Growth and phenological stages of ‘Búlida’ apricot trees in south-east Spain.

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Short running title: Phenological stages of apricot trees

Summary

The different phenological stages of mature apricot trees (*Prunus armeniaca* L., cv. Búlida), drip irrigated and grown under typical Mediterranean conditions are described using the traditional nomenclature of Baggiolini and according to the BBCH General Scale. The predominant dates of each stage are indicated in days and as the number of accumulated growing degree hours (GDH). When the annual pattern of root, shoot and fruit growth was studied, alternating root and shoot growth was evident, and also a relative separation between the main periods of shoot and fruit growth, which is an advantageous characteristic when applying deficit irrigation. This study will improve apricot culture by expressing the timing of most agricultural operations on a standardised scale.

Key words: Apricot, growth pattern, *Prunus armeniaca*, phenological stages

RESUMÉ- **Stades phénologiques et croissance végétative de l’abricotier**.

Les stades phénologiques de l’abricotier (*Prunus armeniaca* L., cv. Búlida) irrigué en goutte à goutte et cultivé dans des conditions méditerranéennes ont eté etudiés d’après les stades de Baggliolini et le BBCH General Scale. Les dates prédominantes de chacun des stades-repères sont indiquées en degré-heure de croissance (growing degree hours, GDH). Si l’on considère la croissance annuelle des racines, des rameaux et des fruits, onconstate une croissance alternative des racines et des rameaux, et aussi une nette séparation entre le période de croissance principales des rameaux et des fruits. Cette étude va améliorer la culture de l’abricotier avec l’utilisation de l’echelle standard des téchniques agronomiques.

Abricotier / croissance / *Prunus armeniaca* / stades phénologiques

1. INTRODUCTION

In agriculture, a knowledge of the growth factors (water, fertilizers, etc.) involved in a particular crop and the annual pattern of crop growth is essential. A study of the phenological stages of growth in trees is very important not only to predict when hormones should be applied and the possible appearance of disease [3] but also to know the sensitivity to water deficit at each stage of development [46], and to adjust the fertilization programmes to the nutritional needs of the plants (especially nitrogen), thus contributing to a more sustainable agriculture.

Regulated deficit irrigation is increasingly proposed for the optimisation of water use in fruit trees in areas with scarce water resources [12, 20, 21, 22, 34]. This strategy is based on the profound knowledge of phenological plant processes, and its success depends on a clear definition of what is the critical phenological period for water deficit, when yield and/or fruit quality may be adversely affected [40]. There is abundant information concerning the critical periods, when irrigation should be applied to fulfil total requirements; in the case of fruits trees these period are related with certain stages of fruit growth [12, 24, 25, 26, 43, 46] and with the postharvest period [40, 28]. Also, it is important to know the separation in time between vegetative and fruit growth for specific trees when applying regulated deficit irrigation, because water deficit will only affect one of these processes [10]. In this sense, Chalmers et al. [9] indicated that irrigation management can be a powerful tool to manipulate plant growth for greater fruit-fullness and less vegetative growth.

There have been some interesting studies on the floral biology of apricot cultivars under Mediterranean conditions, dealing with cold and heat requirements [8, 29], and physiological processes [17, 39, 40].

Research into the relationship between root and shoot growth of trees has provided conflicting results because data concerning species, sizes and climates, etc. cannot be extrapolated [23]. The use of a standard scale to describe the growth stages of crops is a common solution, but a universal scale, which uses a consistent set of numeric codes adaptable to all crops, is needed. Such is the decimal scale, developed jointly by BASF, Bayer, Ciba-Geigy and Hoechst, named the BBCH General Scale, which identifies different developmental stages by a two-digit code [27].

For these reasons, the aim of this paper was to define the phenological stages of Búlida apricot trees, describing the different growth stages using the traditional nomenclature [5] as well as the BBCH code [27, 32]. This information will improve the cultivation of this crop in Murcia Region (which produces 58 % of the total Spanish production) by expressing the timing of most agricultural operations on a standardised scale.

2. MATERIALS AND METHODS

2.1. Plant material and experimental site

The experiment was conducted during two growing seasons (1997 and 1998) in a 2 ha plot of a commercial orchard, located in Mula valley, Murcia (SE Spain), with a loam texture soil, highly calcareous, 7.8 pH, and with low organic matter and cationic exchange capacity values.

During the experimental period the climate was typically Mediterranean, with mild winter and dry summer (Table I). The mean daily evaporation rate from a U.S. Weather Bureau class A pan (on bare soil and located at a weather station in the orchard) ranged from 1.4 mm day^{-1} in December-January to 7.5 mm day^{-1} in July. The annual evaporation for the experimental period averaged 1470 mm, with only minor year-to-year deviations from these values. Annual rainfall averaged 320 mm. The rainy period was as usual in this area, occurring during spring and autumn (Table I).

