

Hass Carmen®, a precocious flowering avocado tree,

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Introduction

In approximately 1986, a distinct avocado tree was observed in the southern region of the Basilia valley in the municipality of Uruapan, Michoacan, Mexico. This tree was in a producing commercial Hass orchard and appeared to be identical to the surrounding Hass trees in its leaves, structure and appearance of fruit. However, this individual tree consistently exhibited an atypical flowering period compared with the adjacent Hass trees. The result of this out of season bloom was that this tree regularly and consistently produced a crop of high quality fruit that achieved physiological maturity with sufficient oil content significantly earlier than Hass.

The maturity of this fruit coincided with that of the off-bloom crop of Hass, which in Mexico is referred to as the 'Loca' Hass crop. This 'Loca' fruit, which translates to 'crazy' in English, occurs in some Hass trees in some years; and is considered to be highly desirable because it matures during a period of high market prices. When it does occur, it is generally a minor volume of fruit, which is secondary to the fruit produced during the principal Hass season. The reason that this fruit is called 'Loca' is because of its tendency to sometimes set impressive numbers of fruits, only to drop them during the first stages of development. Significant yields from the 'Loca' bloom are quite rare in the Hass variety, occurring only in those unusual seasons when excessive rain does not fall during the critical bloom period.

Mr. Carlos Mendez, a well known avocado grower in the region, became aware of the existence of this peculiar tree and continued to observe its behavior over time. Once he became satisfied that its off-season bearing performance was consistent and reliable, he determined that the tree had the potential to produce significant volumes of market quality fruit during a period of low supply and high prices for the Mexican industry. Mr. Mendez then proceeded to topwork a number of trees to this variety in orchards in the Cherangueran area as well as to propagate nursery trees. From this first increase of material, Mr. Mendez was able to determine that the unique and desirable behavior of the mother tree was also expressed in asexually reproduced individuals in different areas.

Over the course of the following 8-10 years Mr. Mendez continued to propagate and plant increasing numbers of these plants, eventually producing enough propagation material to establish commercial orchards. As these new orchards were established and their performance distinguished them from conventional Hass, the fruit came to be referred to as the Mendez type.

Commercial niche and development in Mexico

The fruit from these first orchards was consolidated and the initial commercial volumes were shipped to the most important domestic markets, principally Monterrey. The presence of this Mendez fruit, which is phenotypically identical to Hass, in these key markets during the off season period provided for supply during a critical period of high demand (June – September), low domestic supply and very high prices. The only other Hass fruit present in the markets during this period is the limited volume coming from the highest altitudes in Michoacan and in some years the "Loca" or off bloom Hass crop.

The very clear benefits realized by the first producers to plant and topwork Mendez type trees in Michoacan fueled an enthusiastic surge of new propagation, which was only limited by the scarcity of graftwood. Once new sources of propagation material became available, nurserymen aggressively propagated as many as possible, selling the trees for prices up to double that of conventional Hass.

During the past decade, and especially since 2007 when the US market became fully open to producers in Michoacan, the Mexican share of the US avocado market has increased significantly each year; exceeding 50% in some years. APEAM AC. Reports a total of 266 378 tons of Mexican

avocados exported to this market in 2010. Previously this market had been supplied primarily by Chilean and Californian producers.

With this increase in Mexican supply and the growing overall demand of the US market for year round supplies of avocados, the increased availability of Mendez type or Hass Carmen® has resulted in significant shipments of this fruit to the US market. Its maturity season generally corresponds with the period when the market experiences less availability of conventional Hass of high quality during the period from June to September. Prior to the emergence of the Hass Carmen the only available Hass fruit from Mexico was the 'Loca' fruit from conventional Hass, which only achieves significant volumes in those rare years when the favorable climatic conditions during bloom allows the fruit to set and fully develop. Hass Carmen, on the other hand, tends to produce well under normal weather conditions and therefore provides ample high quality fruit for the export and domestic markets during a very attractive market window.

In recent years and especially during those seasons in which production from California and/or Chile has been constrained by weather or the alternating character of conventional Hass, Michoacán producers of Hass Carmen have benefitted from very high prices relative to those received by producers of conventional Hass during the traditional Hass season. In some cases these prices have been more than double the annual average prices realized by producers of conventional Hass.

