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Reproductive development of lemon (*Citrus aurantifolia* Swingle) under different soil moisture levels

Desarrollo reproductivo del limón (*Citrus aurantifolia* Swingle) bajo diferentes niveles de humedad del suelo

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Abstract

According to the Food and Agriculture Organization of the United Nations, citrus fruits dominate the worldwide production of all fruits. Because of its geographical position, Ecuador has favourable growing conditions for citrus fruit production and most of the country has favourable conditions for plants and their relationships with environmental conditions. The objective of the present research was to determine the reproductive phenology of lemon sutil (*Citrus aurantifolia* Swingle) under varying soil moisture levels. A Database Configuration Assistant) using a Randomized Complete Block design as applied and four treatments and six repetitions were distributed as follows: treatment 1 [crop coefficient (Kc) 0.3], treatment 2 (Kc 0.5), treatment 3 (Kc 0.7) and treatment 4 (Kc 0.9). Fruit quality, skin and pulp weight, seed quantity, juice content, degree Brix and polar and equatorial diameter were evaluated, and the phenology was adjusted to BBCH scale coding. No statistically significant difference was found during the study that resulted from rains that homogenised the entire substrate and maintained soil moisture. We established that from the phenological phase of primordia to fruit harvest, there was an interval of 138–140 d wherein the average weight of the fruit (42.62 g) fluctuated according to the weight of the skin (7.65 g), weight of the pulp (34.73 g), number of seeds (5.05), amount of juice (14.36 mL), degrees Brix (5.5), polar and equatorial diameters (44.32 and 42.12 mm, respectively) and the titratable acidity (6.54%). We concluded that the Kcs proposed in the present research should be evaluated during the dry season because, in this investigation, irrigation was induced by Kc for only 2 months after the rains.

Keywords: Production, quality, primordium, phases, fruit.

Resumen

De acuerdo con una investigación de la Organización de las Naciones Unidas para la Alimentación y la Agricultura, los cítricos dominan el primer lugar en la producción mundial de los frutos. Ecuador, debido a su posición geográfica, tiene condiciones favorables para obtener una buena producción de limón, de la misma manera, la mayor parte del país tiene condiciones climáticas favorables para las plantas y su relación con las condiciones ambientales. El objetivo de la investigación fue determinar la fenología reproductiva de Limón *(Citrus aurantifolia Swing)* sometida a diferentes niveles de humedad en el suelo. Se utilizó un DBCA (diseño de bloques aleatorios completos); cuatro tratamientos y seis repeticiones se distribuyeron de la siguiente manera: Tratamiento 1 (Kc 0,3), tratamiento 2 (Kc 0,5), tratamiento 3 (Kc 0,7) y tratamiento 4 (Kc 0,9). Asimismo, se evaluaron parámetros de calidad como el peso de la fruta, piel y pulpa, cantidad de semilla, contenido de jugo, grados Brix, diámetro polar y ecuatorial; La fenología se ajustó a la escala BBCH (Codificación). No se presentaron diferencias estadísticamente significativas durante el estudio debido a la presencia de lluvias que homogeneizaron todo el sustrato y mantuvieron la humedad del suelo. Se estableció que desde la fase fenológica del primordio hasta la cosecha de fruta hay un intervalo de 138-140 días y el peso promedio de la fruta fluctúa entre 42.62 g, peso de la piel 7.65 g, peso de la pulpa 34.73 g, número de semillas 5.05, cantidad de jugo 14.36 ml, grados Brix 5.5, diámetros polar y ecuatorial de 44.32 mm y 42.12 mm respectivamente, acidez titulable de 6.54%. Se llegó a la conclusión de que los coeficientes de cultivo propuestos en la investigación deberían evaluarse durante la estación seca, ya que en esta investigación el Kc solo indujo el riego durante dos meses porque hubo un período posterior a las lluvias.

Palabras clave: Producción, calidad, primordio, fases, fruto.

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Introduction

Citrus fruits dominate the production of all fruits worldwide. According to research by the Food and Agriculture Organization of the United Nations (FAO), the total production of lemons was 173 MT. The leading lemon-producing countries are Mexico, India, Argentina, Spain, the United States, Iran and Italy (FAOSTAT, 2016).

