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INI-17, New Variety of Coriander (*Coriandrum sativum* L.)

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ABSTRACT

Objective: To describe the variety of coriander (*Coriandrum sativum* L.) based on the guides by the Union for the Protection of New Varieties of Plants (UPOV) and to evaluate their agronomic performance.

Design/Methodology/Approach: The variety was generated through the mass selection method followed by individual mass selection. The varietal description was conducted based on a local guide proposed and on guidelines by the UPOV. The experimental design used was in complete random blocks with four repetitions. Phenological and morphological traits of the plant were recorded. The means were compared with Tukey's test at a level of 5% confidence.

Results: INI-17 is of tall bearing, with growth habit of semi-erect basal leaf. The number of basal leaves is high, of medium length and mean degree of lobulation, with intensity of foliage color. The number of umbels is high, the petals do not contain anthocyanins, and it is of late flowering; it has fruit of medium size and brown seeds that have high linalool content.

Study Limitation/Implications: Seed production is highly dependent on the temperature and presence of vectors, and it is of long cycle.

Findings/Conclusions: The agronomic performance and tolerance to plucking was comparable with commercial varieties, has aesthetic characteristics, of flavor and essential oil content that are demanded by consumers and the fragrance industry.

Keywords: fresh biomass, oil, flowering, yield.

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INTRODUCTION

In Mexico, there are several aromatic species that are cultivated and used in various culinary dishes. This is the case of coriander (*Coriandrum sativum* L.), which is a native aromatic plant of the eastern region of the Mediterranean, which is grown in many parts of the world, from 14 to 2,350 m of altitude (Ayanoglu *et al.*, 2017). The main producing countries are: India, Morocco, Bulgaria, Romania, Canada, China, Syria and Mexico. Meanwhile, the main importer countries are Malaysia, Pakistan, Saudi Arabia, United Arab Emirates, and the United Kingdom (FAO, 2019).

All the production is destined to the fresh produce market, both for national consumption and for export. During the last five-year period, exports of fresh coriander have increased by 100%, with the United States being the main buyer (98%), followed by Canada (1.8%), and another 15 countries intermittently (SIAP, 2020).

More than 7,689.16 hectares per year are planted in Mexico, where Puebla (3,289.63 ha) and Baja California Norte (1,396.69 ha) contribute more than 60% of the surface destined to this crop. The mean fresh biomass yield is 16.84 t ha^{-1}. In the state of Guanajuato, 3,691 t were produced, with a production value per hectare of $740.88 USD (SIAP, 2020), which represented an increase of 5.8% (184.5 ha) in the production compared to 2018, situation that shows a constant growth due to its demand in many countries of Asia, Europe and North America.

The production of coriander in Mexico is highly dependent on the varieties generated by foreign companies and less than 5% of the surface devoted to the production of coriander is with seed that producers reproduce, devaluating the quality and genetic purity, as well as in detriment of the yield (personal communication with producers).

The improved varieties that are introduced to the country are traded at prices that smallholder producers cannot pay ($2.5 USD per lb); in addition, they lack previous evaluations in producers' lands, which can sometimes lead to obtaining plants that do not fulfill the preferences and tastes of consumers. Despite the adaptation that the materials of foreign origin have had, the maximum yield has not been reached in the state of Guanajuato, mainly resulting from the effect of the climate, since cultivation in a warm climate experiences a notable decrease in yield (30%), primarily because of early plucking (premature emission of the floral scape) caused by the impact of days with temperature over 28 °C (González-Pérez *et al.*, 2017).

With the objective of contributing to solve part of the demand for coriander varieties of local germplasm, the National Institute of Forestry, Agricultural and Livestock Studies (Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, INIFAP), implemented coriander for genetic improvement (tolerance to plucking, followed by other traits such as fresh biomass production, odor and essential oil content), since 2013 (Guzmán-Maldonado *et al.*, 2018). The objective of this study was to perform the varietal description of the improved material INI-17, based on the guidelines from the UPOV (2013) and to evaluate its performance in the field.

