

Gibberellic Acid in the Germination of “Achilito” Chili Pepper Seeds (*Capsicum annuum* L.)

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ABSTRACT

Objective: To evaluate the effect of gibberellic acid on the germination percentage of “Achilito” chili pepper seeds (*Capsicum annuum* L.).

Design/methodology/approach: Seeds obtained from ripe fruits collected in Cuicatlán, Oaxaca, were disinfected using Tween 20, 70% alcohol, and distilled water. Six treatments were evaluated: T1, water at room temperature; T2, T3, T4, and T5, gibberellic acid at 10, 100, 250, and 500 mg L⁻¹, respectively; and T6, water at 80 °C for 5 min. Twenty seeds per replicate were placed in Petri dishes and incubated for 14 days. Germination was recorded daily, considering as germinated those seeds with radicles ≥2 mm. Germination percentage (GP) was determined for this variable. Data were analyzed under a completely randomized design using Tukey’s test ($\alpha \leq 0.05$). Mean germination time (MGT) and the percentage of dead seeds (DS) were also evaluated.

Results: The best germination response of “Achilito” seeds (100%) was observed with 10 mg L⁻¹ of GA₃, with an MGT of 3.27, indicating vigorous seedlings.

Limitations on study/implications: The “Achilito” variety, native to Cuicatlán, Oaxaca, is highly valued in Oaxacan cuisine; however, its cultivation remains limited, which increases its market value and restricts its commercialization outside the state. This crop could represent an excellent production alternative.

Findings/conclusions: The chili pepper species *Capsicum annuum* L. var. “Achilito” shows no evidence of genetic improvement. Gibberellic acid at a concentration of 20 mg L⁻¹ promotes 100% germination after 11 days. The use of GA₃ at 500 mg L⁻¹ resulted in fungal growth.

Keywords: Phytohormones, Solanaceae, native species.

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INTRODUCTION

The native “Achilito” chili pepper (*Capsicum annuum*), from Cuicatlán, Oaxaca, Mexico, is highly valued in gastronomy due to its distinctive flavor, which combines a subtle sweetness with a moderate level of pungency. However, its cultivation remains limited, which increases its value and hampers its commercialization beyond the study region. Bissoli *et*



al. (2021) reported that chili pepper seeds exhibit low germination, and that seed longevity is considerably shorter than in other solanaceous species. Sandoval-Rangel *et al.* (2018) attributed the low germination observed in ‘Piquín’ chili morphotypes to both physical and physiological dormancy. Likewise, Dantas *et al.* (2014) stated that the germination of chili pepper seeds (*Capsicum annuum*), even under favorable conditions, is slow and non-uniform, thus requiring the application of techniques that enhance both germination speed and uniformity. Germinability, a test performed on pure seeds, indicates the percentage of seeds capable of germinating at a given time under specific conditions of temperature, light, and duration that promote germination; these conditions vary according to each species. For species lacking official germination standards, tests may be conducted to determine their optimal germination conditions by placing the seeds in a moist environment under suitable temperature and light conditions to induce germination. A native seed is considered germinated when the radicle reaches 1 to 2 mm in length (Frischie *et al.*, 2020). A dormant seed is one that lacks the capacity to germinate within a specific period, even under normal physical environmental conditions such as temperature and light/darkness (Baskin & Baskin, 2004). If the germination percentage exceeds 75% over a wide temperature range and within at least four weeks, the seed is considered viable (Todd *et al.*, 2016). Gibberellins (GBs) are diterpenoid phytohormones biosynthesized through complex metabolic pathways that regulate plant growth and development, acting primarily during germination (Yamaguchi, 2008; Taiz *et al.*, 2017). According to Petruzzelly *et al.* (2003), the accumulation of β -1,3-glucanase (β Glu) is associated with gibberellic acid (GA_3) in the softening of the seed coat in chili pepper and tomato seeds. The response of plant species to the use of GBs in promoting germination is broad and depends on seed age, soaking time, temperature, concentration, light, among other factors. In horticultural species such as *C. annuum*, seed dormancy causes heterogeneous emergence, thereby affecting seedling production and crop establishment. Therefore, it is important to generate information related to GA concentrations in seed germination. The aim of this study was to evaluate the effect of gibberellic acid on the germination percentage of “Achilito” chili pepper seeds (*Capsicum annuum* L.).