During the past ten years, Mexican nurserymen have experienced strong demand for Hass Carmen trees. The estimate of the leading nurserymen is that approximately 260,000 Hass Carmen plants were distributed during the 2009-2010 production year and that approximately 350,000 more will be distributed during 2010-2011 in nurseries throughout the states of Michoacan and Jalisco. Nurserymen anticipate continued increasing demand that is directly related to the increased revenues that growers receive from Hass Carmen fruit.

Unfortunately there is no dependable information on how many hectares of Hass Carmen have actually been planted in Mexico. However, we can safely estimate that there must be at least 5,000 to 6,000 hectares now planted in Michoacan alone. Significant plantings have also been established in other states such as Sinaloa, Nayarit, Colima and Jalisco.

In a fully mature 18 year old Carmen Plantation in the area of Tancitaro, a yearly average of 26.5 tons has been recorded on the high volume years and on the alternating ones it has usually remained with in the 50% to 60% range, no comparative evaluations with the conventional Hass have been made so far as the alternating patterns are concerned, in general in the high volume years the average size per fruit does have a tendency to remain smaller,

Unique characteristics

The Hass Carmen®, cultivar does not show morphological differences with respect to the conventional Hass in Mexico. The trees follow a similar growth pattern and the fruit develops in an oval shape. The bloom, however, is of the indeterminate type and unlike the conventional Hass begins in August - September. The main distinction that can be observed in this first bloom is that the flowering buds are immediately followed by foliar buds which allow for the new leaves to cover and protect the fruit that has just set while in the conventional Hass there is no foliar growth in that period to cover the new fruit. This makes it more vulnerable in its early stages of development. The fruit reaches its physiological maturity in 9 - 10 months and can be harvested as of June - July. After this first and abundant bloom period Carmen usually will also provide at least 2 more less abundant blooming periods and depending on the altitude of the orchards the shape of the fruit will tend to be round and also have smoother skin.

In order to determine whether the Mendez selection is actually genetically distinct from Hass, samples of Hass and Mendez material for analysis were provided, in July of 1996, to the Centro de Investigación y de Estudios Avanzados of the I.P.N. in Irapuato, Guanajuato, in care of Dr. June Simpson. The result of this evaluation was that 14 combinations of molecular markers were examined with a preliminary result that some definite distinctions were identified as well as a number of possible distinctions.

Ongoing development in the rest of the world

Once the distinctions and advantages of the Mendez selection in Mexico were confirmed, contact was made during 1996-97 with Hank Brokaw, of Brokaw Nursery in Saticoy, California. After several meetings in both California and Mexico, where the Mendez selection was observed in various stages of production, Carlos Mendez and Carlos Illsley proposed to Mr. Brokaw that Brokaw legally import the Mendez selection and begin trials as well as legal protection in California. During October of 1997, a U.S. patent application was filed for legal protection of this new and distinct selection that is very similar to conventional Hass, under Docket no. BROKAW – 36564, subscribed in the county of Ventura, California.

During this period of initial trials in California, it was determined that a commercial name for the Mendez selection was needed in order to establish easy identification of the variety internationally and that would be recognizable across language barriers. The name “Hass Carmen®” was selected and legal rights were secured in this name.

Further discussions were subsequently held with Brokaw to determine the best way to establish trials and administer the distribution of the Hass Carmen® in other countries. The result of these discussions was that Brokaw Nursery was selected to administer legal protection, field trials and distribution of the Mendez selection on a global basis.

As of this date the Carmen is either in early commercial development or commercial trial in the major avocado producing and exporting countries. Plant Breeders Rights or Patent protection as well as Trademarks have been secured or are in process in each of these countries.

South Africa: Carmen® was established in South Africa initially in 2002 and 2003, at Westfalia Estate. Preliminary field and production evaluations were established and successful commercial trial fruit shipments made to Europe. Since then considerable plantations have been established and the Carmen is now in commercial production.

An exclusive Carmen Grower club has been organized by Westfalia Technical Services. The club is comprised of Westfalia and a number of private growers who aim to attract higher prices during the pre-Hass season. The club is presently capped at 1,000 hectares, with 31,000 trees planted to date and 34,000 trees to be planted in the near future. Royalties are derived from both tree sales and fruit sales. Fruit deliveries are directed on an exclusive or semi-exclusive basis to targeted high value European retailers.

