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PRODUCTION OF AVOCADO (*Persea americana* Mill.) IN ECUADOR

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In Ecuador there are 60000 ha with potential for avocado cultivation; however, there are currently approximately 4500 ha of this fruit, where the variety 'Fuerte' predominates (85%); while of the variety 'Hass' there are about 800 ha (coast and highland). On the Tropical region, avocado is cultivated in the dry forest, at an altitude of 50 to 800 masl, temperature from 20 to 22°C, an average precipitation of 400 mm per year, alkaline pH in the soil with presence of Ca, Mg and Na salts. There are local cultivars from Antillean race, called 'criollos', in the rainforest (1600 mm of precipitation), in deep loam soils, pH of 5 to 7.5 and high content of organic matter. On the other hand, in the hihgland, it is cultivated in the temperate valleys, at an altitude from 1200 to 2500 m, temperature from 15 to 19°C, shallow loam soils, with a slightly acid to slightly alkaline pH (6.5 to 7.5), poor in organic matter; predominating the Mexican races (nacional) which is used as rootstock; and commercially, the race Guatemalteca (Fuerte) is the most cultivated.

In Ecuador, the variety 'Hass' is being promoted because it is suitable for export due to it has the following characteristics: increased international demand, thick and rough skin, violet-dark to black color, creamy pulp without fiber, fruit weight between 130 and 300 g, oil content from 18 to 24%, precocious and very productive, high planting density (1100 pl ha-1), easy formation with pruning (pyramidal) and resistance to transport. On the other hand, the variety 'Fuerte' has the following characteristics: pear fruit shape, weight from 150 to 400 g, smooth and delicate skin, pulp without fiber, oil content from 18 to 22% , late production, vigorous tree (500 pl ha-1), productive alternation, little post-harvest durability and scarce international demand.

Key words: variety, Fuerte, Hass, traits, Ecuador.

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AVOCADO (*Persea americana* Mill.) IN THE CENTRAL REGION OF THE COASTAL ZONE OF ECUADOR

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Avocado is one of the fruit species found in most of the production systems in the central region of the coastal zone of Ecuador (tropical region), especially in the Province of Los Ríos, part of Guayas and Manabí; generating a considerable production of fruit of different types (shape, size, color, flavor, quality of the pulp, etc.). This fruit at certain times supplies the local market and neighboring countries such as Colombia. It is assumed that these different avocado types come from the Antillean race, which over time were introduced and sown as seed plants in dispersed form in the farms, achieving their adaptation to the environmental conditions of the area and thus creating important variability genetics. It is important to characterize this genetic variability, due to the development prospects that this fruit crop is acquiring in the Ecuadorian coastal zone, in order to identify individuals with desirable characteristics, and to maintain genetic resources that allow generating or selecting cultivars of better quality, productivity and adaptation to climate change.

Between 2014 and 2015, a collection of 52 accessions was realized in the following sites: Los Ríos (Mocache 26, Quevedo 11, Valencia 5); Guayas (The Junction 8); Manabí (Portoviejo 1, Pichincha 1), in areas comprised at altitudes between 44 and 120 masl, with an average annual rainfall of 500 to 2000 mm and an average temperature of 25°C. These materials were planted in the Pichilinge Reserach Station of INIAP for their growth and later morphological characterization based on descriptors established by Biodiversity International. In addition, studies will be carried out to select possible rootstocks that are adapted to the tropical conditions. Currently, preliminary observations of the collected materials have shown variability in growth (height and vigor), color and shape of leaves, plant development habit (vertical or horizontal form) and color of the stem cortex.

Key words: Tropical region, accession, Coastal zone, Ecuador.

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PLANT BREEDERS' RIGTHS AND TEST GUIDELINES FOR AVOCADO VARIETIES AND ROOTSTOCKS

