Introduction and use of Citlali and Ameyali potato varieties in family gardens in Zinacantepec, Mexico

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ABSTRACT

Objective: To introduce and evaluate the performance of the Citlali and Ameyali potato varieties in agroecologically managed home gardens within a rural community, compared to the Dutch variety Fianna.

Design/Methodology/Approach: A randomized block design was implemented, using home gardens as experimental units. Three agricultural cycles were conducted: Cycle one (March-July 2022), cycle two (October-December 2022), and cycle three (June-September 2023).

Results: No significant differences were found in fresh tuber weight per plant among the varieties tested. In the first cycle, yields from Ameyali and Citlali did not differ significantly. However, in cycles two and three, statistically significant differences were observed. Yields decreased in Citlali and Fianna during these cycles due to damage caused by late blight, which affected both foliage and tubers. In contrast, Ameyali demonstrated greater tolerance to late blight.

Findings/Conclusions: Potato production in agroecologically managed home gardens is feasible for small-scale producers in San Antonio Acahualco, Zinacantepec, particularly when using varieties tolerant to late blight (*Phytophthora infestans*) and *Bactericera cockerelli*.

Keywords: variety, home gardens, agroecology, late blight, potato

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INTRODUCTION

Home gardens are agricultural ecosystems located near households, where ecological, agronomic, cultural, and social processes converge (Santana *et al.*, 2015; Rivas, 2014). These systems enable crop production tailored to the living conditions and needs of each family (Chablé *et al.*, 2015), while also providing opportunities to generate additional income through the sale of surplus vegetables (Nicholls *et al.*, 2019). Furthermore, they serve as refuges for wild plant species that have disappeared from their natural habitats (White *et al.*, 2014). The potato (*Solanum tuberosum* L.) is native to the Andes and has been

cultivated for over 7,000 years (Román *et al*., 2015). It is one of the world's most important food crops, following rice, maize, and wheat (Zhang *et al*., 2017). Potato cultivation is vulnerable to both biotic and abiotic factors that can reduce yields and compromise product quality (Dahal *et al*., 2019; Mohanta *et al*., 2017). The most significant disease affecting potato crops globally is late blight, caused by the oomycete *Phytophthora infestans*, which can devastate entire fields within days if not properly managed, resulting in substantial economic losses (Fry *et al*., 2015; Lenman *et al*., 2016). Commercial potato varieties typically have a vegetative cycle ranging from 90 to 160 days. In Mexico, the most commonly cultivated varieties for fresh consumption include Fianna, Orquesta, Caesar, and Ambra, among others. The National Institute of Forestry, Agricultural and Livestock Research (INIFAP) has released several varieties with resistance and/or tolerance to late blight (*Phytophthora infestans*) and potato psyllid (*Bactericera cockerelli*), with industrial-grade quality and smooth skins suitable for washing. These varieties contain 19-21% dry matter and include Citlali and Ameyali, which offer yields between 50 and 70 tons per hectare. They are adaptable to altitudes ranging from 50 to 3,400 meters above sea level and are suitable for cultivation across all recommended potato-producing regions of the country, during both spring-summer and autumn-winter cycles (González *et al*., 2021).

MATERIALS AND METHODS

The present study was conducted in the community of San Antonio Acahualco, municipality of Zinacantepec, Mexico (19° 17' 00" N latitude and 99° 44' 00" W longitude). The prevailing climate is temperate sub-humid. The area is dominated by Andosol, Cambisol, Phaeozem, and Regosol soils. Land use in the region is primarily for seasonal rainfed agriculture. The main crops are grain and forage maize, potatoes, fava beans, and peas (SEDUI, 2024).

Experimental design

A randomized block design was implemented, with each block corresponding to a home garden (60 m^2 area, 5 m wide × 12 m long). The blocks belonged to female producers from the community of San Antonio Acahualco. The research employed both qualitative and quantitative methods, under technical guidance, and was carried out through exploratory and descriptive analysis. Three agricultural cycles of potato cultivation were conducted: cycle one from March to July 2022; cycle two from October to December 2022; and cycle three from June to September 2023. In each cycle and block, random sampling was performed by selecting five plants per variety, considering the following variables: a) physicochemical analysis of the manure used in each block (in cycle two); b) fresh tuber weight; c) number of tubers per plant; and d) quantification of damage caused by climate, diseases, and pests. An analysis of variance and mean comparison among blocks and varieties was conducted using the Tukey test ($p \leq 0.05$), at a 5% significance level, with the InfoStat software, version 2008 (Di Rienzo *et al*., 2010). For the qualitative variables, only a description of climate damage, disease symptoms, pest infestation on plants, and tuber damage was performed.