According to UTEPI (2006), the geographic location and growing conditions in Ecuador are suitable for cultivating lemons that are destined for the fresh fruit markets for domestic consumption and for export. This indicates that there is no real citrus-processing industry in the country. At one time, the main citrus-producing provinces were Pichincha, Manabí and Guayas; therefore , this changed, and by 2011, the Manabí region became the largest planted area (1200 ha) for citrus (El Comercio, 2012). Precipitation is the main climatic factor that influences the growth and development of citrus plants. In tropical climate, soil moisture comes from precipitation, and this humidity (or relative humidity [RH]) can be modified using irrigation (Davies & Albrigo, 1994).

The largest planted area in Ecuador comprises *Citrus aurantifolia* Swingle followed by the Tahiti lime (*C. latifolia*), with both varieties occupying ~4400 ha. Lemons in Manabí are one of the main products that are a source of income for the grower; therefore, it is known as a main source of income for the people inhabiting southeast of Portoviejo. (INIAP, 2016). The phenological behaviour and annual yield of citrus crops vary for each production cycle, especially when there is precipitation during the dry season after floral induction, which is the process before flowering under conditions of water deficit, and this subsequently causes extremely high losses in reproductive structures and a low annual harvest (Mateus, Pulido, Gutiérrez, & Orduz, 2010). Knowing the stages of growth helps in compiling information on the beginning, culmination, conclusion and duration of each stage and to correlate this information with environmental factors and elements (Heuveldop, Tasis, Quiros, & Espinoza, 1986).

The study of plant parts during their growth and development, such as sprouting, flowering, fruiting and fruit maturity, is known as 'phenology'. These structures are primarily the result of environmental settings, and the phenological results can be achieved from the plant stages according to the climate and microclimate in which they are evaluated. These phenological observations provide information on the behaviour of different varieties of plants within the specific territories in which they are being developed (Pérez, Romero, Navarro, & Botía, 2008).

The water requirements for lemons is fundamental and its availability is affected by different environmental scenarios, such as temperature, humidity, lighting, wind speed and the basic characteristics of the plant (leaf area and stomatal regulation of the leaves). The quantity of water necessary for the crops is estimated from the temperature, environmental humidity, soil moisture and evapotranspiration (ET). Maintaining adequate and constant humidity in the soil during cultivation, followed by providing sources of high nutrition, guarantee high production and quality, even in subtropical areas with high rainfall (Enciso, Sauls, Wiendenfeld, & Nelson, 2008).

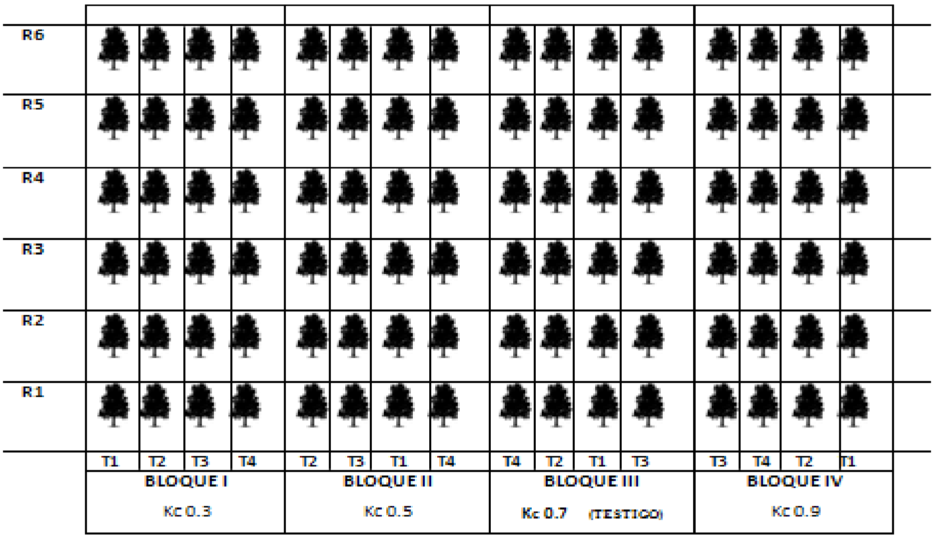
The aim of the present study was to compile information on the reproductive behaviour of the limón sutil (*C. aurantifolia* Swingle) under various humidity levels for determining its development within the Manabí area under its climatic conditions and for assessing the phenology of this species in winter.

Materials and Methods

The study was conducted in Colon parish , Portoviejo, Manabí Province, Ecuador, located 1°05' 19.9" S latitude and 80º 24' 18.6" longitude W at an altitude of 60 MASL (Fig. 1).

Figure 1. Study location. Source: Google Earth Ec, 2018.

Table 1. Field experimental design.