MATERIALS AND METHODS

The generation of the variety was through mass selection, followed by individual selection. The process of mass selection was conducted in 2013, with a genetic base of n=31 populations collected in different producing regions of central and southern Mexico. Seven selections were obtained (Table 1), which were evaluated during two years (three sowings per year=6 cycles). Later, through the process of individual selection, four populations with high yield were identified (fresh biomass production).

During the years 2015 and 2016, the four outstanding populations were cultivated in three cycles per year (S-S, S-F and F-W). In these six cycles individual plants were selected within each population to integrate a new balanced compound with equal number of

Table 1. Origin of the coriander accessions used in obtaining INI-17.

Number	Accession	Origin†	Latitude‡	Longitud	Altitude*
1	L9-CB	Mextiquic de Carmona, San Luis Potosí	22° 15' 03"	101° 07' 36"	2050
2	L13-CB	Tekax, Yucatan	20° 12' 42"	89° 16' 34"	37
3	L17-CB	Tizimin, Yucatan	21° 08' 10"	88° 08' 44"	21
4	L21-CB	San Juan Teposcolula, Oaxaca	17° 33' 03"	97° 25' 29"	2302
5	L25-CB	San Juan Teposcolula, Oaxaca	17° 33' 03"	97° 25' 29"	2302
6	L29-CB	Ixtacuixtla de Mariano Matamoros, Tlaxcala	19° 19' 31"	98° 22' 44"	2282
7	L-31-CB	Paso del Toro, Tlalixcoyan, Verazruz	18° 71' 69"	96° 09' 69"	10

† Place where the original material was collected
‡ Geographical coordinates estimated based on the collection site
* Meters above sea level.

seeds and selection pressure of 10%. The selection criteria were focused on traits related to tolerance to plucking, fresh biomass production, and essential oil content, traits that give high commercial value (Acimovic *et al.*, 2016). In the sixth cycle, the experimental variety called COR-VER-C6 was integrated, which, with the purpose of registry in the National System of Seed Inspection and Certification (*Sistema Nacional de Inspección y Certificación de Semillas*, SNICS) was defined as INI-17.

During the S-S 2016 cycle, the first cycle of varietal description was conducted, and the homologous cycle was carried out in S-S 2017 (20° 34' 39"" N and 100° 49' 13""W) at 1,760 m of altitude. The varietal characterization was based on the guide proposed by González *et al.* (2017) and with the guidelines of the UPOV (2013).

In the S-S 2017 cycle, under a completely random design, the new INI-17 variety was established and as control, the California® variety and a population that producers grow, in a plot found in the locality of Juventino Rosas, Guanajuato (20° 38""04""N and 101° 01' 06" W) at 1,878 m of altitude. The following traits were determined: days to emergence (DE), days to emission of the floral scape (DEFS), days to flowering (DF), days to seed harvest (DSH), fresh biomass production per plant (FBP), and essential oil content (EOC). The data obtained from the traits evaluated were subjected to a variance analysis and Tukey's means comparison test ($P \leq 0.05$) with the statistical SAS package (SAS, 2008).

Since in the F-W cycle there are conditions of temperature and relative moisture required by the crop, as well as the presence of pollinators that improve the seed production, in 2017, in a plot of 2500 m^2 located in the same population where the experimental design was established, the size of the population increased according to the agronomic management recommended by González-Pérez *et al.* (2017).

RESULTS AND DISCUSSION

Characterization

The INI-17 variety presents tall bearing, 70±0.5 cm of height on average, with growth habit of semi-erect basal leaf. The number of basal leaves is high (30±3), with medium color intensity of foliage, medium length, and medium degree of lobulation. The petals do not contain anthocyanins; it has fruit of medium size and brown seed (UPOV, 2013) (Table 2).

Table 2. Differences between traits of the varieties California and INI-17.

Characteristic	Differences	
	California	INI-17
Seedling: anthocyanin coloration of hypocotyl	Médium	Absent
Plant: height	Unreported	Medium
Basal leaf: length	Unreported	
Plant: number of basal leaves	Few	Many
Plant: density of foliage	Sparse	Dense
Basal leaf: degree of lobing	Unreported	Medium
Leaf: size of terminal leaflet	Unreported	Medium
Petals: anthocyanin	Unreported	Absent
Fruit: size	Large	Medium
Fruit: shape	Broad elliptic	Circular
Time of beginning of flowering	Unreported	Late

It is a variety with physiological maturity and late flowering, according to the response presented in the various characterization cycles. The emergence is on average at 15 days, the emission of the flower scape is around 86 days, and the physiological maturity of the seed is reached at 120 days after sowing (das). It presents on average 16 umbels (Figure 1), the weight of 1000 seeds is 11.2 g, and the seed contains on average 7.73±0.15% of essential oil (linalool).