The activities carried out included 1) land leveling; 2) design and preparation of planting beds; 3) disinfection and planting of seed tubers; 4) soil fertilization using the manure available to each producer; 5) foliar fertilization with biofertilizers; 6) pest and disease control using plant extracts and mineral broths; 7) irrigation; 8) sampling and 9) harvesting. The experiment was conducted under an agroecological management approach, considering the interaction of potato crops with other vegetables (leafy, root, bulb, flower, and fruit types) and some medicinal plants.

The genetic material used as seed was provided by INIFAP, consisting of the Citlali and Ameyali potato varieties, as well as the Fianna variety used as a control, which is the most widely cultivated in Mexico. Table 1 shows the amount of manure used in each block, which was applied in two stages: the first at planting, and the second 20 days after the emergence of the seed tuber. Crop nutrition was complemented with foliar applications of biofertilizers three times per week (manure tea at 20 mL L^{-1}; supermagro at 20 mL L^{-1} during the vegetative stage; and banana peel tea at 20 mL L^{-1} during the tuber filling stage).

Agroecological management in this study aimed to minimize the impact on the territory and on the animal and plant species present in the home gardens, while promoting more efficient use of natural resources. The incorporation of various organic sources contributed to increased yield and preservation of ancestral agricultural practices, while also improving the physical, chemical, and biological properties of the soil (Alaluna & Villagarcía, 2000; Bolo *et al.*, 2020).

RESULTS AND DISCUSSION

Physicochemical analysis of the manure

In the second cycle, a one-kilogram sample of the manure used for plant fertilization was collected from each block. All samples were sent to the Soil Science Laboratory of the Faculty of Agricultural Sciences at UAEMEX, Toluca, State of Mexico, where physicochemical analyses were performed. Table 2 shows the differences in the nutritional content of the manures applied across the blocks.

Nitrate content in Blocks I and III was three times higher than in Blocks II and IV. Nitrate availability helps maintain a functional leaf area for a longer period, directly enhancing photosynthetic activity and promoting the translocation of photoassimilates to

Table 1.

Block	Type of manure	Total amount of manure m^{-2}		
		Cycle 1	Cycle 2	Cycle 3
I	Bovine manure 100 %	7.0 kg m^{-2}	14 kg m^{-2}	6.6 kg m^{-2}
II	Manure: sheep 60 %, poultry 30 % and rabbit 10 %.	5.2 kg m^{-2}	10.8 kg m^{-2}	--
III	Manure: bovine 30 %, sheep 30 % and equine 40 %.	10.5 kg m^{-2}	10.7 kg m^{-2}	9.0 kg m^{-2}
IV	Mmanure: rabbit 20 %, sheep 70 % and poultry 10 %.	4 kg m linear	6.25g m^{-2}	6.5 kg m^{-2}

Table 2.

Physicochemical Parameter	Block I	Block II	Block III	Block IV
Organic Matter (%)	24.96	30.42	23.40	23.40
pH	9.85	10.50	8.50	8.70
Electrical Conductivity (dS/m)	0.27	0.73	0.22	0.30
Apparent Density (g/cm³)	1.12	1.75	1.30	1.60
Nitrates (ppm)	5.488	1.392	6.192	2.336
Phosphorus (ppm)	576.03	922.74	851.76	958.23
Potassium (ppm)	7,878	2,067	4,173	7,956
Calcium (ppm)	3,064	3,098	3,098	3,098
Magnesium (ppm)	292.50	163.80	287.04	366.60
Aluminum (ppm)	156,000	23,400	43,920	135,720

Note: pH=potential of hydrogen; E.C.=electrical conductivity; A.D.=apparent density; Mg=magnesium; P=phosphorus; K=potassium; Ca=calcium; Al=aluminum; ppm=parts per million.

storage organs (Ghemam *et al.*, 2016). In contrast, Block I had the lowest phosphorus content, with 576.03 ppm equivalent to only 60% of the value found in Block IV, which had the highest concentration and was considered as 100%. Regarding potassium, Blocks I and IV showed higher concentrations, exceeding 7,000 ppm, while Blocks II and III recorded significantly lower levels, representing only 25.9% and 52.5% of the highest value, respectively.

