per Hectare. Corresponds to Net Cash Income minus depreciation (machinery or equipment used, owned by the producer) and payments to those resources owned by the farmer (Doll and Orazem, 1979).

Income after Labor and Management. Once the Net Income per Hectare is obtained, the interest on capital investments will be deducted. It refers to opportunity cost, the return that a resource can gain when invested on its best alternative use (Doll and Orazem, 1979). Once the data was obtained, the classification of variable costs and fixed costs of the activities carried out during the production of the amaranth crop, with and without chemical fertilizers, was carried out by means of the budget method. The Benefit-Cost Ratio was also calculated.

METHODOLOGY

A case study was developed (Stake, 2000) in which a questionnaire was applied to three amaranth producers, that questionnaire covered costs and income obtained by the producer when he uses and does not use chemical fertilizers in different rain fed production years, technical parameters, as well as the costs for the rental of machinery in the crop during its production, in the municipality of Cuapixtla, Tlaxcala.

This research account for three aspects that affect production costs. The first characteristic is the size of the plot; interviewees are small producers of amaranth in the municipality with plots of 1 to 3 hectares of cultivation. The second characteristic is related to producers who do not own a plot in the municipality, that is, they rent a plot for cultivation during the planting season. The third and last characteristic is the type of producers, those who fertilize or do not fertilize during the production cycle, considering that the producers to whom the questionnaire was applied have experienced both activities, in different years of planting, equipped with the necessary information to break down costs.

The data was obtained in August 2020 in the Cuapixtla municipality, where key aspects were investigated such as: i) identification data, ii) activities carried out during amaranth production, iii) production costs with and without chemical fertilizers; and iv) grain yield and price, all with the purpose of establishing costs and income, to obtain a budget and generate the three measures of profit.

A questionnaire was applied to three amaranth producers who are part of a larger study; the information collected refers only to the cultivation of amaranth. Through the "Agroprospecta" methodology (Agroprospecta, 2010), which is a tool to describe the trend in the short term given the current circumstances and conditions of policy and economic environment, a broad study was addressed to producers from the municipality of Cuapixtla, Tlaxcala, dedicated to the cultivation of amaranth for more than ten years of production. This methodology consists of the development of a panel with three producers with similar characteristics of technological level of production and area destined to the cultivation of amaranth.

For the production of the amaranth crop, the costs are described as follows:

Variable Cost: these are costs for activities for the production in amaranth cultivation, such as soil tillage, planting, fertilization; weed control, combined harvesting, grain shelling and overhead costs.

Fixed Cost: those expenses assumed for the production in amaranth cultivation; depreciation and interest on capital investments (opportunity cost).

Total Cost: it is the sum of the total fixed cost plus the total variable cost.

Once the activities and purchase of inputs for the amaranth crop are classified, within the variable costs and fixed costs, the three measures of profit are calculated respectively to assess whether the amaranth cultivation is profitable.

RESULTS AND DISCUSSION

The activities carried out during the production of amaranth cultivation in the past, for each hectare of land produced, are presented in the form of a list with their correspondent subordinate activities (Table 1).

It is important to mention that grain yield varies when chemical, organic, or other fertilizers are used, and when they are not used.

Grain yield will be higher if chemical fertilizers are used, taking as a reference 1.5 tons of grain per hectare. If the producer decides not to use chemical fertilizers, grain yield decreases to one ton per hectare of amaranth grain (Table 2).

Once the grain yield and the activities required by the crop were identified, variable costs and fixed costs were classified separately, obtaining at the end a table of the three measures of profit (Table 3).

Table 3 presents total costs and calculated returns of rain fed amaranth cultivation per hectare, at Cuapiaxtla, Tlaxcala in 2020, with and without chemical fertilizers.

Variable costs

Starting at Number 1 (Table 3) it begins with soil tillage, primary activities are deep tillage and harrowing for both, with and without fertilizers. The first activity has a cost for the rental of tractor and plow of MXN \$900 pesos, while the harrowing is carried out 15 to

Table 1. Activities in the amaranth crop production system, Cuapiaxtla, Tlaxcala.

Activities in the amaranth crop production system at Cuapiaxtla, Tlaxcala.		
1	Soil tillage	Deep tillage Harrowing
2	Planting	Plowing Sowing sedes Seed
3	Fertilization	
4	Weed control	Racking (hoer) Hand pulling weeds
5	Combine harvesting	Harvesting Threshing
6	Shelling	Hulling spikelets and shelling grains

Source: elaborated by the authors.

Table 2. Grain yield per hectare with and without chemical fertilizers.

Amaranth grain yield	
With chemical fertilizers	1.5 tons per hectare
Without any chemical fertilizers	1.0 ton per hectare

Source: elaborated by the authors.