Australia: An initial field trial was planted in September 2010.

Brazil: Limited field trials are underway.

Chile: Plant material has been introduced under test agreements; trees are being prepared for first trials.

Egypt: Material is present; initial trial planting to be established during 2011 or 2012.

Israel: Material is present and will be increased for field trials.

Morocco: Material is present and will be increased for field trials.

New Zealand: Field trials are underway.

Peru: Material has been introduced for field trials to be established during 2011

Spain: Test plantings have been established but no data has been developed as of this date.

USA: Carmen is commercially available and testing continues in several locations.

Behavior of Carmen Hass in differing climates:

Reports from the first countries outside Mexico to establish the Hass Carmen reveal some indications that the Carmen can behave quite differently depending on its environment. Trials in both South Africa and California emphasize the uniqueness of the variety, but in very different ways:

South Africa:

Therese Bruwer from Westfalia Technological Services, kindly provided the following update:

Carmen® is a Hass-like cultivar managed in South Africa under Grower Club (GC) regulation by Westfalia Technological Services (WTS). Interested parties can contact WTS for more information (e-mail: wts@westfalia.co.za).

The Carmen trees have a round, compact and dense growth habit. The trees are precocious in bearing and a first flower and subsequent crop has been observed on top works of only 6 months of age. Further, in a commercial planting on Westfalia's Goedgelegen Estate (Mooketsi) an excellent first crop of 9kg/tree was harvested from 27 month old trees (on Dusa® rootstock). The cultivar is a consistent producer with a less pronounced alternate bearing pattern when compared to Hass.

The most attractive characteristic of Carmen, over Hass, is its season of maturity. Carmen typically matures earlier than Hass and can extend the Hass harvesting season with up to four weeks. The cultivar also regularly produces an out-of-season flower and subsequent out-of-season crop that is ready for picking from November to December (South Africa). Data collected at Westfalia Estate showed this crop to be as big as 40% of the normal season crop. Carmen fruit are of the same shape (ovate/egg-shaped) and size (190g-305g) as Hass. The cultivar can tolerate an extended period of low temperature storage (28 days at 5.5°C), as is needed for export via sea freight, with no compromise on fruit quality. Carmen fruit are of excellent eating quality and can also be processed (guacamole, evaluated by Westfalia Fruit Products).

An eight hectare "high density" planting of Carmen (on Dusa® rootstock) was established on Goedgelegen Estate in 2007. The trees were planted at a 3m x 3m spacing resulting in 1111 trees/ha. The first crop was harvested in February 2010, amounting to 10ton/ha. Trees were allowed to develop and grow without any interference until Jan. 2009 (14 months old). By then, some of the trees had reached the recommended height of 2.2m ($\pm 70\%$ of row width) and were topped.

By September 2009 (when trees were 22 months old), the between – row areas had grown shut and regular pruning became necessary to maintain tree width and allow sufficient penetration of sunlight. The width of the trees was thus restricted to 2m in diameter. A stick of 1m in length was simply held against the stem of the tree and any growth extending past the length of the stick was removed. The plant growth regulator uniconazole (Sunny®) was also used to aid with vegetative growth control.

The biggest challenge with this planting will be to maintain the size of the tree by pruning regularly but without compromising the expected yield. It remains to be seen whether this high density planting will be manageable in the long term.

California:

In general the Hass Carmen's behavior in California has been difficult to pin down. As in Mexico, the intensity of the off-season bloom appears to be determined by the preceding crop and there can be notable alternation. However, in California the conditions during the Carmen's autumn/winter bloom are not conducive to fruit set and the off-season crop tends to be light. The off season bloom continues at varying intensity throughout the winter until the time of the classic Hass' normal bloom in spring. At that time the Carmen bloom gains in intensity to match and sometimes exceed that of Hass. In most years this is the period when most of the Carmen fruit is set. This may be an advantage in California due to the fact that the Carmen's bloom that coincides with classic Hass produces fruit during the season of highest fruit values, which in California is during the traditional Hass season.