The plant material consisted of twelve-year-old apricot trees (*Prunus armeniaca* L., cv. Búlida, on Real Fino apricot rootstock), spaced 8 x 8 m, with an average height of 4.5 m, ground cover of 52 % and leaf area index (LAI) of 1.69. The shape of the trees resulted from an open-centre tree training-pruning system. Annually, trees were manually pruned in spring and at the beginning of the rest period (November) in order to eliminate suckers from branches and old wood, respectively. Trees were drip irrigated using one drip irrigation line for each row, with seven emitters per tree, each with a flow rate of 4 l h^{-1}. The experimental design was a randomised block, with four blocks. Each block consisted of two rows of seven trees. The central five trees of the second row were used for experimental measurements (control trees), and the others served as guard trees.

Irrigation amounts were scheduled weekly based on crop coefficients [2], reference crop water use (ETo), as determined from data collected the previous week in a class A pan, and the estimated application efficiency (95 %). The water amounts applied for the control treatment averaged 7154 m^3 $ha^{-1}year^{-1}$, maintaining the soil close to field capacity values in the main root zone, and a predawn leaf water potential of around -0.45 MPa (data not shown),

Trees were fertilised with 164 kg N, 60 kg P_2O_5 and 118 kg K_2O, per ha per year. A routine pesticide programme was maintained. No weeds were allowed to develop within the orchard, resulting in a clean orchard floor for the duration of the experiment.

Chill requirements were 460 hours, calculated according to Sánchez-Capuchino [42] as the number of hours below 7 ºC, and 600 chill units, according to the method of Erez and Couvillon [15]. Harvest was carried out following local commercial criteria on several dates during one month, the first pick taking place in mid-May (15th May, 1997 and 20th May, 1998). The average yield for the studied period was 256 kg $tree^{-1}$ (5300 fruits $tree^{-1}$), which is more than three times the apricot yield of commercial plantations in the area, which points to the good degree of orchard management, mainly due to the drip irrigation scheduling applied.

2.2. Measurements

Following a fixed plan, phenological and growth measurements were made on the same dates in 1997 and 1998. The different phenological stages of apricot growth were defined according to the BBCH General Scale [32], while reproductive phenological stages were described according to Baggiolini [5]. To record the phenological stages, as well as the duration of every stage, four healthy trees were selected at random from control trees of each block. From each tree, four two-year-old branches (1 m long and 1.5 cm^2 in diameter, each containing 150-200 bud flowers) for each compass direction, were tagged. Twice a week, from the end of January (at stage A, dormant buds) to leaf fall in December the different phenological stages were recorded separately. From fruit-set to harvest, counting was only carried out once a week.

The shoot length of four tagged shoots per tree, one from each compass direction, was measured on one tree per block every 14 days, while the trunk diameter in all control trees (five per block) was measured every two months, 30 cm above the soil line. The diameter of 10 tagged fruits per tree was measured weekly in all control trees per block using an electronic digital calliper.

The minirhizotron method was used for root growth measurement, as described by Abrisqueta et al. [1]. One minirhizotron tube per tree (one per block) was placed in the wetted area and root length per unit of soil volume was obtained according to Upchurch and Ritchie [47].

The influence of temperature on the duration of each phenological stage was studied using the growing degree hour (GDH) model [37], calculating the

GDH’s by subtracting 6ºC (base temperature according to Tabuenca and Herrero [44]) from each hourly temperature.

The physiological fall of buds, flowers, fruits and leaves was evaluated using catching nets of 1/8 of tree canopy (3.5 m radius) installed under one tree per block. Weekly, the different organs were collected, cleaned and separately weighed (fresh). The number of each organ in a sub sample of about 20 g was counted and the dry weight was determined, calculating the total number per net using the fresh/dry weight ratio.

3. RESULTS

3.1. Phenological stages of development

The phenological growth stages of Búlida apricot trees, according to the BBCH and Baggiolini codes, are shown and Table II and illustrated in Photograph 1. The growing degree hour (GDH) accumulated at the beginning of each stage is also shown in Table II. The description of the main stages (first digit) and some of the secondary stages (second digit), both scaled 0 to 9, is as follows:

Stage 0. Bud development.

00: completely closed bud, corresponding to stage A of the Baggiolini code. With increased temperatures, vegetative bud swelling begins (**01**), starting when 1035 ºC GDH has been accumulated. **07**: beginning of bud burst, and **09**: buds open.

Stage 1. Leaf development.

This covers the time from which the first leaves emerge (**10**), expanding leaves (**11-15**), to **19** (fully expanded leaves), which occurred during mid March, starting with 5150 ºC GDH.

Stage 3. Shoot development

31: beginning of the first shoot growth, starting at the beginning of March, with 2334 ºC GDH accumulated. This occurred simultaneously with the leaf development (stage 1). **32**, **35**, **37**: shoots about 20, 50, and 70 % of the final length, respectively. **39**: second shoot growth, initiated at the end of May.