Table 3. Total costs and calculated returns per hectare of rain fed amaranth cultivation at Cuapiaxtla, Tlaxcala in 2020; with and without chemical fertilizers.

Three measures of profit for the cultivation of amaranth in Cuapiaxtla, Tlaxcala in 2020; with and without chemical fertilizers.				
Variable costs		With chemical fertilizers	Without chemical fertilizers	
	Unit			
1	Soil tillage		\$1,500	\$1,500
	Deep tillage	Moldboard tractor/plow (renting machinery)	\$900	\$900
	Harrowing	Chisel and disk plow (renting machinery)	\$600	\$600
2	Planting		\$1,300	\$1,300
	Plowing	Plow and rower (renting machinery)	\$600	\$600
	Sowing	Daily wages (2)	\$300	\$300
	Seed	4 kg x \$100	\$400	\$400
3	Fertilization		\$2,968	
		Daily wages (2)	\$300	-
		18-46-00 (2 bags × \$515)	\$1,030	-
		UREA (3 bags × \$385)	\$1,155	-
		Potassium chloride (1 bag × \$483)	\$483	-
4	Weed control		\$2,700	\$2,700
	Racking (hoer)	Tractor and hoer (renting machinery)	\$1,200	\$1,200
	Hand pulling weeds	Daily wages (10)	\$1,500	\$1,500
5	Combine harvest		\$3,500	\$3,500
	Mowing	Daily wages (10)	\$1,500	\$1,500
	Threshing	Combine harvester (renting machinery)	\$2,000	\$2,000
6	Shelling		\$750	\$750
	Hulling spikelets and shelling grains	Daily wages (5)	\$750	\$750
7	Overhead costs		\$1,000	\$1,000
8	TOTAL VARIABLE COST		\$13,718	\$12,250
9	Depreciation		\$0	\$0
	None, all machinery was on rental basis		\$0	\$0
10	Return investments by rate		\$3,000	\$3,000
	Opportunity cost: rainfed land	1 hectare	\$3,000	\$3,000
11	TOTAL FIXED COST		\$3,000	\$3,000
12	Net cash income (15-1 a 7) –overall costs		\$16,282	\$7,750
13	Net income per hectare (12-9)		\$16,282	\$7,750
14	Net income to the producer (12-10)		\$13,282	\$4,750
	Grain yield (tons)		1.5	1.0
15	Price per ton		\$30,000	\$20,000
16	Gain		\$16,718	\$15,250
17	Benefit/Cost Ratio (B/C) (15/13)		1.84	2.58

Source: elaborated by the authors.

30 days before planting, when the producer determines and the first rains of April or May occur. For soil tillage the producer spends a total of MXN \$1,500 pesos per hectare for renting machinery.

Once the soil is prepared, we observe at Number 2 (Table 3) which begins with planting, for this activity the producer requires MXN \$1,300 for plowing, sowing and seed. For seed sowing, machinery is used that plows and sows at the same time, using two daily wages, one goes to the tractor operator and the second to whom is observing that the seed falls into the row. Also, four kilograms of seed are required for one hectare. This activity is done in an approximate time of 3 hours in a single day.

The cost of the seed if purchased in companies dedicated to the sale of seeds fluctuates around MXN \$160.00 per kilogram. The producer has two options, to save seed from the previous harvest and use it next year, or to sell it at the price found at that time. For this case study, the cost of amaranth seed is MXN \$100 pesos per kilogram (Number 2), data addressed during the application of a questionnaire to producers in the area, where they were requested to give a value to the amaranth seed for sale.

In regard to fertilization (Number 3), one out of the three interviewed producers commented that the first fertilization is carried out joined with planting; the other two producers fertilize 15 to 20 days after planting. Applying chemical fertilizers, during and after planting has the same cost and does not affect the crop in any way, since they use the same amounts of fertilizers in proportion.

Producers recommend three fertilizers for the cultivation of amaranth: urea, 18-46-00, and potassium chloride; fertilizers that favor amaranth in its growth and grain yield. Regarding the second fertilization, it is carried out 40 days after planting; producers use two daily wages for it.

This activity (Number 3) has a cost of MXN \$2,968 pesos; it is one of the most expensive activities involved in this crop, due to the purchase of fertilizer. It is also important to clarify that producers have not applied any type of chemical fertilizer in some years of amaranth crop production in order to evaluate the difference in grain yield.

Producers perform two rackings during the production cycle of amaranth for weed control (Number 4); this depends mainly on agronomic conditions. In this research, two rackings were considered during the crop production cycle each at MXN \$600 pesos, for an overall expense of MXN \$1,200 pesos.