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A *sui generis* international system was established in 1961 to have plant breeders' rights over new varieties, with the mission "To provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society". This system aims to encourage those who have developed new varieties and thus promote that they continue to obtain new and better varieties, so that both producers and consumers benefit from the product of these varieties. The organization developed for this purpose is called UPOV, which is composed of the Members of the Union that can be countries or organizations. The operation is coordinated by the UPOV Office, which has its headquarters in Geneva, Switzerland. To have a plant breeder's rights title, within the Member States, the candidate variety should be evaluated to determine if it is distinct, uniform and stable (DUS), which is done in a test, in conditions where it grows and develops properly, along with other "similar" varieties. For this, within UPOV have been developed Test Guidelines, which lead to a harmonization between Members of the Union, which gives strength to the system. For the avocado case, there are two developed DUS test guidelines, one for varieties and one for rootstocks. The test guidelines for avocado (TG/97/4) was revised and adopted in April 5, 2006, were Mexico had the responsibility as expert leader. The test guidelines have 70 characteristics to evaluate new avocado varieties, of which: 4 characteristics are of the tree and shoots; 16 leaf characteristics and its parts; 9 characteristics of inflorescence and flower; 41 characteristics of fruit and its parts. Due to the rise of avocado rootstock selection worldwide and the need for guidelines for testing of these rootstocks for granting plant breeders' rights in a shorter time, guidelines were developed under the leadership of Mexico. In the case of the test guidelines for avocado rootstocks (TG/318/1), its adoption was in March 6, 2016 and published in September 6, 2016. The test guidelines for rootstocks have 36 characteristics, of which: 15 characteristics are of the tree and shoots and 21 leaf characteristics and its parts. The two test guidelines for avocado are now in use for all member states for the evaluation in DUS testing and are available in the UPOV web site (www.upov.int) in two popular formats. A graphic handbook for the description of avocado varieties was developed to facilitate the evaluation of each of the characteristics in the field, for which they were illustrated with photographs each of these and their levels.

Key words: *Persea americana* Mill., intellectual property, plant characterization, variety distinction, UPOV.

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IMPROVEMENT OF AVOCADO GROWTH (*Persea americana* var. Hass) WITH THE USE OF NATIVE ROOTSTOCKS IN COLOMBIA

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The center of origin of avocado (*Persea americana*) occurs in the forest of tropical highlands of Central America, including Mexico, Guatemala and Honduras. The avocado trees a large canopy spreading in its original habitat. The several species are genetically very heterozygous with long juvenile period and very high rate of flower abscission and immature drop. The physiology, genetics and production have been study for several investigators, growers and producers, however the need of conventional breeding programmes have been moderately successful. However, the avocado subspecies /races and some cultivars are hybrids involving two or more subspecies. The widely grown "Hass" and "Fuerte" avocados are considered from Guatemalan x Mexican hybrids. Because of the quality of the fruit, size and test, Hass has been accepted very quickly in several tropical countries (Peru, Colombia, Costa Rica, Chile, Ecuador) and their introduction to establish crops was very well accepted.

Persea americana "Hass", as woody plant species of avocado, needs every good strategy for dealing with the above problem of grafting onto the appropriate rootstock. Because of it, we are looking to find a good rootstock and for this purpose we found a Colombian legendary avocado tree that we are improving this material in for grafting. Buds of 1-2 cms in size with four leaves were placed on the vascular ring of a decapited rootstock and then, inserted to the depression cut as Y method, after this step, shoots developed four two six weeks after initiation under greenhouse at 20-22° C. We are improving this material and we will evaluate for the later crops. The success of the graft union was dependent on scion size. The larger the apical buds, the size of the vegetative buds for a probable a successful compatibility union as means of a successful micrografting. Shoots apex micrografts should be suggested using the same rootstock on the in vitro conditions to produce healthy plants, especially for virus free. The importance to establish the cost of accounting to the conventional and shoot tip methods in vitro to determine which technology might be more profitable for the propagator.

Key words: grafting, *in vitro* method, Hass, Fuerte.

Cite this abstract as: Rodríguez Jairo, Fischer Gerhard, Magnitskiy Stanislav, Perea Margarita **(2017)** Improvement of avocado growth (*Persea americana* var. Hass) with the use of native rootstocks in Colombia. *International Journal of Clinical and Biological Sciences*, Volume 2 (Suppl. 1), pp S4

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DIVERSITY OF AVOCADO (*Persea americana* Mill.) GERMPLASM FOR USE AS ROOTSTOCK

