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THERMAL AND HYDRIC BEHAVIOUR IN MEXICAN VARIETY AVOCADO (*Persea spp*) FLOWERING IN THE COASTAL NORTH-CENTER REGION OF VENEZUELA

M. Pérez[1], L. Avilan[1], E. Soto[1], M. Rodriguez[1] and J. Ruiz[1].
[1]INIA-CENIAP, e-mail: mercedesperez@inia.gob.ve Apdo. 4846, Maracay 2101, Venezuela

Thermal and water factors, as well as hours of light were related with the beginning of flowering in a population of 26 Mexican-variety avocado trees (*Persea spp*), cultivars and hybrids, older than 10 years, located in a dry tropical forest. Phenological behaviour was described during three annuals cycles of production between 2002 and 2005. Ecological characteristics of the locality, placed at 450 masl were not the most suitable for this variety. It is estimated that flowering induction occurs three months before the beginning of flowering, this period was characterized for its thermal and water conditions in the four flowering cycles evaluated. Daily maximum temperatures were high (30° a 32°C) and there was few frequency of low-temperature days (≤19°C); daily thermal amplitude average was 11°C, and accumulated degree-days until the beginning of the flowering were 1475°C. The accumulated precipitation in this period varied between 110.3 and 768.9 mm, and it was partially or totally absent during the flowering. The addition of hours of light in this period varied between 524 and 619 hours of shine, with an average day^{-1} of 5.8.

COMPORTAMIENTO TÉRMICO E HÍDRICO EN LA FLORACIÓN DEL AGUACATE (*Persea* spp.) GRUPO MEXICANA EN LA REGIÓN CENTRO-NORTE COSTERA DE VENEZUELA

M. Pérez[1]; L. Avilan[1]; E. Soto[1], M. Rodríguez[1] y J. Ruiz[1].
[1]INIA-CENIAP, e-mail: mercedesperez@inia.gob.ve Apdo. 4846, Maracay 2101, Venezuela

Se relacionó el comportamiento térmico, hídrico y horas de luz con el inicio de la floración de una población de 26 árboles mayores de 10 años, cultivares e híbridos de aguacate (*Persea* spp.) del grupo mexicana, localizado en un bosque seco tropical. Se describió el comportamiento fenológico durante tres ciclos anuales de producción comprendidos entre el 2002 y el 2005. Las características ecológicas de la localidad ubicada a una elevación de 450 msnm no fueron las más propicias para las exigencias de este grupo. Se estima que la inducción floral ocurre en los tres meses que anteceden el inicio de la floración, caracterizando el régimen térmico e hídrico de este período, en los cuatro ciclos de floración evaluados. Este periodo que antecede el inicio de la floración se caracterizó por presentar temperaturas máximas diarias altas (30° a 32°C) y escasa frecuencia de días con temperaturas bajas (≤19°C); amplitud térmica diaria promedio de 11°C y grados-día acumulado de 1475. La precipitación acumulada en este periodo varió entre 110.3 y 768.9 mm y estuvo ausente de manera parcial y/o total durante la

floración. La suma de horas de luz en este periodo varió entre 524 y 619 horas-brillo, con promedio día^{-1} de 5.8.

1. INTRODUCTION

In Venezuela the presence of the Mexican group, very spread to world-wide level, is null or very little because its small fruits and high fat content, does not adjust to the exigencies of the national consumers; nevertheless they have a great potential to be used as rootstock to induce the small size of the trees (Gaillard, 1987, Avilán et al. 1997). The avocado of the original Mexican group presents, two or more annual of flows growth, being the first most intense which is associated with rainy periods and accompaned the process by flowering, whereas the rest stages appear frequently in periods of drought (Venning y Lincoln, 1956; Rodríguez-Suppo, 1982; Avilán *et al*, 2007). In the region center-north of the country the flowering of this group occurs in the final months of the year, September-November, and it was characterized by a long extension of 20 to 29 weeks and low intensity that vary between 25% and 50% (Avilán *et al*, 2007). The floral stimulus according to Gaillard (1987) takes place around two months before the flowering and it is attributed to low temperatures, short days and hydric stress. Butrosse and Alexander (1978) using 'Fuerte' cultivar in controlled conditions, established that smaller maximum temperatures to 20℃ promoted the floral induction; while maximum temperatures superior to 25℃, inhibited it completely. Salazar-Garcias *et al,* (1998) found a good correlation between the development of the inflorescencia and the nocturnal temperatures bellow to 15℃ but do not consider this one as inductive but that plays a roll like promoter of the floral expression. In plants of Hass cultivar in controlled conditions Salazar -Garcias *et al*, (1999), emphasizes the positive effect that has regime 20/15 ℃ on the flowering. The trees maintained in regime of 25/20 high temperatures ℃ and short days (10 hours of photoperiod) did not bloom. Chaikiattiyos *et al*, (1994) emphasizes that a rank of neutral temperature between 23℃ /18℃ and 29℃/25℃ exists for the avocado where it does not happen the flowering nor the vegetative development. According to Salazar-Garcia *et al*, (1998) a period of rest is not a prerequirement for the development of the inflorescencia. In relation to the humidity Chaikiattiyos *et al*, (1994, demonstrated that when it is reduced or paralized the vegetative development the floral induction is favored, but that hydric stress by itself does not induce the process. Plants in regime of 29°/25° and hydric stress did not bloom.
In the present study was characterized the thermal and hydric behavior of the three months that preceded the beginning of the flowering of cultivars and hybrids the avocado of the Mexican group, in the coastal region center-north of Venezuela during three annual cycles of production between July of the year 2002 and July of the 2005.