MATERIALS AND METHODS

Location of the experiment

The study was carried out in the Soil Fertility and Plant Nutrition Laboratory of the University Center Tenancingo, Autonomous University of the State of Mexico.

Plant material. Fully mature red fruits of chili pepper (*Capsicum annuum*) var. Achilito were collected in Cuicatlán, Oaxaca

In April 2025, germination tests were conducted. Seeds were extracted from the fruits and disinfected as follows: they were washed with Tween 20 soap and rinsed three times with distilled water; subsequently, they were immersed in 70% alcohol and rinsed three additional times with distilled water. The seeds were then soaked for 12 h in the different treatments of gibberellic acid (GA_3), expressed in $mg L^{-1}$, as follows: T1, water; T2, 10; T3, 100; T4, 250; T5, 500; and T6, seeds immersed in distilled water heated to 80 °C for

10 min. Subsequently, 20 seeds were placed in 90 mm Petri dishes containing filter paper moistened with the corresponding treatment solution. The dishes were then placed in an Ecoshel[®] incubation chamber for 12 d. During this period, the paper was moistened with 1 mL of solution whenever necessary. The number of germinated seeds was recorded daily. A seed was considered germinated when radicle protrusion from the seed coat reached at least 2 mm in length.

Variables

Descriptive analysis of the chili pepper sample

Each Achilito fruit was weighed on an OHAUS analytical balance with a precision of 0.0001 g. Fruit length was measured from the base of the chili to the tip, and width was measured at the middle section using a Vernier caliper. Subsequently, the mean, median, mode, lower and upper limits, and coefficient of variation were determined to perform the descriptive analysis of the sample.

Germination percentage (GP): the ratio between the number of germinated seeds and the total number of seeds, expressed as a percentage.

$$PG = \frac{Ng}{Nt} \times 100$$

where: GP =Percentage of germinated seeds; Ng =Number of germinated seeds; Nt =Total number of seeds.

$$TMG = \frac{\sum(Ni \times ti)}{\sum Ni}$$

where: Ni =number of newly germinated seeds on day t_i ; t_i =number of days from the start of the germination test; $\sum Ni$ =final germination.

Dead seed percentage (DS): All seeds that failed to germinate were counted, and the mortality percentage was calculated.

Experimental design: Germination percentage data were statistically analyzed by date using a completely randomized design with three replicates, each consisting of 20 seeds. Treatment means were compared using Tukey's test ($\alpha \leq 0.05$). Subsequently, the data were plotted by date. Mean germination time and dead seed percentage were also evaluated.

RESULTS AND DISCUSSION

The fruits of *C. annuum* "Achilito" exhibited a weight range of 0.5 to 1.7 g, with a nearly symmetrical distribution and most fruits concentrated between 0.7 and 1.5 g. The median (1.20 g) was slightly higher than the mean (1.13 g), suggesting a left-skewed or negatively

skewed distribution; that is, most fruits weighed less than or equal to 1.2 g. The most frequent fruit weight was 1.30 g (Figure 1). Regarding fruit length, “Achilito” fruits averaged 3.4 cm, with a median of 3.33 cm, indicating that 50% of the population measured ≤ 33.3 mm. The most frequent length was 28.3 mm, which suggests a distribution with several low values shifting the mode toward the left tail (Figure 2). A similar pattern was observed for fruit width, where the mode (15.6 mm) was lower than both the mean (22.2 mm) and the median (22.5 mm). These results indicate the presence of numerous small observations dominating the frequency distribution of the data (Figure 3). According to Andrawus *et al.* (2014), the fruit of this chili species is a triangular berry with an average size of 2.4 cm in length and 1.0 cm in equatorial diameter. The sampled chili peppers exhibited greater average fruit length and width. These results suggest that it is a native species.

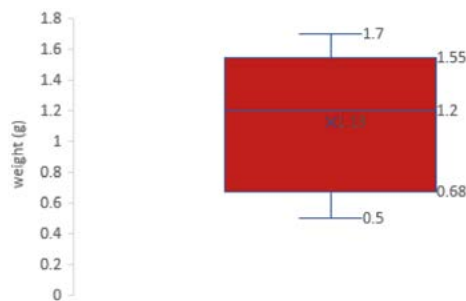


Figure 1. Variability of the dry weight of chili (*Capsicum annuum*) “Achilito”.