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There is a great variability of avocado germplasm considered as cultivar 'National' (Mexican race) in Ecuador because this fruit is cross-pollinated; however specific characteristics that they present to be considered as rootstock are unknown. The success of a good yield of this fruit in adult plants depends on the quality and health of the seedlings used for planting. In the nurseries of the Tumbaco Experimental Farm (INIAP), seeds of cultivar 'National' were obtained from the provinces of Pichincha and Imbabura and clustered in 16 groups based on their shape, color and size. The purpose of this research was selecting materials that show good traits to be used as rootstocks. The following variables were recorded: percentage of germination, plant height, caliber and root dry matter. It was observed that there was a slightly correlation (0.48) between the polar diameter of the fruit and seed, whereas it was not with the equatorial diameter; thus, there is not a direct relation in the size of both fruit and seed. On the other hand, the percentage of germination was in a range of 35 to 45 days after sowing. There were two groups (AP5 and AP7) with high percentages of germination and in less time (100 and 98% of germination in a time of 35 and 32 days respectively); while the later one was the material AP10 with 83% of germination in a time of 60 days. The material AP13 obtained the lowest percentage of germination (78%). About the variable plant height, the groups AP7 and AP12 were highlighted, with an average of 67.6 and 61.54 cm respectively. In relation to the caliber, groups AP12 and AI15 shared the same range of significance with 6.07 and 6.06 mm respectively; nevertheless the former reached this value in less time (136 days) while the latter it did in 146 days. In the root dry matter variable, there was no statistical difference between materials; however, the material AP12 was highlighted because it obtained the highest weight (30 g) in less time from germination (136 days). In addition, the group AP2 with a root dry matter of 40 g obtained in 154 days and AP7 with 32 g in 157 days were over the average dry matter value although they needed more time for growing. With this research, it can be concluded that there is great seed variability that is expressed in the phenotypic traits evaluated during the development of the seedlings. However, an individualized selection of the materials should be made based on favorable characteristics that determine the vigorous and rapid development of the seedling for later use as a rootstock. Additionally, further research is needed to determine the resistance/tolerance of these germplasm to the attack of soil pathogens such as *Phytophtora cinnamomi* and *Fusarium* sp.

Key words: avocado, rootstocks, variability, seeds, Ecuador.

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INIAP ADVANCES IN BIOTECHNOLOGICAL RESEARCH APPLIED TO AVOCADO: SOMATIC EMBRYOGENESIS RESPONSE AND SCREENING OF GENETIC VARIABILITY OF GERMPLASM

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Due to its high demand, avocado (*Persea Americana* Mill.) has become a high value product in the agricultural sector of Ecuador. Consequently to aid in material selection, INIAP has focused on two research areas: first to evaluate *in vitro* clonal multiplication, and second to characterize the genetic variability of existing germplasm. For clonal multiplication, we have evaluated the somatic embryogenesis response of genetic material with interesting traits (reduced growth and resistance to root diseases). For the induction stage, an experiment was established applying different doses of auxins and cytokinins alone or in combination with two types of explants for the formation of an embryogenic callus. The results showed the formation of embryogenic calli with good morphological characteristics derived from leaf and nuclear tissue in the varieties *Mexicola*, *Puebla*, and *Duke-7*. Later, in order to regenerate the somatic embryos, we evaluated histologically somatic embryogenesis of *Duke-7* and *Puebla* varieties, using three different explants: foliar tissue, nucelar tissue, and immature zygotic embryos. A successful somatic regeneration was obtained using immature zygotic embryos in the evaluated varieties. Additionally, to evaluate the germplasm for future use, variability of 182 accessions and 66 "National" samples collected in the Andean valleys were scored for polymorphic loci using 10 microsatellite markers. Genetic diversity analysis revealed a total 110 alleles in the examined loci with an average of 11 alleles/locus. The PIC (Polymorphism Information Content) value was 0.73, the expected heterozygosity (H_E) was 0.77 and the observed heterozygosity (H_O) was 0.65, suggesting a high genetic diversity in the collection. The UPGMA and the multivariate analysis (PCO) showed a weak genetic structure except for the differentiation of samples collected in Pichincha and Tungurahua provinces. The global analysis revealed that "National" samples were less differentiated than the accession materials which had higher genetic variability. These results will contribute to the use of this germplasm in the breeding program.

Key words: avocado, biotechnology, *in vitro* culture, SSRs, Ecuador.

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POLLINATION IN AVOCADO (*Persea americana* Mill.)