Stage 5. Flower emergence

51: flower bud swelling, corresponding to stage B of the Baggiolini code, which occurred during the second half of February, with 1827 ºC GDH accumulated. **55**: calyx perceptible, corresponds to stage C of the Baggiolini code, which lasted one week and started with 1447 ºC GDH. **58**: flower petals perceptible, corresponding to Baggiolini stage D; this stage was very ephemeral (2 days) and started with 3274 ºC GDH, and **59**: anthers perceptible, corresponding to stage E of the Baggiolini code.

Stage 6. Flowering.

61: beginning of flowering (10 % of flowers open). **65**: full bloom, corresponding to Baggiolini stage F (50 % of flowers open), and occurring during the first week of March, with 3784 ºC GDH. **67**: flowers fading, corresponding to stage G of the Baggiolini code, and **69**: end of flowering, which occurred during mid March, with 4725 ºC GDH.

Stage 7. Fruit development.

71: fruit set, corresponding to stage H of the Baggiolini code; this stage lasted 13 days and occurred with 4725 ºC GDH. **72**: green young fruits, corresponding to Baggiolini stage I. **73**: physiological fruit drop, starting at the beginning of April, with 9269 ºC GDH. **75** and **79**: fruits about 50 and 90 % of the final size, respectively.

Stage 8. Fruit maturity.

81: colour-break; this occurred at the end of April, when 15124 ºC GDH had been accumulated. **89**: fruit ripe for consumption.

Stage 9. Senescence.

93: beginning of senescence, starting with 86139 ºC GDH accumulated. **95**: leaves starting to fall. **97**: total leaf abscission (winter dormancy period), occurring in mid December, with 93367 ºC GDH accumulated.

The accumulation of GDH at full bloom (65 BBCH code, Table II) was 3584 and 3983 ºC GDH in 1997 and 1998, respectively, which resulted in a difference of three days between the respective full bloom (5 and 8 March). It must be pointed out that in 1996 full bloom occurred on 20 March (data not shown), which implied a delay of 15-12 days with respect to 1997 and 1998, respectively, but GDH accumulation was 3935 ºC GDH, with a minor deviation from the mean value recorded in Table II (3834 ± 218). This fact was mainly due to the cooler February temperatures registered in 1996 with a GDH accumulation during the second fortnight of 1405 ºC GDH, unlike the figures seen for 1997 (2523 ºC GDH) and 1998 (2145 ºC GDH).

The first pick of the harvest does not refer to a BBCH code, because it followed local commercial criteria. However, this would correspond to something between 81 and 89 BBCH code (Table II). GDH accumulation for this cultural procedure occurred at an average of 20859 ºC GDH for 1997 and 1998. In 1996 apricot were first picked on 24 May, when 20439 ºC GDH were accumulated, which represented a delay of 12 days with respect to 1997 (with 19197 ºC GDH accumulated).

The evolution of the reproductive stages of Búlida apricot, according to the Baggiolini code is shown in *figure 1*. It is clear that the progress from stage B (flower bud swelling) to stage F (full bloom) was very rapid, lasting less than 20 days, all stages occurring simultaneously during 8 days. From full bloom (stage F) to young fruit (stage I) lasted 20 days, with less overlapping of these stages.

3.2. Pattern of root, shoot and fruit growth

The annual pattern of root, shoot and fruit growth of apricot trees is shown in *figure 2*. Root growth was active all year, with some fluctuations. In February, immediately before full bloom, there was an important increase in root growth, while maximum root growth activity occurred in April. Minimum values were reached during summer and similar values were observed in autumn-winter.

Shoots had two periods of active growth, both of a short duration (*figure 2*). The first, which was the more intense, occurred after flowering (mid March) and the second after harvest (mid June), affecting only long-type shoots. Both periods coincided with the minimum values of root growth (*figure 2*).

Fruits showed two periods of active growth (*figure 2*), the first at the end of March and the second at the end of May, separated by the lag phase of slower growth and dominated by lignification of the endocarp. The first period occurred after the first shoot growth period (*figure 2*) and coincided with maximum root growth (*figure 2*). The second shoot growth period began during the second rapid fruit growth period. It is clear that both peaks of shoot growth occurred simultaneously with the lowest rate of fruit growth.

The trunk grew from July to October after shoot and fruit growth was completed and coinciding with minimum root growth (data not shown). The trunk growth rate from January to July was constant at about 1.1 mm month^{-1}, whereas it was about 2.6 mm month^{-1} from July to October.

This pattern indicates that maximum growth periods of the three organs are distinct and take place sequentially. First of all, roots start to grow to absorb water and nutrients. This mobilizes reserves for the flowering process. After that, shoots began to grow, followed by maximum root growth and coinciding with the first fruit growth stage and lower values of shoot growth. This is followed by a second rapid fruit growth stage and finally by a secondary shoot growth period, which maximum occurred after harvest (*figure 2*).