Fresh tuber weight per plant

In the first cycle, no statistically significant differences were found between the means of the Ameyali and Citlali varieties. However, Citlali had the highest average fresh tuber weight, with 493.25 g per plant, compared to Ameyali (Figure 1). In the second cycle, where Ameyali and the control variety Fianna were evaluated, a significant difference was observed between their means. Fianna had a higher average weight (301.7 g per plant),

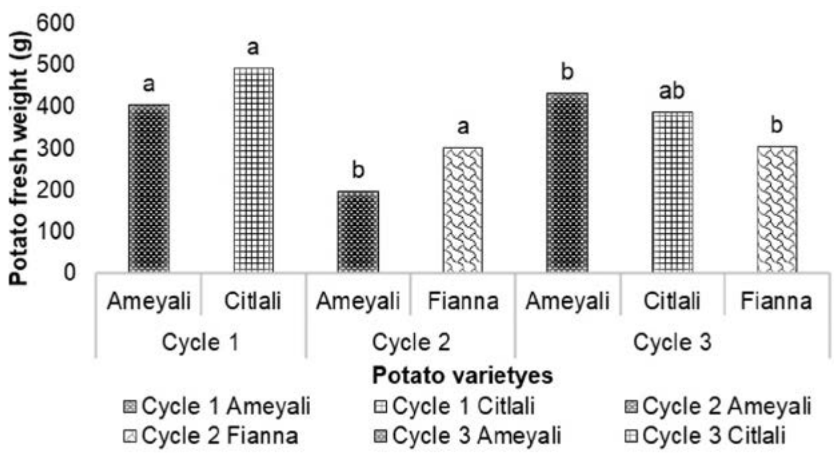

Figure 1. Mean comparison of fresh tuber weight for the Ameyali, Citlali, and Dutch variety Fianna in home gardens of San Antonio Acahualco, Zinacantepec. Means followed by the same letter are not statistically different (Tukey, p≤0.05).

which was attributed to frost damage affecting more than 80% of Ameyali plants. In the third cycle, no statistically significant differences were found among varieties; however, Ameyali showed a higher average weight (432.44 g per plant) than Citlali and Fianna. During this cycle, all three varieties were affected by late blight, which caused damage to both plants and tubers, with Ameyali demonstrating greater tolerance to the disease.

Total number of tubers per plant

As shown in Figure 2, in the first cycle there was no statistically significant difference between the means of the Ameyali and Citlali varieties. However, Citlali stood out with an average of 12 tubers per plant. In the second cycle, a significant difference was observed between Ameyali and Fianna, with averages of 8 and 10 tubers per plant, respectively. In the third cycle, statistically significant differences were observed among Ameyali, Citlali, and Fianna. Although Citlali and Fianna produced a higher number of tubers, these were of lower weight. The smaller tuber size was attributed to damage caused by late blight, which affected plant health and led to premature death, preventing the completion of the vegetative cycle..

Quantification of damage caused by climate, diseases, and pests

During all three cultivation cycles, a diagnosis was conducted as part of the technical assistance, evaluating damage caused by frost and rainfall, plant and tuber diseases, and pest infestations. Damage was classified into three categories: severe, minor, and absent. In the first cycle, pest problems were observed, including whiteflies, aphids, and cutworms, as well as damage caused by *Spongospora subterranea*. The latter was classified as severe, as it affected a large portion of the tubers in both the Citlali and Ameyali varieties (Table 3).