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Spain is the only country in continental Europe with a significant commercial production of avocados, mainly confined to the Andalusian Mediterranean coast. Avocado is a subtropical fruit tree with bisexual flowers with functional male and female organs. The maturation of those organs is separated in time through a particular breeding system called synchronous protogynous dichogamy in which each avocado flower opens twice. During the first flower opening, the flowers are functionally female (with the stigmatic surface receptive for the arrival and germination of pollen grains). After this first opening the flowers close and reopen the following day functionally as male (during this phase the anthers dehisce and the pollen grains are released). This pattern is synchronised in all the flowers of a given avocado cultivar. There are differences in the flowering behaviour among cultivars. Thus, depending on the flowering behavior we can classify the different avocado cultivars in two groups (A or B). In type A cultivars, the flowers open in the female stage in the morning of the first day of the flowering cycle, close at mid-day and reopen during the afternoon of the following day at the male stage. In type B cultivars, the flowers open at the female stage in the afternoon of the first day of the cycle, close overnight and reopen during the morning of the following day. A single avocado tree can produce millions of flowers during the blooming period; however, more than 99% of the flowers produced do not develop into fruits. With the purpose of understanding the reproductive factors that limit avocado production under the growing conditions of the Spanish Mediterranean coast and why most flowers prematurely abscise while some of them develop into fruits we have been analyzing for several years the progamic phase, which is the phase from pollination to fertilization, in 'Hass' avocado and its implications in final fruit set paying special attention to the pollination process. We analyzed pollen deposition in flowers left to open pollination in a monovarietal 'Hass' orchard and we observed that most of the flowers in the female stage had received no pollen at the time of closing and that a high pollen adhesion occurs during the male stage, apparently due to a higher attraction of honeybees to male flowers although no fertilization was observed in flowers pollinated during the male stage. The results obtained indicate that pollination is a critical step for avocado fruit set and that pollen limitation is one of the main causes of the low production in avocado. Among the factors causing pollen limitation, low pollinator visiting frequency and low pollinator abundance seem critical. The percentage of flowers with pollen on the stigma increased significantly after placing more beehives in the field suggesting that this could be a feasible method to increase pollen deposition in monovarietal avocado orchards. On the other hand, a significant increase on pollen deposition was observed in mixed orchards planted with cultivars of the two complementary floral groups suggesting the need to interplant cultivars of complementary floral types. Moreover, avocado is native to the Americas where honeybees were introduced by the Europeans. Consequently, although honeybees are currently the main pollinators of commercial avocadoes worldwide, avocado coevolved with other native pollinating insects and it would be of interest to study additional avocado pollinating insects to complement honeybee pollination. Additional experiments were performed using hand-pollination with

pollen from 'Fuerte' on stigmas of 'Hass'. In spite of the higher fruit retention observed after hand-pollination, final fruit set rate is still very low (2.7%). This suggests that additional factors together with pollination problems might be involved in the low fruit set in avocado. In this sense, removing the styles one day after hand-pollination allowed to monitor the fate of the ovaries left in the tree while having the style of each flower. The analysis of those styles showed a highly significant relationship between the amount of boron, starch and other carbohydrates at anthesis and the capacity of a flower to set a fruit. This suggests that flower quality at anthesis is a determinant factor in the capacity of a flower to become a fruit. Work is currently underway to design appropriate management methods to increase flower quality at anthesis.

Key words: Spain, flower, pollinator, cultivar, Hass.