According to *figure 3*, the abscission of buds (stage A), and reproductive organs (from B to F) occurred from the beginning of February to the end of April, with maximum values during March. Fruits started to drop in March (after fruit set), with a maximum at the beginning of April and a lower peak in May, just before harvest. Leaf abscission started at the beginning of November, with total leaf fall occurring at the end of the year.

4. DISCUSSION

The use of GDH accumulation for each phenological stage (Table II) enables comparisons to be made across different years and geographical areas, so that the beginning and duration of a given stage can be predicted on the basis of a quantitative parameter, instead of a fixed calendar date [31, 37]. Apricot phenological stages were identified by a universal scale using a decimal code, the BBCH General Scale (*figure 1* and Table II), a nomenclature already used by several authors in different trees: pomegranate [33], citrus [3], quince [30], stone and pip fruits [32], as well as vegetables [27].

Although studies related to phenological stages in apricot trees are scarce, some authors, such as Burgos et al. [8] indicated that the stigma becomes receptive when it has accumulated 300 ºC GDH, receptivity lasting 4-6 days. Maximum flowering for late apricot cultivars occurred at around 4900 ºC GDH [29], whereas in Búlida (early-medium cultivar) maximum flowering occurred at around 3800 ºC GDH (Table II).

Costes et al. [11] indicated that harvest in Rouge du Roussillon apricot started 110 days after full bloom. The use of number of days is an imprecise way of timing (the duration or the initiation) of a phenological process, since there may be substantial year-to-year variations in processes such as bloom or harvest, a problem that is avoided using energy units accumulation as the GDH model does [37]. In this sense Melgarejo et al. [33] indicated that the use of degree days allows for comparisons to be made between different years and geographical areas. Our results using GDH accumulation confirm this statement because only minor year-to-year variations were found (Table II). Standard deviations of the mean values are of the same order as those found for blooming time and related processes in peaches in different years [37].

It must be taken into account that, in spite of the relation between fruit maturity and GDH accumulation, fruit maturity is influenced by other factors, such us cultivation techniques, water availability and fruit competition [35, 49].

Similar to the conclusions that can be drawn from *figure 3*, Tamássy and Zayan [45] indicated that there are two periods of abscission in the reproductive stages of apricot trees. The first stage was at bud swelling (the end of winter dormancy) and the other coincided with maximum flowering. The initial fruit abscission observed (*figure 3*) was due to an anomalous fruit set [14, 18]. The main period of fruit abscission, which coincides with the end of cell division (stage I of fruit growth), is due to competition for carbohydrate between fruits [13] and/or the lack of auxins [6]. Near-harvest fruits drop through the effect of fruit abscission layer formation [36].

Such an alternating root and shoot growth pattern (*figure 2*) has also been found in other fruit and forest trees [16, 23, 48]. In this sense, Ross and Catlin [38] indicated that the main almond root growth period occurs immediately after the shoot growth period. Our results in apricot trees indicate the existence of a first root growth period before bud burst and a second period between the first and the second shoot growth periods; in any case, the peaks of maximum growth of shoots and roots did not coincide (*figure 2*). Bevington and Castle [7] indicated that maximum orange shoot growth coincides with minimum root growth, due to the inhibitory effect of the auxins produced during active shoot growth [4].

A relative separation between the most intense periods of shoot and fruit growth (*figure 2*) has also be observed in pear and peach [10], pistachio [19], lemon [12] and mandarin trees [22]. Torrecillas et al. [46] pointed to a clear distinction between the main periods of shoot and fruit growth in apricot trees. This can have a clear advantage when irrigation has to be managed under restricted water supply conditions, as is the case of regulated deficit irrigation strategies, since water deficit will affect only one of these processes at a time [20, 41]. In this sense, it has been reported that regulated deficit irrigation may be applied to control vegetative growth without having a negative impact on yield or crop revenue [9, 12, 21].

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FIGURE LEGENDS

Photograph 1. Phenological growth stages of Búlida apricot trees, according to BBCH (numbers) and Baggiolini (letters) codes.

Figure 1. Reproductive stages according to Baggiolini code (flower buds) of Búlida apricot trees under non-limiting conditions. 1997/98. Each box plot is the average of eight replicates. Vertical line in the box line indicates the median. Points outside the box are ± Std.

Figure 2. Appearance of new roots, expressed as root length density (RLD, cm cm^{-3} soil), shoot growth rate (SGR, cm day^{-1}) and fruit growth rate (FGR, g day^{-1}) in Búlida apricot trees under non-limiting conditions. Full bloom 1997: 5 March, 1998: 8 March. Harvest: mid may. Each point is the average of eight replicates ± Std

Figure 3. Fall of buds (stage A), reproductive organs (stages B to F), fruits and leaves of Búlida apricot trees under non-limiting conditions. 1997/98. Each point is the average of eight replicates of different elements collected in the catching nets, on a dry weight basis ± Std.