Source: Own elaboration. Caption: Borders Experimental unit

The study was conducted in a 15-year-old in a commercial plantation of lemon (*C. aurantifolia Swing.)* grafted onto mandarin Cleopatra (*C. reshni*) and planted in rows and plants 6 × 6 m apart on flat topography using a drip irrigation system. The experimental design (Table 1) was a Randomized Complete Block (RCB) using a Database Configuration Assistant (DBCA) with four treatments and six repetitions. The plants to be evaluated were marked with a different coloured tape for each experimental unit. For this study, physical–chemical and foliar analyses were conducted in the plants, and a chemical analysis of the soil was performed for assessing the nutritional content in both the crop and soil. Five soil samples were obtained from each hole in the ground. The variables to be analysed were based on the Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie (BBCH)-scale proposed by Agustí, Martínez, Mariano and Almela (1987). The author created this scale

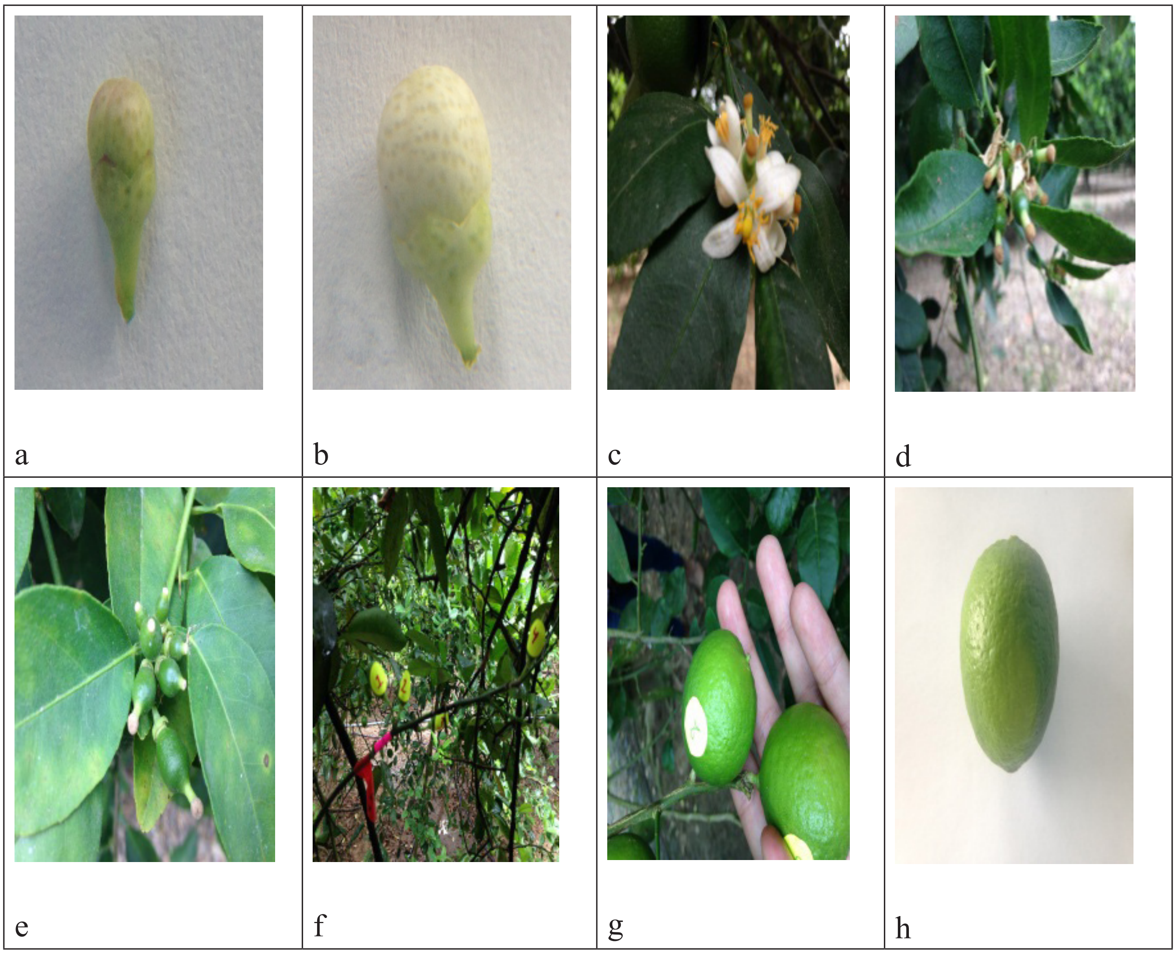


Figure 2. Graphic illustration of the reproductive stages of limón. Source: Images**.** Caballero Mario, 2018.Pale green–white closed button (a); open button (b); open flower (c); senescent (dry) phase; falling petals (d); appearance of new fruits (e); fruiting (f); background colour (g) and appearance of coating colour (h). Graphs based on BBCH scale of citrus (Agustí, 2003).

to categorise phenological descriptions using codes and stages in plant development under the environmental conditions found in Manabí province. The analysed variables were as follows: primordium growth, fruit growth, days to flower opening and fruit quality.