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ADVANCES ON AVOCADO PRUNING AND NUTRITION IN SOUTHERN SPAIN

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Two key management practices that should be taken into account to optimize commercial avocado production are nutrition and pruning, which must be set up for each specific environmental condition. In southern Spain, where avocado industry is relatively new, many avocado management recommendations were directly adopted from other countries, although information related to local conditions have being released over the last years by researchers of the IHSM La Mayora, CSIC. Regarding avocado nutrition, some important traits to consider are a low mineral nutrients requirement, a good response to organic amendments, a common deficiency in some microelements and a great difficulty to incorporate foliar applied fertilizers. Under this background, some of the goals of avocado nutrition studies developed in southern Spain have been establishing leaf deficiency thresholds for P and K in order to avoid K/Ca and P/Zn antagonisms, assessing the response of avocado trees to organic amendments obtained from local wastes, identifying ways to efficiently apply three microelements (boron, copper and zinc), and optimizing nitrogen fertilization. Results from these studies showed that: i) Fertilization programs with no application of P and K (equivalent to leaf content down to 0.08 % and 0.5 %, respectively) for a long time (up to 30 years) did not reduce significantly avocado yields, probably due to high populations of arbuscular mycorrhizal fungi promoting root nutrients assimilation; ii) Organic production systems based on thick mulches of almond shells (a local agroindustry waste) increased avocado average yields in a 12 year-period when compared with conventional fertilization management, mainly because of the development of a new superficial organic layer, described as an OH horizon, with an average bulk density similar to those found in natural organic peat soils, and to some changes concerning pH and organic carbon, Kjeldahl N and available-P contents in the upper soil 0-25 cm layer; iii) Composts made by mixing gardening pruning residues and guacamole production wastes were suitable for nursery avocado plant production; iv) Efficient applications of microelements included fertigation for boron, hand application to soil in a 60 cm-diameter circle around water emitters for zinc, and foliar spraying just after flowering for copper; and v) Decreasing soil pH down to 6.0 with phosphoric acid and applying 30% of total N in autumn (October-December) significantly increased avocado yields when compared with soils with pH around 6.5 only receiving N between February and October. On avocado pruning, different objectives of studies developed in southern Spain allowed establishing proper dates and cincturing needs for summer pruning to control tree size in hedgerow grown trees, control of alternate bearing by preflowering shoot tipping, and early recovery of production in stumped trees of overcrowded orchards. Results from these studies showed that: i) Shoot tipping of vigorous branches at bud break stage before an "on" year reduced significantly alternate cropping in adult trees; ii) Both single and double trunk cinturing of main branches with a knife (straight or saw) increased early production of stumped trees by increasing the percentage of flowering buds; and iii) Recommended dates for summer pruning of hedgerow grown trees are July with cincturing in coastal orchards, and August or September with cincturing in inland orchards.

Key words: pruning, fertilization, organic, nutrient.

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PHYSICAL AND CHEMICAL CHARACTERISTICS IN RIPE FRUITS OF FUERTE AND HASS VARIETIES OF AVOCADO IN TWO LOCATIONS OF THE SUBTROPICAL VALLEYS OF ECUADOR

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One of the causes of postharvest losses in avocado is that the conditions and the harvest season in the subtropical valleys of Ecuador have not been established. The quality and nutritive value of the fruit are influenced by the environmental conditions during fruit set, especially in climacteric fruit such as avocado which shows a rapid increase in respiration and production of ethylene after harvest. The climatic factors that affect the quality of the fruit in the pre-harvest are temperature and relative humidity, being able to influence the phenology and physical-chemical characteristics of the fruit. This research was carried out in two lcalities: Tumbaco Experimental Farm (L1) of the National Institute of Agricultural Research (INIAP) located at 2348 masl, average temperature of 16°C and 68% of relative humedity; and in San José de Minas (L2) at 1850 masl, average temperature of 22°C and 59% of relative humidity. The objective was evaluating the number of days for harvesting and the physical and chemical characteristics in the physiological maturity of the 'Hass' and 'Fuerte' avocado varieties. For statistical analysis, a completely randomized block design was used in a 2 x 10 factorial arrangement (2 varieties and 10 evaluation periods) with 3 replicates for each locality. According to the results, it was determined that in L1 the physiological or harvest maturity of varieties 'Hass' and 'Fuerte' started at 201 days after fruit set, whereas in L2 the cycle was shortened at 171 days due to the greater temperature and lower relative humidity. In relation to the fruit physical characteristics, in L1 the fruit length was 115.59 and 79.00 mm, diameter of 64.75 and 52.92 mm, fruit weight of 232.55 and 180.97 g and pulp yield of of 70.59 and 68.22% for 'Fuerte' and 'Hass', respectively. In L2, the measures increased for the two varieties, obtaining bigger fruit, thus 'Fuerte' presented fruit of 250.5 g, that represents 8% of increase against L1, and 'Hass' increased on 11.3% . On the other hand, in L1 the titratable acidity (tartaric acid) was 0.088 and 0.078%, dry matter was 21.78 and 20.62%, and fat content of 10.69 and 13.07% in 'Fuerte' and 'Hass', respectively. While, in L2 there was an increase of with 0.09 and 0.11% in titratable acidity and 16.00 and 16.90% in fat content and reduction of dry matter of 18.90 y 18.40% for 'Fuerte' and 'Hass', respectively. It is concluded that the environmental conditions influenced the phenology and fruit traits, being L2 where the 'Hass' and 'Fuerte' fruit had bigger weight and percentage of fat content.