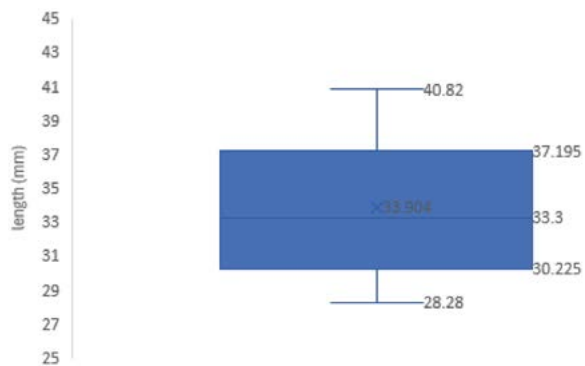


Figure 2. Variability in the length of the chili pepper (*Capsicum annuum*) “Achilito”.

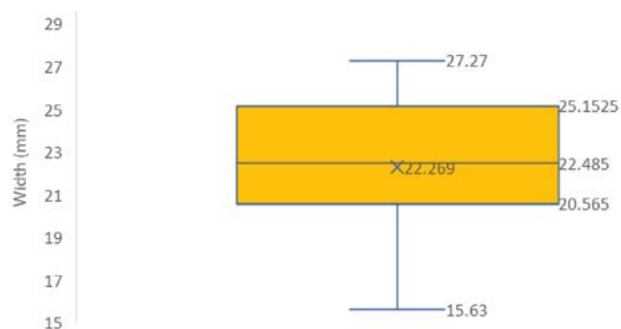


Figure 3. Variability of the width of the chili pepper (*Capsicum annuum*) “Achilito”.

The germination of “Achilito” seeds began on April 20, three days after the experiment was established, and significant differences were observed among treatments (Figure 4). At this stage, the highest germination percentages were recorded in the treatments with 100, 250, and 500 mg L⁻¹ of gibberellic acid, whereas the seeds treated with water showed the lowest germination value at the beginning of the experiment.

Figure 4 shows that seeds immersed in the GA₃ solution at 10 mg L⁻¹ exhibited highly significant differences 10 days after the establishment of the experiment, reaching 96.67% germination, and by day 11, 100% germination was achieved. Petruzzelly *et al.* (2003) indicated that gibberellins promote the softening of the seed coat in chili pepper and tomato seeds, thereby breaking dormancy through their association with β-1,3-glucanase (βGlu). The germination response of seeds across different plant species depends on seed age, soaking time, temperature, concentration, light, among other factors. At the end of the experiment, after 14 d, no significant differences were observed among treatments, and all of them achieved germination percentages equal to or greater than 85%, with the seeds immersed in water showing the lowest germination percentage. According to Berke (2000), chili pepper seeds should exhibit a germination percentage above 70%. Todd *et al.* (2016) further noted that a seed is considered viable when germination exceeds 75%; therefore, according to these authors, the seeds evaluated in this study were viable. Seeds treated with distilled water heated to 80 °C for 10 min reached 96.67% germination at this stage, despite showing slow germination at the beginning. González and Mendoza (2008) reported that hot water at 80 °C for 2 min increased germination percentage in grass and forage seeds by softening the seed coat and increasing its permeability, thereby breaking physical dormancy caused by hardness and impermeability, which hinder water