For determining plant phenology, two branches were selected from each cardinal point (N, S, E and W) of the tree. Using the methods by Garrán, Ragone, and Ciuccio, (1993), two trees were marked as references for each treatment, two branches were selected and the floral primordia in the green state (smaller primordium) were chosen. The trees were evaluated every 3 day from initial primordium until flower development, and every 8 d when the fruit was tied, depending on fruit growth. The considerations of data collection were obtained from the initial baseline to the harvested fruit using the visual criteria of physiological maturity illustrated in Fig. 2.

The BBCH extended scale is a system of uniform coding for the phenological identification of the growth stages for all species of mono- and dicotyledonous plants. It is the result of a working group formed by the Federal Center for Biological Research for Agriculture and Forestry of the German Federal Republic, the Federal Institute of Varieties of the Federal Republic of Germany, the German Association of Agrochemicals and the Institute for Horticulture and Floriculture in Grossbeeren/Erfurt, Germany. The decimal code is divided primarily between the main and secondary growth stages and is based on the well-known codes developed by Zadoks, Chang, and Konzak, (1974) to provide greater detail to the phenological keys.

The data collected were classified and coded as follows: primordium (Pr), intermediate button (Bi), inflated button (Bh), open flower (Fa), fruit1 (F1), peach fruit (Fr.a), fruit chickpea (Fr. g), fruit marble (Fr.c), fruit pin-pon (Fr.p), fruit tennis (Fr.t), fruit developed (Fr.d) and fruit collected (Fr.). These terms of identification are placed taking into account the growth and morphology of the lemon, as a part of the field visual observations.

General water requirement for citrus crops

We used the methods proposed by FAO (2006), which defines specific coefficients for each crop (Kc) and then calculates the evapotranspiration of the crop (ETc) using the following formula:

$$ETc = Kc \times ETo$$

The Kc suggested by FAO—0.75 for rainy months and 0.80 for dry months—was used in this study. For calculating the reference ET (ETo), the Penman–Monteith equation described by FAO (1998) was used with data obtained from the meteorological station in Lodana parish processed with CROPWAT Version 8.0 in 2016.

For determining when and how much to water, the following water balance method was used (Sokolov, 1981):

$$\Delta \theta = (P + R + Ac) - (Et + Es + Pp),$$

where, $\Delta\theta$ = the change in water content, P = precipitation, R = irrigation, Ac = capillary contribution, Et = evapotranspiration, It = runoff and Pp = deep percolation.

Irrigation in lemon cultivation

For determining the spacing of the irrigation rings, a search was conducted for the effective plant roots, which for the subtle lemon were at a depth of 0.25–0.30 cm and 1.0–1.70 m from the base of the stem to the horizon. Using these criteria, irrigation rings were placed and the Marriotte bottle technique was used for determining the number of droppers per ring (Fig. 3).

Figure 3. (Search for effective roots)

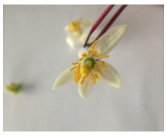
For guaranteeing that all NETAFIM self-compensating drippers (fig. 4) produced the same water outlet, 15 drippers were placed with the two rings, one with five drippers located near the stem and the other with 10 drippers located along the outer perimeter. Each dripper had a flow rate of 5 L water/h.

Figure 4. NETAFIM self-compensating drippers.

Testing

The amount water used was calculated on the basis of the water demand of the crop, its water behaviour and the climatic conditions of the area. Initially, the irrigation frequency was arbitrary and soil moisture was determined once a week using the gravimetric method to provide an adequate supply of water to the crop (ET). The samples were weighed when wet, dried in a stove at 105°C to a constant weight and reweighed. The difference between the weight of the wet and dry sample represented the moisture content in the plant at the time of sampling (Burgos, Perdomo, Morales, & Cayón, 1998).

Table 2. Reproductive phenology scale of the subtle lemon.