2. MATERIALS AND METHODS

For the description of the thermal characteristics and hydric presents during the floral induction, which happens both in to three months which precede the beginning of the flowering (Gaillard, 1987), volume as fenologíco bases the behavior observed on a population of 26 mainmasts of 10 years, you will cultivate and hybrids, of avocado of the Mexican group pertaining to the collection of Centro Nacional de Investigaciones Agropecuarias (CENIAP-INIA), located in the region North center of the country characterized like Tropical Dry Forest (Avilán *et al.,* 2007). The beginning of the flowering was established by the presence of the corresponding structure described by Aubert and Lossois (1972) and demonstrated by the presence of the globosa structure of the inflorescencia and the visible one of pedúnculo primary, corresponding to stages B and C, in 5% of the outer surface of each tree in 30% of the population. Its location in the time was established entering the number of weeks passed as of the last week of July considered like the beginning of each annual cycle of production (week 1), which culminates in the penultimate one of July of the following year (week 52). The duration of the flowering flow (Total of weeks) it was determined by the difference between final week (W_{end}) where stops the emission of inflorescences (state G) and the initial week ($W_{initial}$) where happens and/or is detected the presence of the same ones. (Duration = W_{end} - $W_{initial}$). From climatologic station "CENIAP-INIA", located 10º17' N, 67º37' W to about 100 meters of the orchard, the daily registries of maxima and minim temperature of the air, precipitation were obtained, evaporation and insolation, in the three months that preceded the different cycles from flowering. The potential evapotranspiración (ETo) determine by the method of the tank type "A" using the recommended factor of correction of 0.8 for Venezuela (López 1968)**.** Considering the influence of the temperatures and the hydric regime on the induction and floral initiation, the agroclimáticos indices calculated: simple: Accumulated precipitation (Pacum) and the number of days with equal and inferior temperatures to the 23, 22, 21, 20, 19, 18, 17 16 and 15 ºC., that they preceded to the event, in addition to the Indices Compound: Degree-days (GD), from the date (25/07) of beginning of each annual cycle of production to the beginning of the flowering using the methods: Residual, td = Tx – Tbase, where: Tx= average temperature of the day (°C) and Tbase = temperature bases (°C) considering like "zero physiological" 10°C

3. RESULTS AND DISCUSSION

The flowering most frequently was demonstrated between September-November, and in the course of the three annual cycles of production 4 flows were determined (Table 1) whose intensity and duration went away increasing gradually with happening of the cycles. In Cycle 1 two flows happened (Flows 1 and 2) while in Cycles 2 and 3 only one (Flows 3 and 4)

Table 1. Weeks of beginning, duration and Maxima flowering, during the Cycles of production 2002 to the 2005.

Cycle of produción	week beginning flowering (W initial)	week final lowering (W end)	Total weeks	weeks of maxima flowering
1	Flow 1 Week 16 (4 to 10 November 2002)	Week 17 (11 to 17 November 2002)	2	Week 17 (11 to 17 November) (25%)
	Flow 2 Week 25 (5 to 11 January 2003)	Week 36 (23 to 29 March 2003)	11	Week 29 a 30 (4 to 13 February) (25%)
2	Flow 3 Week 19 (23 to 29 November 2003)	Week 40 (18 to 24 April 2004)	20	Week 26 a 27 (14 to 20 de January del 2004) (50%)
3	Flow 4 Week 10 (14 to 25 September 2004)	Week 39 (10 to 16 de April 2005)	29	Week 27 a 28 (21 to 28 de January 2005) (50 %)

Cycle 1 =2002-2003, Cycle 2 = 2003-2004, Cycle 3=2004-2005

The monthly averages of the registered daily maximum temperatures during the three months that preceded the flowering (Table 2) varied between 31℃ and 32℃, superior to 25℃ indicated by Buttrose and Alexander (1978) like inhibiting of the floral induction, while the daily minims between 19,1℃ and 21.3℃ in addition, established for Fuerte (hybrid of Mexican by Guatemalan) that the smaller minimum temperatures to 20℃ promoted the floral induction.