Weed control is carried out with labor accounting for 10 daily wages, each wage is MXN \$150 pesos for an approximate time of 6 hours of work at the field, this shall depend on how effective each daily worker is. For this activity (Number 4) the total expense was MXN \$2,700 pesos.

Once the weed control is carried out, the next variable cost that the producer has to pay is the combine harvest. Regarding the activity of threshing the producers of the case study use this mechanism through paying the rental of a thresher.

For this activity 10 daily wages are required for the mowing of plants, the expense is MXN \$1,500 pesos. Bearing in mind that the plant is left in the field for a period of 8 to 15 days in the ground so that the grain dries and may be in conditions to thresh.

Then the combined is also get on rental basis, which is the machinery that threshes the plant to remove the amaranth grain with a cost of MXN \$2,000 per hectare, obtaining then as the total for combined harvest MXN \$3,500 per hectare of amaranth crop. This makes that activity one of the greatest expenses within the crop production system.

The last activity that is classified as variable costs is the shelling of grain, in this activity the producer hires 5 people on daily wage to make the threshing effective since the grain shelling is done once the amaranth grain is threshed. For this activity (Number 6) the producer spends MXN \$750 pesos.

Variable costs include overhead expenses, those expenses made by the producer if necessary, for example, food, gasoline, etc. Overhead costs were considered it in this research within the variable costs (Number 7), an amount of MXN \$1,000 pesos.

The total variable costs (Number 8), during the production system of amaranth cultivation were MXN \$13,718 pesos, in the case of using chemical fertilizers; or on the other hand, MXN \$12,250 pesos without chemical fertilizers. This is a cost that the producer has to pay to obtain a good crop management.

Fixed costs

Within the fixed costs, two variables are classified within the budget method, which are independent of the amaranth crop production system. The first is depreciation and the second is interest on capital investments. The depreciation (Number 9, Table 3) is not used in this investigation since all the machinery was on a rental basis and the producer pays for machinery and operator to carry out those activities in the production system of the amaranth crop. The producers do not use their own machinery, but they rent it at an effective cost for the work of machinery that the producer does not necessarily have to buy. Regardless, it is considered part of the fixed costs that generated an expense of zero pesos. For the second variable, interest on capital investments, this research considers the plot cultivated with amaranth as the object of the opportunity cost. That is, if the producer does not want to grow amaranth, a decision is made to assign that land to a better alternative, which would renounce the benefits of producing amaranth in order to choose the best optional alternative action; this is called opportunity cost (Doll and Orazem, 1979).

To this end, the producers were asked how much they would rent their land if they did not want to plant amaranth, to which they determined an amount of MXN \$3,000 pesos in the event that they had no interest in the production of the amaranth crop. This is then the opportunity cost determined in Number 10.

The total fixed costs (Number 11) that was generated during the production system of the amaranth crop is MXN \$3,000 pesos, a cost that the producer has to pay to carry out a good crop management.

Generation of the three measures of profit

In Table 3, the overall table of costs, three measures of profit were generated in the end. Through two linear production functions: costs and revenues by the budget method. These measures of profit are shown in detail in Table 4.

Numbers 12, 13 and 14 are observed (Table 4). Although broadly speaking, we observe that the first two measures of profit (numbers 12 and 13) obtained the same amount, this is because there was not any machinery depreciated in Number 14) since all machinery was on rental, as it is detailed below. This measure of profit corresponds to the income that is incorporated into the budget method.

Net Cash Income in the municipality of Cuapiaxtla, Tlaxcala (Number 12)

In the Total Product Revenue (Table 5), the expense related to taxes, commissions or amortizations (\$0) and the total of variable costs (MXN \$13,718 pesos) are deducted. Then we generate the first measure of profit which resulted in MXN \$16,282 pesos in the case that producers use chemical fertilizers in the production of the crop.

But if the producer does not use chemical fertilizers, from the Total Product Revenue, the variable costs are also discounted. In such a case, the costs subtracted decrease the Total Product Revenue, but we should remember that, when chemical fertilizers are not applied, the grain yield is also lower. So that from MXN \$20,000 pesos we discounted MXN \$12,250 pesos, resulting in a net cash income equal to MXN \$7,750 pesos.

During 2020, amaranth grain was paid MXN \$20,000 pesos per ton, according to producers in the case study. If one hectare of amaranth crop has a yield of 1.5 tons of grain, then we account MXN \$30,000 pesos for the sale of the grain per hectare.

Table 4. Generation of three measures of profit for one hectare of Amaranth.