Key words: phenology, Hass, Fuerte, localities, traits.

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TEMPERATURE EFFECT ON THE PHENOLOGY OF TWO AVOCADO VARIETIES (*Persea americana* Miller) IN ECUADORIAN ANDEAN VALLEYS

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Avocado (*Persea americana*) is native to Mesoamerica. Three types of avocado are known: Mexican, Guatemalteco and Antillean. Avocado shows open pollination, which occurs entomologically causing avocado´s genetic variability. In Ecuador, avocado is grown mainly in the Andean Valleys (1800 and 2500 masl), which have an average temperature of 17 °C, annual rainfall ranging from 400 to 1000 mm and 85 % of relative humidity. The growth and development of the plant can be measured by means of its periodic events that occur during the life cycle of the plant in relation with the environmental conditions. Phenology can be measured by the statistical distribution such as time occurrence, duration, synchronicity and skewness. Phenology can be assessed by means of thermal units (TU) and days (d). Thermal units involve the combination of temperature and chronological plant phenological events, which are critical for the survival, reproduction and crop management. The present study focused to know the thermal units and days (d) needed to reach the different phenological reproductive phases by means of assessing the structures (dormant bud to fruit physiological maturity) of two avocado varieties (Hass and Fuerte) in two localities of the Andean Valleys (Tumbaco and Perucho, both located in Pichincha Province). Four branches (cardinal points) were selected from four trees per variety in each location. The experimental design was carried out by a Complete Randomized Block design in factorial arrangement 2 x 2 with four replicates.

When the latent to swollen bud stage were assessed from swollen bud to flowering, no statistical differences were found between localities (L), varieties (V) and the interaction L x V. However Perucho required less number of days an TU respectably (37.5 and 307.4) and TU than Tumbaco (46.7 d; 200.9 TU) for the last stage. This is due to the fact of Perucho lies at lower altitude (1850 masl) than Tumbaco (2350 masl), which directly influenced the temperature. When time from flowering to fruit-set was assessed, statistical differences were evidenced in days to setting. Tumbaco required a greater number of days (53.6) than Perucho (28.1). Among varieties there were statistical differences: Hass variety required less number of TU (217) than Fuerte (246.4). This difference might be explained by the genetic origin of the two varieties. Comparing the interaction between variety x locality, the results showed that the Hass variety in Perucho required only 189.5 TU, while the Fuerte variety needed to accumulate 264.3 TU. In general, the results of this study indicated that there are differences between varieties in terms of the TU requirements for the different phenological phases. In Perucho the varieties showed an earlier growth than Tumbaco´s, due to the the altitude and temperatures differences. Finally, it is concluded that it is better to measure the phenology stages by thermal units than in days due to its lower variance coefficient of data analysis recorded.

Key words: avocado, phenology, thermal units, Hass, Ecuador.

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POSTHARVEST QUALITY TRAITS DURING CONSERVATION PERIOD OF HASS AND FUERTE VARIETIES OF AVOCADO (*Persea americana* Mill.) IN ECUADOR