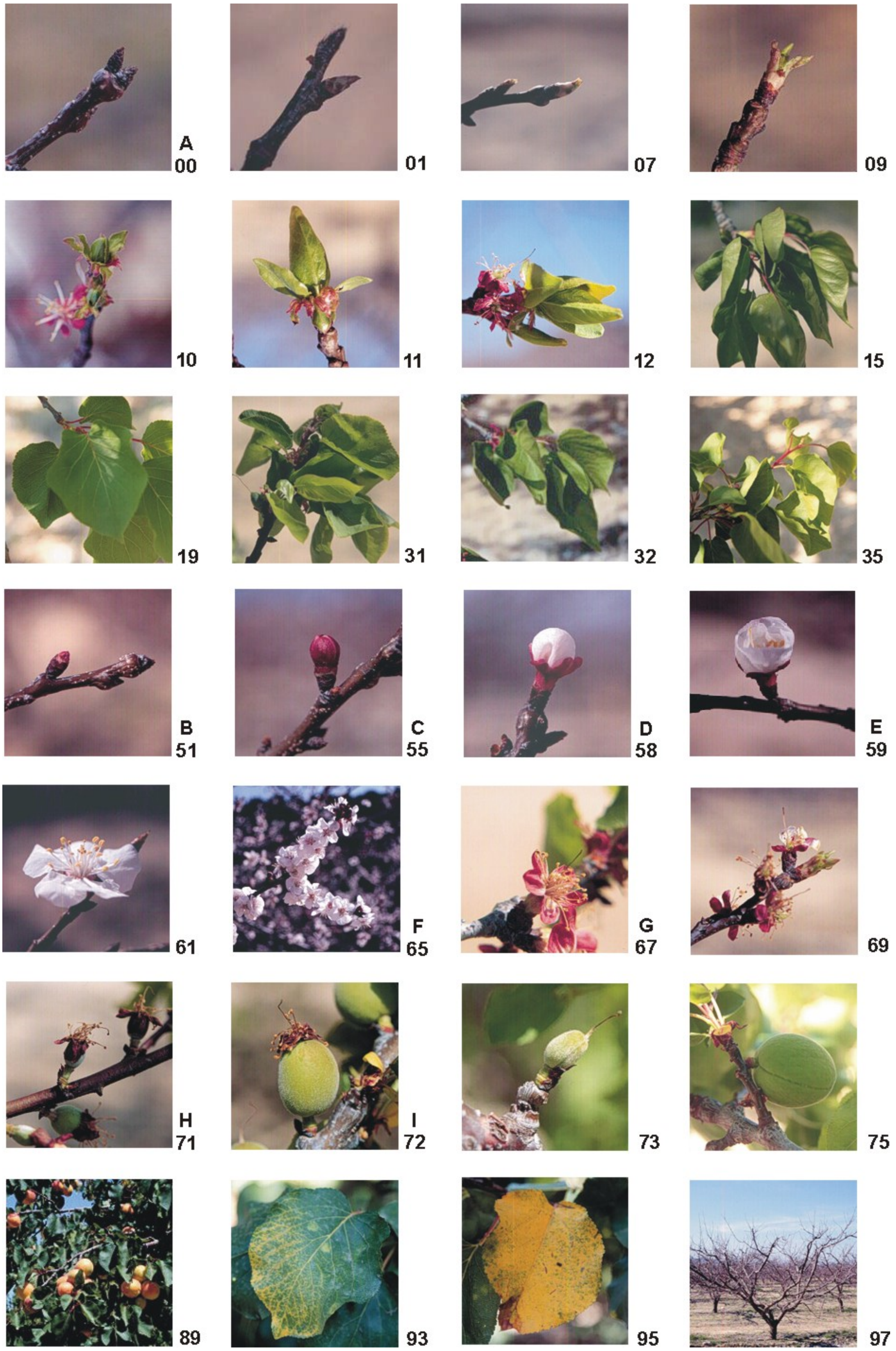
Table I. Monthly maximum, minimum and mean air temperatures, relative humidity (HR), rainfall, mean daily evaporation rate (Epan), wind speed (2 m) and net radiation.