Typically, a California block of Carmen trees during the extended bloom period will have a checkerboard look. Some trees will, at a given moment, be full of blooms while others might have little

or no flowers. Similarly there is normally a broad range of crop loads on individual trees in a given block even though tree size, care, soil conditions etc. appear to be nearly identical.

Like Hass, Carmen can and does alternate in its productivity from year to year. In a high density plot in Santa Paula, California a graph of the relative production between Hass and Carmen shows interesting results:

Date planted: August 2006

First commercial harvest: early 2010 at 3 1/2 years from planting (previous crop damaged by frost)

	2010	2011	Accum
Hass	23.06	2.99	26.05
Carmen	12.17	17.05	29.22

Figures are extrapolated to tons per hectare based upon 196 Hass trees and 183 Carmen trees planted at 10' x 12'.

As can be seen, the Hass produced very heavily in 2010, then rested during 2011. This is consistent with the California Hass industry, which enjoyed a very large crop in 2010 and a very light crop during 2011.

However the Carmen, which appeared to underperform in 2010, went on to produce a very acceptable crop of 17 tons per hectare in 2011, and cumulatively produced more fruit over the two year period. Interestingly, if Carmen's pattern of alternation in opposition to that of the Hass is sustained, it makes for an interesting hedge against alternating crops.

Carmen in California has some interesting characteristics. In addition to its enthusiastic flowering habit, it tends to produce very thick young branches at the green stage. After these harden off, a process that may take longer than in classic Hass, the subsequent growth from the terminal of this thick stubby branch can be explosive, sometimes producing multiple lateral shoots without a clear apically dominant leader. We speculate that the Carmen has a unique protocol for accumulation and release of energy both in blooms and vegetative growth. Possibly this is an effect of a hormonal balance that is distinct from that of Hass.

Carmen fruit from the classic Hass bloom achieves maturity at the same time as Hass. However, during years of heavy fruit set, Carmen fruit tends to be smaller than Hass.

To sum up, we can see the Carmen in California as a Hass fruit that is borne on a quirky tree with an alternating explosive and quiescent growth habit, and a very enthusiastic and oversexed approach to fruit production. We are still uncertain how it will fit into the California industry, but if its tendency to act as a hedge against the alternating nature of classic Hass is sustained, there is great promise for the future.

Conclusions

The Hass Carmen® has become an established and significant cultivar in the Mexican avocado industry. Its emergence was based on in-the-field grower experience and the variety was widely adopted despite a lack of formal research or analysis. On the strength of the variety's success in Mexico, it was introduced to diverse international avocado producing countries for trial.

In South Africa the most detailed analysis has been performed over nearly a ten year period. As a result of successful and consistent off-season production and demonstrated shipping qualities, the variety is enjoying commercial success.

In California's climate, which experiences colder and more extreme winters than either Mexico or South Africa, the Carmen's off-season production tendency appears to be partially suppressed. However, it distinguishes itself from Hass in intensity of bloom and, at least during the past two seasons has alternated in opposition to the traditional Hass crop.

More recently trials have been initiated in many additional countries but as of this date very little data is available. We can speculate that the off season producing habit will be more pronounced in semi-tropical climates which experience wet summers and dry, mild winters; while in more extreme Mediterranean climates with cold winters the bloom will be more concentrated during the traditional Hass spring season.

Depending on the location, the Carmen's positive attributes include: out of season availability of fruit, increased overall productivity, a potential hedge against conventional Hass alternation and fruit that is basically indistinguishable from conventional Hass to the consumer.

The Hass Carmen's potential flaws include: potential for alternating crops, smaller sizes during very heavy crop years and in some climates, off bloom fruit can be smooth and round, just as Hass off-blooms.

The hope is that the Carmen will provide growers in diverse countries with an extended season and higher productivity of excellent quality fruit. Trials underway in several countries will reveal the Hass Carmen's attributes as well as its flaws under diverse conditions, and teach us how to optimize the variety's attributes in each area.

Acknowledgments

We would like to thank Mr. Carlos Mendez for his foresight in detecting the important potential of the Hass Carmen and his invaluable enthusiasm and dedication in the initial stages of its propagation, as well as his continued work on new plantations in Mexico, undoubtedly he has contributed to a significant new option for the global development of the avocado.