In the second cycle, whiteflies, aphids, leafhoppers, and cutworms were recorded. Block I experienced damage from late blight, frost, and pocket gophers, affecting 17 Ameyali plants. In Block III, Ameyali was also affected by frost. In the third cycle, all blocks were affected by late blight. The Fianna variety (control) showed 100% damage, while Ameyali showed 16% of damaged plants, and Citlali showed 20%. During cycles two and three,

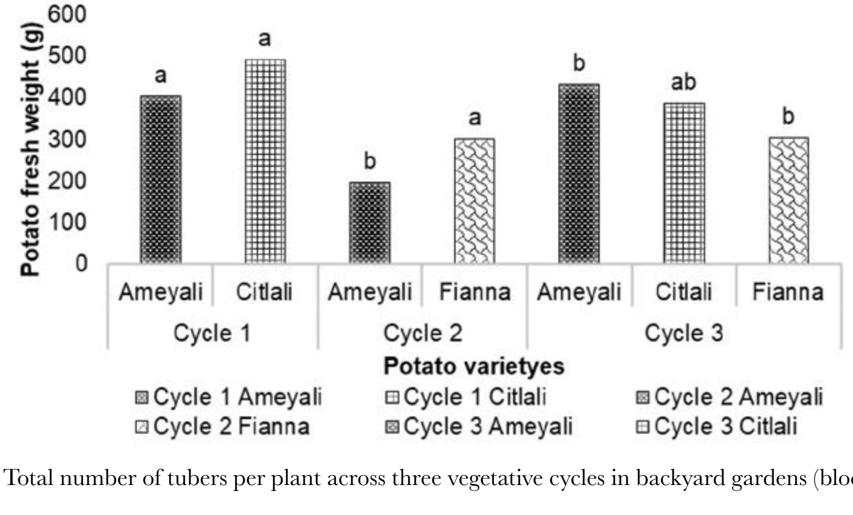

Figure 2. Total number of tubers per plant across three vegetative cycles in backyard gardens (blocks).

Table 3.

Vegatative cycle	Variety	Block	Pests			Diseases		Environmental factors
			1	2	3	4	5	
Cycle 1	Ameyali	I	++	−	−	++	−	−
		II	++	++	−	++	−	−
		III	++	++	−	++	−	−
		IV	−	++	−	++	++	++
	Citlali	I	−	++	−	++	−	−
		II	++	+	−	++	−	−
		III	++	−	−	++	−	−
		IV	−	++	−	++	−	++
Cycle 2	Ameyali	I	++	++	−	+	++	+
		II	++	−	−	+	−	++
		III	+	−	+	+	+	−
		IV	−	−	−	+	−	−
	Fianna	I	++	++	−	+	+	−
		II	+	−	−	−	++	+
		III	+	−	+	+	−	−
		IV	+	−	−	+	−	−
Cycle 3	Ameyali	I	++	++	+	+	+	+
		II	−	−	−	−	−	−
		III	−	−	+	+	+	+
		IV	++	++	++	+	++	++
	Citlali	I	++	++	+	+	++	++
		II	−	−	−	−	−	−
		III	−	−	+	+	+	−
		IV	++	++	++	++	++	++
	Fianna	I	++	++	+	+	++	++
		II	−	−	−	−	−	−
		III	−	−	+	+	++	++
		IV	++	++	++	+	++	++

++=Major damege; +=Average damage; −=No damage. Pests: 1=Aphip; 2=White fly and 3=Choppers. Diseases: 4=Subterranean Spongospora and 5=late blight.

weekly applications of silico-sulfo-calcium broth (an insecticide-fungicide-nutrient solution) were made to the soil to control *Spongospora subterranea*. As a result, disease incidence was reduced, with symptoms appearing only as small spots, and typically affecting no more than one or two tubers per plant.

In the second and third cycles, the presence of late blight was observed in the Citlali and Fianna varieties, affecting both plants and tubers, which resulted in decreased yields. In contrast, the Ameyali variety demonstrated resistance to the disease, with only partial damage to the plant. According to Niks *et al.* (2019), Gabriel *et al.* (2016), Moncayo *et al.*

(2019), and Rubio *et al*. (2016), effective pest and disease prevention and control throughout the crop cycle reduces yield losses. In addition, genetic resistance is considered an active plant defense mechanism in crop management.

CONCLUSIONS

The women producers involved in this study recognized that the Ameyali variety developed by INIFAP delivered better yields compared to the Citlali variety. Both varieties were noted for their tuber quality, particularly in terms of taste, color, and suitability for food processing. Ameyali exhibited resistance to late blight and potato purple top wilt, despite the challenges posed by seasonal changes. However, the control variety Fianna was significantly affected by late blight, which compromised its yields.

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