	Temperature (ºC)			**RH (%)**	**Rainfall**		**Epan**	**Wind**	**Net radiation**
Month	**Max.**	**Min.**	**Mean**	**Mean**	**mm**	**days**	**mm d^{-1}**	**km d^{-1}**	**W m^{-2}**
1997									
Jan	13.1	7.6	10.4	90.5	42.3	9	1.29	105.4	74.6
Feb	18.4	8.9	13.6	78.9	1.3	1	2.87	102.5	150.9
Mar	20.5	8.6	14.5	74.9	24.0	1	3.72	82.6	205.6
Apr	20.6	10.5	15.5	85.2	92.3	6	3.10	79.5	209.4
May	24.3	13.1	18.7	78.2	13.6	1	5.22	91.5	270.5
Jun	28.2	16.5	22.3	74.3	65.8	3	6.75	85.1	273.4
Jul	29.7	16.9	23.2	74.0	0	0	7.22	87.0	287.2
Aug	29.4	18.2	23.8	76.2	0	0	6.14	81.0	250.9
Sep	26.9	15.3	21.1	71.7	135.8	5	3.87	144.0	208.3
Oct	23.8	13.9	19.2	86.8	12.3	2	2.86	47.8	147.5
Nov	18.4	9.6	14.0	84.7	20.7	5	1.77	61.8	99.1
Dec	15.7	8.1	11.8	84.2	28.6	5	1.23	94.3	72.4
1998									
Jan	14.6	6.9	10.8	85.3	10.5	1	1.87	145.2	82.5
Feb	14.9	7.8	11.3	88.9	32.5	2	1.82	162.1	137.9
Mar	20.4	9.1	14.7	71.6	4.0	1	3.85	106.2	186.5
Apr	21.3	9.6	15.4	65.9	0	0	4.70	96.3	219.1
May	22.2	12.2	17.2	83.0	45.0	2	4.61	99.2	275.3
Jun	29.1	16.1	22.6	76.3	0	0	6.24	103.7	291.3
Jul	32.4	18.1	25.3	72.2	0	0	7.70	112.4	300.6
Aug	30.3	18.3	24.3	85.5	0	0	6.76	108.7	262.8
Sep	27.9	17.9	22.9	63.3	23.0	1	4.66	90.4	206.3
Oct	22.3	12.4	17.3	58.9	0	0	2.95	79.5	139.3
Nov	19.2	5.6	12.4	68.5	34.5	1	1.96	109.1	102.9
Dec	15.5	4.4	9.9	71.6	53.0	1	1.54	91.8	69.2

Table II. Pheno-climatology for Búlida apricot. Predominant dates of growth stages, occurrence of BBCH codes, and growing degree hour (GDH) accumulated at the beginning of each stage.

BBCH code	Growth stage	Date	Duration days	GDH (ºC) Initial*
00	Bud completely closed covered by brown scales	< 15 Feb	-	-
51	Flower bud swelling. Buds are closed and light scales are perceptible.	15-25 Feb	11	0
01	Beginning of vegetative bud swelling	21-25 Feb	5	1035 ± 58
09	Bud open and green leaf tip perceptible	26-27 Feb	2	1827 ± 77
55	Calyx perceptible, sepals closed forming a red ball	26 Feb-4 Mar	7	1827 ± 77
10	First leaves emerging	28 Feb-5 Mar	6	2153 ± 213
31	Beginning of the first shoot growth, internodes lengthen.	1-12 Mar	12	2334 ± 262
58	Flower petals perceptible, forming a hollow ball	5-6 Mar	2	3274 ± 319
11-15	Expanding leaves, not yet full size	6-12 Mar	7	3504 ± 275
59	Flower starting to open and the pistil anther perceptible	7 Mar	1	3784 ± 283
65	Full bloom, 50 % of open flowers	7-9 Mar	3	3784 ± 283
67	Flower fading	8-14 Mar	7	4125 ± 402
69	End of flowering, all petals fallen	10-14 Mar	5	4725 ± 413
71	Fruit set, beginning of ovary growth	10 Mar-1 Apr	23	4725 ± 413
19	Fully expanded leaves	13-20 Mar	8	5150 ± 337
32-37	Shoots about 20 and 70 % of the final length	20 Mar-2 Apr	14	6596 ± 357
72	Green fruits surrounding by a wilted sepal crown	24 Mar-8 Apr	16	7177 ± 338
73	Physiological fruit drop	2-9 Apr	8	9269 ± 329
75	Fruits about 50 % of final size	10-14 Apr	5	11234 ± 735
79	Fruits about 90 % of final size	15-27 Apr	13	11886 ± 386
81	Beginning of fruit colouring	28 Apr-8 May	11	15124 ± 447
89	Fruit ripe for consumption, and showing full organoleptic characteristics	26 May-3 Jun	9	23116 ± 573
39	Second shoot growth	20 May-21 Jul	63	21332 ± 686
93	Beginning of senescence	10-20 Nov	11	86139 ± 1831
95	Leaves turned yellowish and started to fall	20-30 Nov	11	88377 ± 1976
97	Total leaf abscission. Winter dormancy period	15 Dec	-	93367 ± 1901

*Growing degree hour (GDH) accumulation after completion of rest as determined from time of 600 chill unit accumulation. Values are mean of the two years ± Std



Photograph 1.