Graphic	Date	Code	Registred Name	Day	Code BBCH	Temp.	Hum	Precip	Helio	Description of the scale
	01/06/2018	1	Primordio	6	55	27.4	75	0	1.5	Reproductive shoot, its colour is green in the form of a button many times isolated, or in clusters, it is usually found with or without leaves
	01/12/2018	2	Botón intermedio	4	56	26.8	73	0	9.5	The Growth of the floral button, where the petals grow pass to white colour the sepals that wrap the crown of the floral button become visible
	01/14/2018	3	Botón hinchado	2	59	26.6	81	8.7	1.4	With great relevance appear floral buds ready to burst, fully developed petals appear
	01/17/2018	4	Flor abierta	2	60	27.2	75	0.9	6.1	Opened flower in its entirety, and more than 50% open where its reproductive structures are appreciated
	01/23/2018	5	Fruto 1	6	72	26	83	0.3	2.9	After flowering, you see a fruit already formed; there are falling petals and stamens
	02/03/2018	6	Fruto ‘arverja’	11	74	26.1	88	1.4	0.3	Fruits in the growth process, the growth is slow even having the right conditions for its development
	02/17/2018	7	Fruto ‘garbanzo’	14		25.5	93	5.6	0.1	
	03/09/2018	8	Fruto ‘canica’	22		27.6	82	0	4.6	
	03/29/2018	9	Fruto ‘pinpon’	20		26.1	86	7.2	0.2	
	04/24/2018	10	Fruto ‘tenis’	26	79	27.6	77	0.1	7.5	
	05/08/2018	11	Fruto ‘desarrollado’	14	81	26.8	76	0	4.9	It begins to have indexes in its change of colouration, and its softer shell, and its ease to detach itself from the branch when touching it
	05/14/2018	12	Fruto ‘cosechado’	6	83	25.6	87	0	0.6	Fruit in 80% to collect, in this phase it turns a yellowish green colour which is a criterion of harvest in the farmer

Source**:** Own elaboration, author photos, Caballero, Mario, 2018. Taken as an example of the BBCH scale de (Agustí, 2003). Data from weather station Lodana-Manabí-Ecuador, 2018

Fruit quality

The fruit was harvested at physiological maturity using the grower's criteria and the keys by which the grower determined the quality of the fruit. The following variables were measured: fruit, skin and pulp weight; number of seeds and amount of juice. A Brix American-made ATC RANGE E-line brand Brixometer was used for determining degrees Brix.

Table 3. Meteorological data on temperature, relative humidity, heliophane and precipitation during the evaluation months.

Month	Temp.	RH %	Precip. (mm)	Heliofo. (h)
November	27.23	87.4	0.0	1.25
December	27.90	87.2	0.2	1.82
January	27.00	2.4	4.0	4.63
February	25.80	90.0	3.5	0.20
March	26.85	90.0	3.5	0.20
April	27.60	77.0	0.1	7.50
May	26.20	81.5	0.0	2.75

Source: INAMHI. Instituto Nacional de Meteorología e Hidrología del Ecuador. Quito. Datos tomado de estación Meteorológica la Teodomira, Lodana - Manabi - Ecuador. Lodana-Manabí-Ecuador, 2018.

Results and Discussion

The growth of floral primordium into an initial bud was between 4 and 6 d at 27.5°C. Growth from the initial button into the intermediate button as 6 d at 27°C and from the intermediate button into a swollen bud was 4 d at 26°C and 3 d at 25.5°C. The time between primordium to open flower fluctuated between 12 and 14 d. The time range from floral primordium to harvested fruit varied between 138 and 140 d and depended on environmental conditions, crop management and plant genetics.

The reproductive phenology scale of the subtle lemon was based on the BBCH scale proposed by Agustí, Almela, Aznar, Juan, and Eres (1995) (Table 2) for which the code and name are of the authorship based on the morphological characteristics.

Figure 5 shows how the growth of the lemon fluctuates as a function of temperature. The growth trend is directly proportional to temperature and when the temperature increases, the phenological phase of 'fruit type marble' benefits. In addition, temperatures <24ºC inhibit the growth of the lemon fruit. Valiente and Albrigo (2000) have reported that temperature has a more significant influence on lemon growth and flowering than rainfall in Florida. According to Hardy and Sanderson (2008), the duration of the phenological stages can vary on the basis of different climatic conditions, particularly temperature, in different years. The value of the sum of grades dais (Level of winter rigor in a locality) must remain constant with the temperature among locations or years, this being the most important factor in determining the phenological stages. Stenzel, Neves, Marur, Scholz, & Gomes, (2006) have reported that there are other variables (solar radiation, soil temperature, water availability, atmospheric humidity, winds, nutrition and health status) that affect the metabolism of plants and influence the development processes of citrus.