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It is necessary to develop technological alternatives adapted to the conditions of Ecuador, in order to know the right moment of the best quality avocado fruit harvest according to the different markets, evaluating conservation and shelf life. This information will serve to obtain fruit that satisfy the demand of the local and international market. In this research, quality postharvest traits of the 'Hass' and 'Fuerte' varieties were assessed. Fruit were harvested from the orchards belonging to Tumbaco Experimental Farm of INIAP (2348 masl). Subjective and objective maturity indexes were determined for harvest, evaluating the behavior of the quality of harvested fruit in three stages of maturity. It was taking as reference a minimum content of 9% of fat and reaching the appropriate physiological maturity, being 201 days after initiation of fruit set in a state clearly visible for both varieties. Conservation in a natural environment under cover (16 °C and 79% of relative humidity) was carried out until reach optimum condition of consumption; in addition, controlled conditions (7 °C and 90% of relative humidity) was also evaluated. Through establishing shelf life conditions, the fruit quality is guaranteed to achieve the appropriate organoleptic conditions during the marketing, which will allow easier access to different markets. In the natural environment conservation, weight loss was lower with 3.67% for 'Hass' at maturity 2 at 5 days. Pulp yield was highest with 78.82% in 'Fuerte' at maturity 1 at 10 days. The pH with the titratable acidity closest to neutrality was observed in 'Hass' at maturity 1 at 15 days. Highest accumulation of dry matter recorded by the two varieties was at maturity 3 at 15 days with 28.93% ('Fuerte') and 36.02% ('Hass'). Fat content was at maturity 3 at 15 days with 29.16% ('Fuerte') and 32.39% ('Hass'). Fruit firmness was stable until 10 days after harvest, then softening began until 15 days, when optimum firmness was obtained for the commercialization of the two varieties. Damage from dehydration was minimal and with greater emphasis for 'Fuerte'. The color of the exocarp in 'Hass' corresponded to green color that disappears at 10 days turning to dark color and little bright. In terms of 'Fuerte' the luminosity disappeared as the conservation progress continues. During conservation under controlled conditions, the lowest weight loss (1.25%) was recorded for 'Fuerte' at maturity 1 at 14 days. Pulp yield was higher in 'Hass' with 73%. The pH closest to the neutrality was in 'Fuerte' in maturity 2 at 21 days. The highest accumulation of dry matter (28.21%) was in 'Fuerte'. Fat content did not show significant statistical differences, confirming that biochemical processes that minimized at low temperatures. The two varieties up to 28 days did not reach the maturity of consumption. The time needed for these fruit to reach the maturity of consumption after 28 days, placed in environment conditions, was of 7 and 4 days for maturity 1, 4 and 2 days for maturity 2, and 3 and 2 days for maturity 3, for 'Hass'and 'Fuerte' respectively.

Key words: Hass, Fuerte, quality, postharvest, conservation.

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ADVANCES ON AVOCADO PEST AND DISEASE CONTROL IN SOUTHERN SPAIN

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Avocado production in mainland Spain, mostly located in a 100 km-long narrow strip running along the coast of two provinces, Malaga and Granada, is almost pesticide-free due to a low pressure of pests and diseases. One of the reasons to explain this low pressure is probably that Spain, the only country in continental Europe with a significant commercial production of subtropical fruit crops, is far away from most other avocado producing countries in the world. In addition, Spanish avocado industry is relatively new and small, and located in an area with more extreme climatic conditions than those found in many tropical countries. Regarding pests, only one is considered as a key pest in this region, the persea mite, native to Mexico and firstly detected in a commercial orchard in southern Spain in July 2004. Initial studies on biological control of this pest, performed by researchers of the IHSM La Mayora (CSIC) and IFAPA Churriana (Andalucian Government), allowed the identification of different predators naturally occurring in avocado orchards, especially two phytoseiid mites whose populations were highly correlated with those of the pest. These studies also showed that some control approaches based on releasing pollen, such as interplanting maize plants in avocado orchards and spraying commercial bee collected pollen on the avocado canopy, could increase the effectiveness of these predators and reduce pest damage on avocado leaves. Pesticide-free strategies were also developed to control occasional outbreaks of minor pests, such as mealy bugs, aphids and mites. These strategies include management of the avocado canopy to have proper light and air penetration into the trees, spraying water at high pressure on the avocado canopy to reduce pest pressure and wash dust away, and maintaining natural weed covers in the alleys to increase populations of natural enemies and reduce populations of argentine ants by promoting the presence of granivore ants. Regarding diseases, two root rots are the major concerns, Phytophthora root rot, caused by *Phytophthora cinnamomi*, present in most avocado producing countries in the world, and white root rot, caused by *Rosellinia necatrix*, which is only a serious avocado disease in Spain, probably because many avocado orchards have been established in sites that in the past were devoted to almond trees, olive trees or grapes, all of them hosts of this fungus. Studies on control of avocado root rots, mainly those caused by *Rosellinia necatrix*, performed in Spain by researchers belonging to CSIC, the University of Malaga and IFAPA Churriana (Andalucian Government), could identify some successful approaches. These include soil solarization in our summer (June-September) for at least six weeks, alternate irrigation (ie, watering trees only on one side and switching sides when soil water content is close to wilting point), which seems to be effective at initial stages of this disease, use of mulches of composted organic amendments, such as yard waste, avocado pruning residues and almond shells, which showed suppressive capability against this pathogen, and selection of rootstocks with tolerance to white root rot from both "escape trees" detected in commercial orchards and a few accessions of the avocado germplasm collection maintained at the IHSM La Mayora.