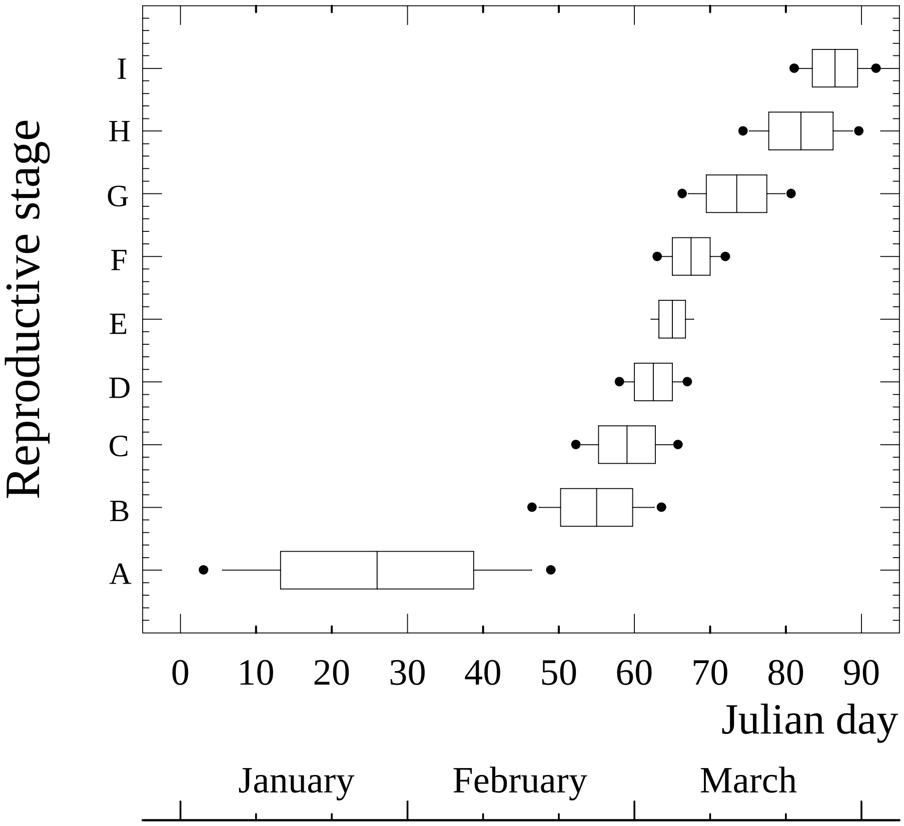

Reproductive stage
I
H
G
F
E
D
C
B
A
0
10
20
30
40
50
60
70
80
90
Julian day
January
February
March

Figure 1.