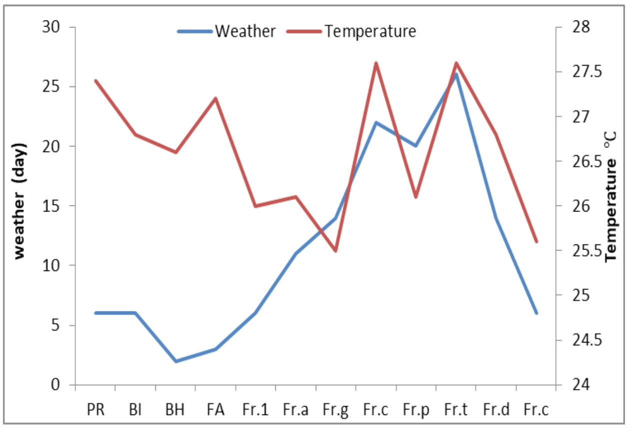


Figure 5. Fluctuation from initial primordia into fruit harvested as a function of temperature in lemon (*Citrus aurantifolia* Swingle).

It can be postulated that within the study location, a temperature range that fluctuates between 25°C and 30ºC, such as that during the months evaluated in this study, is optimal for vegetative development, fruit set, growth and quality of the fruit; however, a temperature of >30ºC reduces the metabolic activity of the plant. This may be because when temperatures are >30ºC, the carbohydrate reserves in the fruit reduce. Figure 6 shows that the humidity is constant during the evaluation dates with an outstanding peak in the phenological phase of 'tennis-type fruit'.

Most citrus fruits adapt well to different moisture lev-

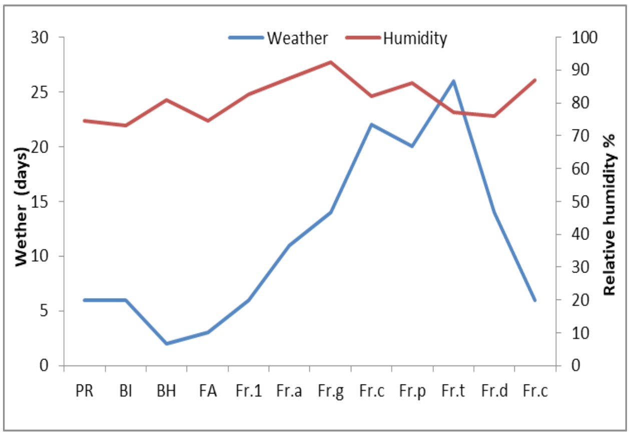


Figure 6. Fluctuation of subtle lemon (*Citrus aurantifolia* Swingle) from primordium to fruit harvested as a function of humidity.

els, such as those in tropical regions where during the period of vegetative development, the RH almost never drops below 70% during the day and reaches saturation at night. For fruit to set, it must have moderate environmental humidity. Changes in environmental RH causes physiological changes in the timing and amount of fruit fall, and the lower the RH, the greater the fruit fall (Albornoz, 1992).

In tangerines and 'Valencia' oranges, for example, changing RH values during the night reduce fruit growth. When there are fluctuations in environmental factors, such as rain, temperature, RH and soil moisture, the fruit is damaged, making it less desirable in the market. Changes in RH also affect the shape of the fruit in tropical and subtropical climates, often making them ovoid instead of round. Figure 7 shows that when there is precipitation during the primordial phenological phase, the rains affect the timing and amount of fruit falls; however, rainfall does not affect fruit mooring during the developing fruit phase as much as during the initial stage of fruit formation.

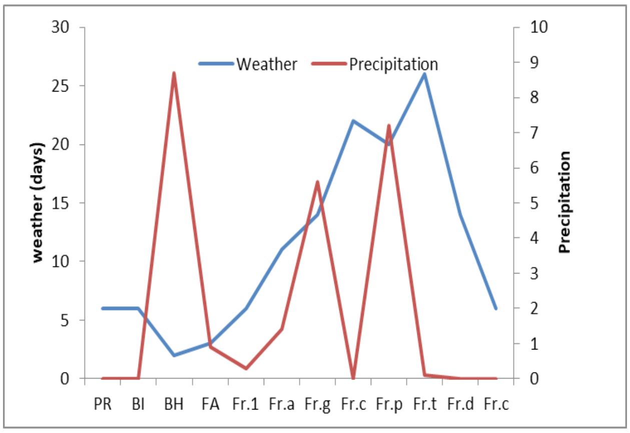


Figure 7. Fluctuations of subtle lemon (*Citrus aurantifolia* Swingle) from primordium to fruit harvested as a function of precipitation.