Key words: subtropical fruit, strategies, solarization, mulches.

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EFFECT OF BENEFICIAL MICROORGANISMS ON THE GROWTH OF AVOCADO (*Persea americana* Mill.) SEEDLINGS

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Plant quality in nursery is important because it determines future field development of this fruit tree. Many activities are currently being carried out to increase yield, however very little has been done in relation to nursery management, specifically about rootstock growth applying beneficial microorganisms. This is an alternative to increase the vigor of the seedlings (rootstocks) for grafting the commercial varieties such as 'Hass' or 'Fuerte'. The effect of apply beneficial microorganisms such as Arbuscular Mycorrhizae (AM) and Trichoderma (T) on the development of avocado seedlings was evaluated in this research. Two local avocado cultivars (black and green) called as 'National' (Mexican race) were inoculated with the above microorganisms and a control (without inoculation) were set in this assay, each treatment with three replications. Recorded variables were percentage of germination, plant height, caliber, dry matter of root. In addition, the initial and final populations of Trichoderma in the substrate as well as the percentage of root mycorrhizal colonization were measured. Trichoderma was applied each 15 days, at a dose of 0.36 g l^{-1}; applying 0.5 ml of solution distributed in 4 holes of 15 cm of depth around the seed. Arbuscular Mycorrizahea was placed at a dose of 700 spores by 50 g of commercial product; which was mixed with the substrate. The average germination for black avocado was 96% while for green avocado was 93%. In terms of plant height, the green avocado obtained the best results with both T (56.69 cm) and AM (52.07 cm) while control obtained 38.05 cm. Caliber was higher in plants inoculated with T (6.45 mm) than those inoculated with AM (5.96 mm) and the control (5.58 mm). Dry root weight was different between avocado cultivars; green avocado was higher (3.65 g) compared to black avocado (2.85 g). On the other hand, T population decreased in both black and green avocado from 1.5 x 10^9 CFU to 2.2 x 10^5 and 6.4 x 10^4 CFU, respectively; nevertheless these values are adequate for the recovery of this microorganism in the soil. Black avocado showed a high mycorrhizal colonization percentage (19.33%) whereas green avocado obtained a low value (10%). Microorganisms had influence in avocado seedling growth (plant height and caliber). However, there were differences between cultivars (black and green), indicating that genetic effect is also involved in the responses obtained in this research.

Key words: Nursery, rootstocks, Trichoderma, mycorrhizae.

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VALIDATION OF TRAINING TOOLS TO FACILITATE THE LEARNING OF AVOCADO MANAGEMENT

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The National Institute of Agricultural Research (INIAP) through the Technology Transfer Direction develops "training guides" in several crops, and the tools generated are validated with technicians of several institutions and agricultural promoters (avocado farmers) to make adjustments in the framework of methodologies and technical content. Avocado is an important economic crop for small and medium farmers; for this reason, it is necessary to generate technologies that can be transferred through training tools to producers and technicians interested in the management and production of this fruit crop. The validation of these tools allows generating a technical guide that facilitates the learning of the avocado agronomic management. For the validation of the training tools, theoretical-practical workshops were held with avocado producers and technicians from the Provinces of Carchi and Imbabura. The methodology of "learning by doing" was used, depending on the different themes. The topics focused during the validation were: 1) Soil and agro-climatic requirements of the avocado, including the components and types of soil, sampling of soil, and climatic and soil conditions for planting avocado; and 2) Varieties and production of avocado plants, including avocado varieties, types of flowers, rootstocks, selection of plant material for grafting, and the grafting process. These training tools were evaluated based on criteria related to their originality, graphic material, recipient, structuring, ordering of elements, learning objective, simple language and learning through practical exercises. This evaluation allows knowing if the tools are well developed to be used by other trainers. The validity of the tools also includes the evaluation of trainers about their knowledge on the crop, the ease in the development of the training, the use of the tools to correctly transmit the message and transfer the technologies appropriately.

Key words: microorganisms, nursery, rootstocks, Trichoderma, mycorrhizae.

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