Table 2. Daily average temperatures maximum and minimum, daily thermal amplitude and Degrees accumulated days (GDA) in the three months that preceded the beginning of the flowering. Period 2002-2005

N° Flows	Months that preceded Beginning flowering	Temp. Max Media (℃)	Temp. Min Media (℃)	Daily thermal amplitude	GDA* 10℃
Flows 1:	September - :November (4/08 to 4/11/ 2002)	31.3	21.3	10	1662
Flows 2:	Octubre-Diciembre: (5/10 to 5/12/ 2002)	32.2	20.2	10	_
Flows 3:	September - November (23/08 to 23/11/ 2003)	32.0	19.6	12.4	1920
Flows 4:	July-October (14/07 to 14/09 /2004)	31.1	19.1	12	793

GDA =25/07 date of beginning of the cycle of production until the beginning of the flowering

In Table 3 where the frequency of equal and/or inferior days with temperature to the appears 15, 16, 17, 18, 19, 20, 21, 22 and 23℃, during the months that preceded the flowering, it is observed that as of August it is increased gradually the number of days with inferior temperatures to 20℃.

The statistical analysis of the registries of the minimum temperatures for the same locality and times indicate (Avilán et al., 2005) that the frequency of days in the periods of 30, 60 and 90 before the beginning of the flowering, they presented significant differences. Also that 20℃ and 19℃ were those of greater frequency, representing as a whole between 48.6% and 57.7% of the considered layers.
The monthly averages of the daily thermal amplitude varied between 10 and 12℃, 4℃ (Table 2) which is a daily oscillation, diurnal-nocturnal of the very high temperature, that probably interferes with the accumulation of hours fried necessary to induce the flowering.

The intervals reported in the Literature of the regimes of diurnal-nocturnal temperature, by Buttrose and Alexander (1978), Sedgley and Annells (1981), Chaikiattiyos et al., (1994) and Salazar-Garcia et al., (1999), in general do not exceed 5℃. Buttrose and Alexander (1978) obtained the maxima flowering with 20℃, 15 hours to the day and 15℃, 9 hours at night.

Table 3. Frequency of equal and inferior days with temperature to the 15, 16, 17, 18, 19, 20, 21, 22 and 23℃, respectively, in the annual Cycles of production 2003 - 2004 and 2004-2005.

Months	>14°≤15°	>15°≤16°	>16°≤17°	>17°≤18°	>18°≤19°	>19°≤20°	>20°≤21°	>21°≤22°	>22°≤23°
July 2003	0	0	1	0	2	17	7	3	1
August	0	0	0	2	7	12	10	0	0
September	0	0	0	2	7	11	8	2	0
October	0	0	1	1	3	10	13	3	0
November	0	1	0	3	9	10	7	0	0
December	2	7	6	4	7	5	0	0	0
January	17	6	4	2	1	1	0	0	0
February	16	4	4	2	2	0	0	0	0
March	6	3	4	4	9	3	2	0	0
April	0	1	2	0	2	6	9	6	4
May	0	0	1	1	3	4	12	4	6
June	0	0	1	6	6	12	2	2	1
July 2004	0	1	3	3	9	11	3	1	0
August	0	0	0	2	7	11	4	4	3
September	0	0	1	2	10	12	5	0	0
October	0	0	0	1	12	12	6	0	0
November	0	0	4	3	7	11	5	0	0
December	5	2	4	10	8	1	0	1	0
January	4	5	8	5	5	2	2	0	0
February	5	3	3	5	4	5	1	2	0
March	2	7	4	8	5	3	0	1	1
April	0	0	0	3	2	14	4	2	5
May	0	0	0	0	2	9	5	14	1

The extension of the process (Flow 3 and 4) with 20 and 29 weeks of duration, the low intensity (50%) and the occurrence of two flows (Flow 1 and 2) as it happened in Cycle 1 (Table 1) seem to be associate to the thermal conditions (maximum, minimum temperatures and amplitude thermal daily) prevailing that are not propitious to favor the accumulation of hours of fried required by the group of you will cultivate and hybrids Mexican.