Generation of the three measures of profit		With chemical fertilizers	Without chemical fertilizers
12	Net cash income (15-1 a 7) – overall costs	\$16,282	\$7,750
13	Net income per hectare (12-9)	\$16,282	\$7,750
14	Net income to the producer (12-10)	\$13,282	\$4,750

Source: elaborated by the authors.

Table 5. Generation of the first measure of profit, Net Cash Income.

First measure of profit	Total Product Revenue	–	Total of Variable Costs	=	Net cash income
With chemical fertilizers	\$30,000	–	\$13,718	=	\$16,282
Without chemical fertilizers	\$20,000	–	\$12,250	=	\$7,750

Source: elaborated by the authors.

Net income per hectare in the municipality of Cuapiaxtla, Tlaxcala (Number 13)

The second measure of profit is generated when the depreciation of own machinery is discounted to the producer. In this research, depreciation was not accounted for, since the machinery was rented; therefore, the depreciation remains at zero pesos.

If depreciation is deducted from the Net Cash Income (Table 6), the net income per hectare is obtained; using chemical fertilizers is MXN \$16,282 pesos and without using chemical fertilizers is MXN \$7,750 pesos. Thus, it is the same amount for the first and second measures of profit, which do not vary by depreciation effect.

Income to the producer in the municipality of Cuapiaxtla, Tlaxcala (Number 14)

This third measure of profit is the most important, both for the producer and for this research, since it generates what the producer will earn for each hectare planted with the amaranth crop in the municipality of Cuapiaxtla, Tlaxcala.

In order to generate this measure of profit we have to subtract from the net income per hectare, the interest on capital investments; that is, the opportunity cost on the rain fed land (Table 7).

CONCLUSIONS

The producers of this case study mentioned that the payment for a ton of amaranth grain was MXN \$20,000 in 2020. Therefore, Amaranth cultivation is profitable, proving the hypothesis stated in this research (Table 8), referred to the Net Cash Income to the Producer. Since the income obtained by the producer for one hectare of amaranth cultivation was MXN \$13,282 pesos, MXN \$26,564 pesos for two hectares, and for three hectares planted and produced of amaranth grain with chemical fertilizers was

Table 6. Generation of the second measure of profit, Net Income per Hectare.

Second measure of profit	Net cash income	–	Depreciation	=	Net income per hectare
With chemical fertilizers	\$16,282	–	\$0.00	=	\$16,282
Without chemical fertilizers	\$ 7,750	–	\$0.00	=	\$7,750

Source: elaborated by the authors.

Table 7. Generation of the third measure of profit, net income to the producer.

Third measure of profit	Net income per hectare	–	Opportunity cost	=	Net income to the producer
With chemical fertilizers	\$16,282	–	\$3,000.00	=	\$13,282
Without chemical fertilizers	\$7,750	–	\$3,000.00	=	\$4,750

Source: elaborated by the authors.

Table 8. Income (MXN \$ - Mexican pesos) to the producer for one, two, and three hectares of Amaranth, grown with chemical fertilizers.

Hectares	1ha		2ha		3ha	
	Grain Yield 1.5 ton	Grain Yield 1 ton	Grain Yield 1.5 ton	Grain Yield 1 ton	Grain Yield 1.5 ton	Grain Yield 1 ton
	With chemical fertilizers	Without chemiccal fertilizers	With chemical fertilizers	Without chemical fertilizers	With chemical fertilizers	Without chemical fertilizers
Total product pevenue	\$30,000	\$20,000	\$60,000	\$40,000	\$90,000	\$60,000
Net income to the producer	\$13,282	\$4,750	\$26,564	\$9,500	\$39,846	\$14,250

Source: elaborated by the authors.

MXN \$39,846 pesos. All of them resulting when all costs carried out for production are discounted, in the municipality of Cuapiaxtla, Tlaxcala.

If the producer decides not to apply any type of chemical fertilizers, the grain yield is less than 1.5 tons. However, despite the lower yield of the amaranth grain, the producer obtains an income of MXN \$9,500 pesos per hectare of amaranth cultivation produced, as it is shown in Table 8.

This research concludes that labor, such as sowing (2 daily wages), fertilization (2 daily wages), weed control and hand pulling weeds (10 daily wages), mowing and threshing (10 daily wages), and grain shelling (5 daily wages) are the activities that require the greatest expenditures in the cultivation of amaranth, due to the use of man labor in these activities. Also the rental of machinery is an option that benefits the producer, since the machinery is not depreciated; that is, renting reduces costs during amaranth cultivation.

Through the budget method and the classification of variable and fixed costs, the activities that require the greatest expenditures are observed. The generation of the three measures of profit helps the producer to make a decision according to his income, and have an approximate calculation of his profit if he decides to use chemical fertilizers during the cultivation of the amaranth grain.

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