One of the factors that most influences fruit flowering in tropical climates is water stress. When there is drought followed by high amounts of rain, there is a large effect on the ability of the tree to flower. The fruit stomatal opening and transpiration are significantly reduced under drought conditions, which delays fruit development and substantially reduces its final size. Notably, the rains also enhance the shape of the fruit and the thickness of the shell of the fruit. Water stress reduces its consistency and turgor, which makes the fruit more vulnerable to handling and transport.

Agustí (2003) has indicated that the harvest and the quality of the fruits tend to be better during the rainy season. Figure 8 shows how soil moisture influences flowering and fruiting.

Exogenous factors such as soil moisture are associat-

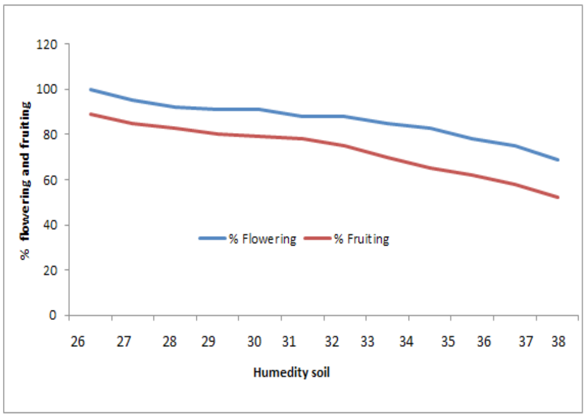


Figure 8. Percentage of flowering and fruiting in relation to soil moisture.

ed with the fall of flower, and citrus fruits can grow and fructify under very diverse environmental conditions, from subtropical climates to tropical zones, There does not appear to be a common climatic characteristic that can act as an essential factor for inducing flowering; therefore, citrus fruits have been considered to be self-inductive species. Carbohydrates levels, hormones, temperature, mineral nutrition and water balance are other factors that influence flowering behaviour. Under tropical conditions, the dominant force on floral induction is water stress. The fruits and roots during development act as negative moderating factors because of their participation in the synthesis of gibberellins, which are the main inhibitors of floral induction. Blooms can present continuously throughout the year, but they peak more after the beginning of a rainy season that is preceded by a dry period. The intensity of flowering and the curdling behaviour are determined by the availability of water.

Rebolledo (2012) indicates that in the tropics water stress is the main factor affecting flowering, while in the subtropics, low winter temperatures concentrate flowering in spring. It is known that a prolonged drought or soil temperatures <12ºC cause the initiation of bud dormancy. The increase in soil temperature or the initiation of periods of rainfall increases the percentage of sprouted nodes by

Table 4. (fruit quality)

Analysis of variance/variables*	P. de fruit (g)	P. of the rind (g)	P. of pulp (g)	N. of the seed	Juice (ml)	º Brix	D. polar (mm)	D. ecuatorial (mm)	% Acidity titulable
Cv.	20.3	24.07	20.45	37.26	32.2	11.12	9.09	7.28	18.33
P-value	0.0003	0.0021	0.0004	0.261	0.0076	0.0001	0.0013	0.0049	0.8986
Media	42.62	7.65	34.73	5.05	14.36	7.5	44.32	42.12	6.54
Experimental error	25.87	3.39	22.38	3.55	21.4	0.7	16.25	9.4	1.44

*Analysis of variance with the INFOSTAT STUDENT statistical package, in addition to the Tukey's a multiple range test = 0.05 for comparison of means.

modifying the balance in the synthesis and/or transport of hormones from the root to the shoot.

Summary analysis of variance of fruit quality

To fully investigate fruit production, the biometric characteristics of limón sutil were determined and are presented in Table 4.

The variance analysis of the quality of the subtle lemon fruit in Table 4 shows that the average total weight of the fruit is 42.62 g, average weight of the shell is 7.65 g, average weight of the pulp is 34.73 g, average number of seeds is 5.05, average percentage of the juice is 14.36 mL, average degrees Brix is 7.5º, average polar diameter is 44.32 mm, average equatorial diameter 42.12 mm and average titratable acidity is 6.54%.