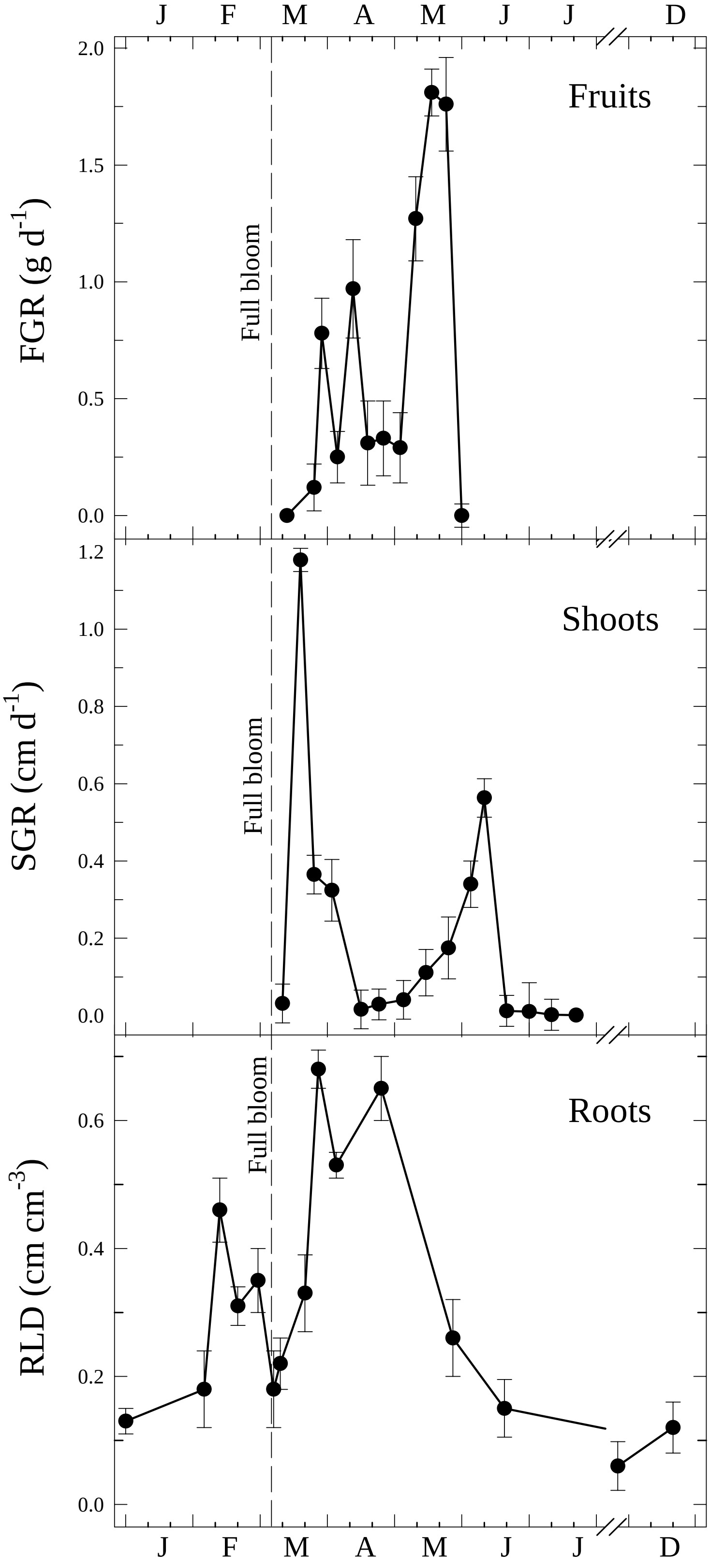

J
F
M
A
M
J
J
D
Fruits
FGR (g d^{-1})
0.0
0.5
1.0
1.5
2.0
Full bloom
Shoots
SGR (cm d^{-1})
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Full bloom
Roots
RLD (cm cm^{-3})
0.0
0.2
0.4
0.6
Full bloom
J
F
M
A
M
J
J
D

Figure 2.

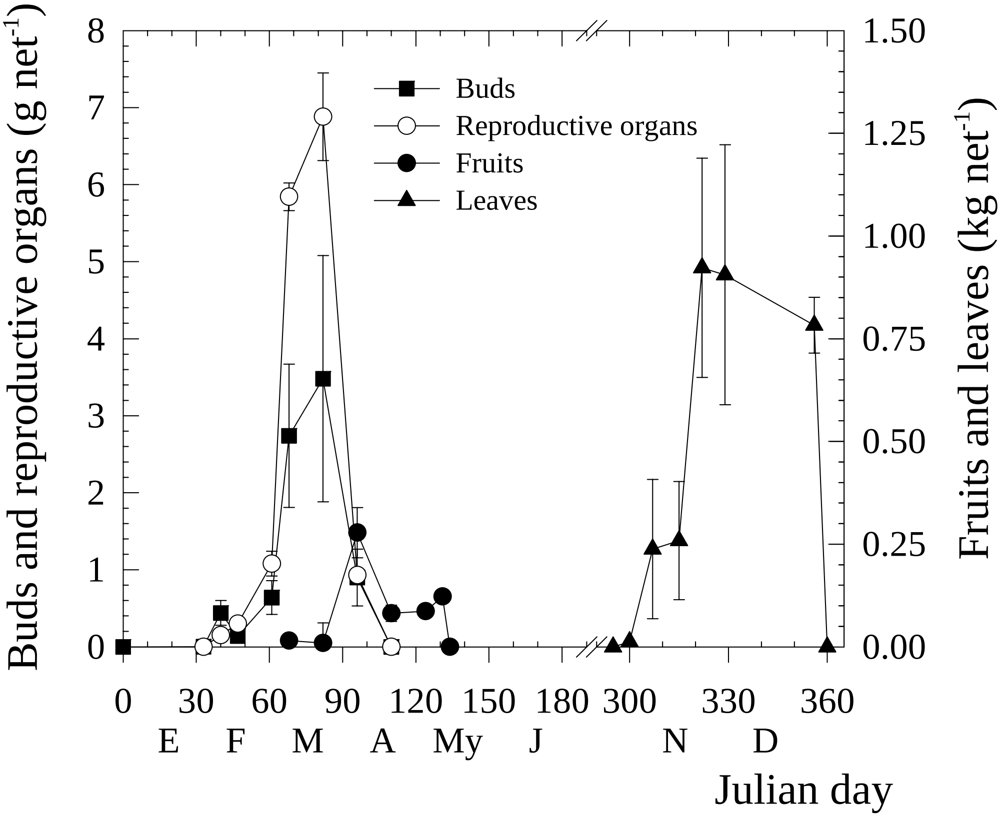

Buds and reproductive organs (g net^{-1})
Fruits and leaves (kg net^{-1})
Buds
Reproductive organs
Fruits
Leaves
0
1
2
3
4
5
6
7
8
0.00
0.25
0.50
0.75
1.00
1.25
1.50
0
30
60
90
120
150
180
300
330
360
E
F
M
A
My
J
N
D
Julian day

Figure 3.