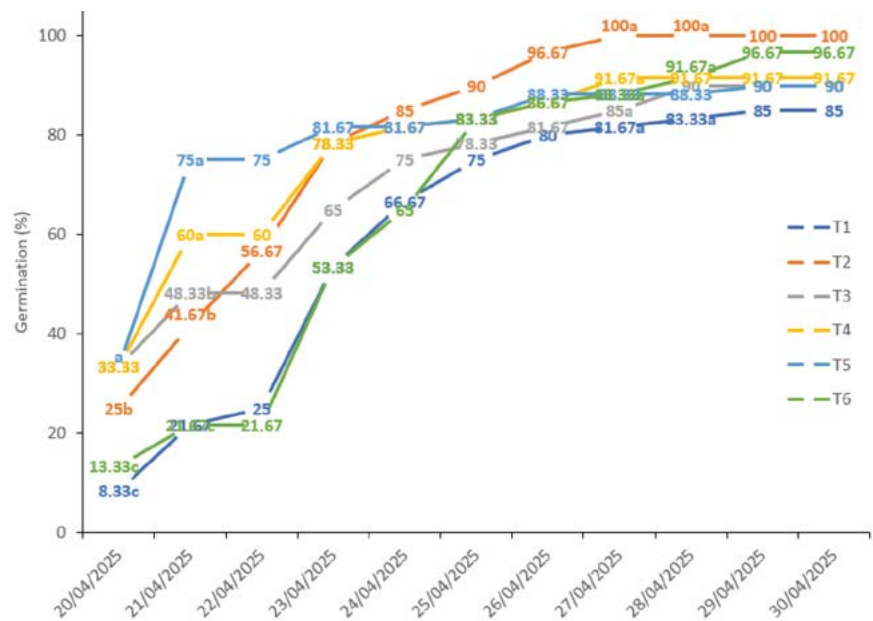


Figure 4. Germination percentage of “Achilito” chili pepper seeds (*Capsicum annuum*) treated with different concentrations of gibberellic acid in ppm (T1: water; T2: 10; T3: 100; T4: 250; T5: 500), and T6: distilled water heated to 80 °C for 5 min.

and gas uptake required for adequate germination. Similarly, Sánchez (2021) found that high temperatures of 80 and 100 °C during prolonged soaking in hot water (48 h) reduced germination time and increased germination percentage in seeds of the forage species *Leucaena leucocephala*. Doll *et al.* (2013) emphasized that soaking seeds in either cold or hot water improves germination percentage; however, the response to these treatments depends on the species.

Mean germination time (MGT) is an indicator of germination rate and predicts seed size, vigor, and uniformity (Table 1). Based on the data obtained for each treatment, the overall mean germination time of “Achilito” seeds was estimated at 3.2 d (Table 1).

The same table shows that seeds treated with GA₃ at T3: 100, T4: 250, and T5: 500 mg L⁻¹ accelerated the germination process; however, they reached only approximately 90% germination at the end of the experiment, 14 d after establishment. As MGT increases, germination tends to be more dispersed over time, resulting in smaller seedlings with greater variability in quality. Figure 4 also shows that seeds immersed in the 10 mg L⁻¹ GA₃ solution reached 100% germination 11 days after the beginning of the experiment. Although this treatment did not show significant germination at the initial stages, but only after 10 days, it ultimately proved to be the most effective treatment. Saldívar *et al.* (2010) reported that GA₃ at a concentration of 250 mg L⁻¹ increased germination rate, or reduced MGT, in ground tomato (*Jaltomata procumbens*), and indicated that each species responds differently to the concentration of this phytohormone.

According to Berke (2000), chili pepper seeds should exhibit germination percentages above 70%. Todd *et al.* (2016) further emphasized that a seed is considered viable when germination exceeds 75%. It is worth noting that all treatments produced germination percentages equal to or greater than 85%, confirming that the seeds were viable. It is important to highlight that the best treatments showed the highest MGT values, contrary to what would be expected, since higher values for this variable indicate greater dispersion of germination over time and the production of less vigorous and more heterogeneous seedlings.

Mean germination time (MGT) has predictive value and constitutes a useful indicator of seed quality before sowing, allowing producers to anticipate potential problems related to seedling size and uniformity. Regarding mortality percentage (Table 1), seeds treated

Table 1. Effect of gibberellic acid on mean germination time (MGT) and mortality percentage of “Achilito” chili pepper seeds (*Capsicum annuum*) on day 10.

Gibberellic acid (GA ₃)	MGT	Mortality (%)
T1: Water	3.95	15.0
T2: 10	3.27	0.0
T3: 100	2.94	10.0
T4: 250	2.69	8.3
T5: 500	2.14	10.0
T6: Water at 80 °C (5 min)	4.08	3.3

The data represent the mean of the replicates.

with water and gibberellic acid at concentrations of 100 or 500 mg L⁻¹ showed the highest mortality percentages. It should be noted that seeds treated with 500 mg L⁻¹ also showed fungal incidence.

CONCLUSIONS

The descriptive analysis indicated that “Achilito” chili pepper (*Capsicum annuum* L.) exhibits traits consistent with an undomesticated morphotype lacking genetic improvement, as the individuals tend to be smaller than the average and show a certain degree of bias in their morphological variables. Gibberellic acid at a concentration of 20 mg L⁻¹ achieved 100% germination in “Achilito” chili pepper (*Capsicum annuum*) within 11 days, with a moderate mean germination time. Although seeds treated with GA₃ at a concentration of 500 mg L⁻¹ exhibited rapid germination at the beginning of the experiment, they ultimately showed the lowest germination percentage and a high mortality rate due to fungal contamination.

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