Agronomic performance

The response of the improved material was statistically similar to the controls in three traits: days to emergence, number of umbels, and weight of 1000 seeds (Table 3). In days to flower scape (86 days), days to flowering (98 days), days to seed harvest (125 days), and fresh biomass production (221.7 g), INI-17 was statistically superior to the two controls (Table 3; Figure 2). Meanwhile, in the number of basal leaves (31) and the content of essential oil (7.06-7.73%), it was similar to California and higher than the producers' seed (6.95%).

Local variety INI-17 California variety

Figure 1. Contrast between INI-17, the commercial California variety, and a landrace. The tolerance to plucking and a higher fresh biomass production by INI-17 stand out.

Table 3. Means comparison of traits of agronomic importance evaluated in the INI-17 variety and two commercial controls of coriander (*Coriandrum sativum* L.). F-W cycle, 2017.

Character	Farmer seed	California	INI-17
Days to emergency (DE)	12.0*‡a	12.0a	15.0a
Days to flower scape emission (DFSE)	58.0b	58.0b	86.0a
Days to flowering (DF)	78.0b	84.6b	98.0a
Days to seed harvest (DSH)	100.0b	100.0b	125.0a
Number of basal leaves (NBL)	17.0c	26.0ab	31.0a
Number of umbels (NU)	14.2a	16.0a	16.0a
Fresh biomass production (FBP; g)	91.8c	149.2b	221.7a
Weight of 1000 seeds (WS; g)	10.7a	11.2a	11.2a
Essential oil content (EOC; %)	6.95b	7.06ab	7.73a

*means within the row followed by a different letter indicate statistical differences ($P \leq 0.05$).
‡mean values of four repetitions.

Figure 2. INI-17 variety in the stages of flowering and seed formation.

The performance of the INI-17 variety was similar to the California variety in several traits. However, INI-17 is a coriander variety of long cycle (125 days), which is an advantage for fresh production. The plant accumulates fresh biomass of 221.7 g on average. It showed medium tolerance (50%) to powdery mildew (*Erysiphe heraclei*). It is not sensitive to day length, although days with high temperatures (>26 °C) and sunny during the flowering period favor the formation and the accumulation of essential oil in the seed (linalool). This indicates that INI-17 can be competitive, preferably in regions with warm climate such as the state of Guanajuato, for which this variety was generated as a response to the demand for materials tolerant to premature plucking.

For the management of this variety it is advisable to have a plantation density of 50 to 100 plants per m^2, and this is achieved with 13 to 20 kg of seed, which contributes to

a better benefit-cost rate (B/C=1.65), when it is produced for fresh consumption. Seed production depends on pollination by different species of insects, and to a lesser degree by the wind. The F-W cycle is the recommended season to produce seed of the INI-17 variety, which is whey sunny and warm days between 17 and 18 °C took place, conditions that favor the vegetative development and activity of the insects that stimulate the formation of seeds.

INI-17 has the breeder Title 2184 and is inscribed with the registration number CIL-001-080819 in the National Catalog of Plant Varieties (*Catálogo Nacional de Variedades Vegetales*, CNVV) of the National Service for Seed Inspection and Certification (*Servicio Nacional de Inspección y Certificación de Semillas*, SNICS). The basic seed is available to farmers in the Bajío Experimental Field of the CIR-CENTRO-INIFAP, in Celaya, Guanajuato, Mexico.

CONCLUSIONS

The INI-17 variety is of tall bearing with growth habit of semi-erect basal leaf. It has medium intensity of foliage color, leaves of medium length, and mean degree of lobulation. The petals do not contain anthocyanins, fruit of medium size and brown seed. It is of physiological maturity and late flowering with tolerance to premature plucking and high content of essential oil (linalool).

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