The fruit was weighed 1 d after the harvest. These data on fruit quality agree with those by Orozco (2014) in his study on the application of four vegetable regulators in the productive potential of subtle lemon in the canton grit. The results his study are associated with greater leaf area of the reproductive shoots, which provides for increased photosynthetic activity in the plant, resulting in more and larger fruit and better nutritional reserves.

These data coincide with those of the study by Puente (2006) that was conducted for determining the physical and chemical characteristics of the subtle lemon. Further, these data also agree with those in the study by Olazabal, Bravo and Hernández (2005). Comparing data of the studies mentioned with those of the present investigation, Brix degrees and titratable acidity are below those detailed by these authors, and these variations may be due to the harvest season, the type of soil and climatic factors that influence the yields and biometric characteristics of lemon.

Temperature is the most influential factor in the amount of fruit acidity. The higher the day/night thermal regime, the lower the acid concentration. The fruit yield in the 3456 m^2 study area was 122.7 kg/ha.

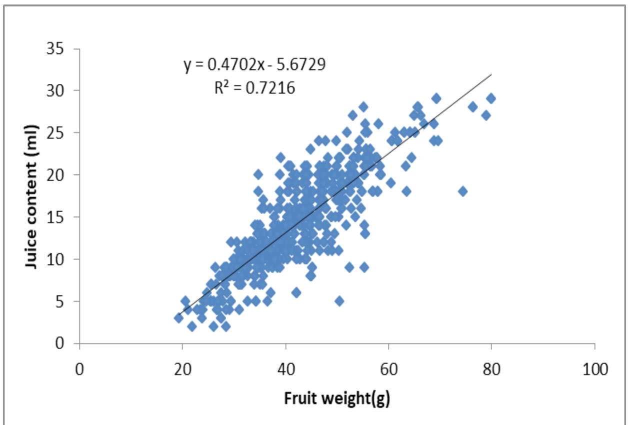


Figure 9. Relationship between fruit weight and juice content.

Figure 9 indicates that the larger the fruit, the greater the juice content. Water is the main component of the fruit, representing between 85% and 90% of its total weight; consequently, under drought conditions or very prolonged summers, citrus orchards suffer water stress from low water availability. Less water available to meet their physiological needs causes delays in plant growth and, if the fruits have already developed, their growth and quality are reduced from low juice content and lower acidity.

In areas with high temperatures, the fruits show more rapid metabolic and morphological development, reaching a good size, high acidity and pleasant aroma; however, they are also more prone to rapid degradation resulting from a higher rate of respiration and, thus, a shorter storage life compared with fruits from areas with lower temperatures. In general, because a fruit tree needs a lot of water, irrigation influences the amount of juice in the fruit; however, the juice content and quality of fruits from the same tree are not always homogeneous. This may be the result of competition among the fruits for resources or the lack of photoassimilates resulting from a tree crown that was not adequately controlled by pruning.

In general, the size or weight parameter of the fruit is associated with equatorial diameter and volume (Bain, 1985). In the early stages, total soluble solids (TSS) increases with the increase in the size of the fruit (Agustí, 2003). Hardy and Sanderson (2010) mentioned that the content of soluble solids increases mainly from the accumulation of sucrose during the maturation phase. The same behaviour was reported by Agustí (2003), who pointed out that in varieties that mature early, the sucrose content rapidly increases and that the fruits continue to mature when the temperature decreases (in subtropical regions); however, in varieties that mature later, fruits ripen when the temperature increases and the sucrose content in the fruit increases relatively little (Agustí, 2003).

Conclusions

The Kcs proposed in the present investigation should be evaluated during the dry season because, in this study, irrigation was induced by the Kc for only 2 months before the rainy season. For the phenological evaluation, some primordia were observed, which, as a result of rainfall, In drip irrigation, the roots of the plants were concentrated and developed only within the moist areas of soil; however, under Ecuadorian coastal conditions, where there are two distinct periods (dry and rainy), lemon roots extended much farther than they did in areas with less rainfall.

Our limited knowledge on the ecophysiological parameters that determine the growth and development of the fruit in each area makes the technological options more non-specific. The technological development achieved under subtropical conditions serves as a starting point for adjusting the methods and techniques that allow the creation of a management platform for the species grown in the Ecuadorian tropics. The subtle lemon has high acidity, which helps preserve food and keep it fresh; therefore, it is more commercialised and very desirable in the culinary industry.

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