These results are concordant with the fugitive by Schroeder (1951) mentioned by Gaillard (1987), that indicates that the extension of the period of flowering of 1 to 6 months, happens because the climatic conditions are unfavorable, and in cases very accentuated one second flowering can exist, as it happened in Cycle 1.

The fenologico behavior of hybrids of Guatemalan by Antillean in the same locality and time (Avilán et al., 2005) characterize per periods of smaller extension and greater intensity of the process demonstrating better adaptability to the conditions of the zone. According to Gregoriou et al. (1982) and Chaikiattiyos et al, (1994) exists a critical temperature that varies with the species and cultivating, in which takes place the transition of the vegetative growth to the reproductive one.

In relation to the precipitation in the months that preceded at the beginning of the flowering in Flows (August, September and October) and to Flow (3 June, July and 4 August) the accumulated precipitation (Pacum.) was of 593.5 and 396.6 m.m respectively (Table 4).

Table 4. Precipitation (m.m) and temperature (℃) maxima daily monthly average during the three understood annual Cycles of production between 2002 and 2005.

Months	**Cycle 1**		**Cycle 2**		**Cycle 3**	
	mm	**℃**	**mm**	**℃**	**mm**	**℃**
July	67,3	32,1	135,9	30,9	122,9	31,3
Agust	128,2	32,1	229,3	31,3	170,2	31,0
September	139,3	32,1	144,0	31,9	177,4 *	31,4
Octuber	72,6	32,8	194,3	32,4	107,2	31,3
November	37,1 *	32,9	201,3 *	32,1	87,5	30,5
December	0,6	32,8	6,7	32,2	17,8	31,7
January	0,0 **	34,1	0,0	32,7	67,5	31,9
February	0,0	34,6	0,0	33,4	24,1	32,6
March	0,0	35,9	0,0	34,2	0,0	34,1
April	84,1	33,9	77,9	34,0	76,3	32,8
May	146,0	33,3	172,1	31,4	80,8	31,1
June	82,7	31,8	82,7	31,2	-	30,1
Total	757,9	-	1244,2	-	931,7	

(*)Climatic registries of the Station CENIAP, Latitude 10º17´, Length 63º17´. Altitude 455 m.s.n.m. Cycle 1=2002-2003, Cycle 2 =2002-2004, Cycle 3 = 2004-2005. (*) An annual cycle begins in the last week of the month of July and culminates in the penultimate week of the month of July of the following year.

The relation of hydric supply (precipitation) and the demand (potential evaporation) expressed as humidity index (IH) such indicates for periods (Table 5) values of 2.2 and 1.6 respectively; while for Flows 1 and 2 with Pacum. of 314.9 and 106, values of IH were of 0.99 and 0.34, respectively.

This indicates that the floral induction happened in conditions of good and limited humidity. Gaillard (1987) emphasizes that a hydric deficit of short duration (2 months) is favorable for a floral initiation, specially in some tropical climates not characterized by a diminution in the temperature sufficient to carry a complete halting of the vegetative growth. Nevertheless as it limits Salazar-Garcia *et al*. (1998), a period of rest, is not a prerequirement for the development of the inflorescencia.

Table 5. Conditions of humidity in the 3 months before the beginning of the flowering of the avocado. Period 2002-2005

	Precipitation		Evaporation		IH= P/eto
Period 2002-2005	(mm) in the period	% annual total	(mm) in the period	% annual total	
Flows 1: 4/08 to 4/11/ 2002	314.9	39.0	418.9	39.3	0.99
Flows 2: 5/10 to 5/12/ 2002	106.7	13.2	402.2	37.8	0.34
Flows 3: 23/08 to 23/11/ 2003	593.5	48.3	406.5	21.8	2.2
Flows 4: 14/06 to 14/09 /2004	396.6	39.0	416.7	24.1	1.6

Although for the floral induction the occurrence of a hydric stress is favorable, during the process, can cause problems in function to the demand of the plant.
Whiley ET to. (1988) emphasize that during this one it fenofase near 13% of the total sweating of the canopy of the plant, can be attributed to the floral organs, which indicates that during the process the hydric demands are elevated.

4. CONCLUSIONS

The characteristics of you live located to 450 msnm were not most propitious for the expression of the flowering.
The beginning of the flowering happened in the final months of the year (September-November) and the process characterize myself by its long extension (20 to 29 weeks) and low intensity (25% to 50%), as a result of the thermal regime characterized by temperatures maximum daily discharges (30° to 32°C) and little frequency of days with low temperatures (≤19°).
The accumulated precipitation in the period of floral induction varied between 314.9 and 593.5 mm and was absent total partisan and/or during the flowering.

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