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# Spring and summer pruning in apricot and peach orchards

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*Key words*: Catalonian open vase, early and late pruning, plant architecture, shoot heading back, shoot thinning.

**Abstract: Spring and summer pruning are based on the possibility to manipulate the physiological control of axillary sylleptic growth and carbon allocation in the shoot through alteration of the apical dominance and light distribution in the canopy. The practical result in modern orchards is a higher flower bud differentiation for apricot and an easier training system maintenance for peach with more efficient use of labor. Cultivated apricot varieties show diverse tree architectures, habit and fruiting branches. The effect of pruning intensity at different times during spring and summer seasons is specific for the singular growth habits. Differences among the peach varieties are less evident than in the apricot. The ease with which peach water sprouts produce axillary sylleptic shoots makes the use of mechanical topping possible in the first two years of intense growth in order to train the tree as a bush and then to open it as a vase with manual pruning (Catalonian open vase). In all modern peach orchards, pruning in late summer results very useful to obtain a better light distribution in the canopy and a more efficient carbon allocation to fruiting shoots, preventing and reducing the need for winter pruning.**

## 1. Apricot

In apricot, growth habit and fruiting behavior are strongly inter-related. Accordingly, the varieties of apricot can be classified into five groups (Guerriero and Xiloyannis, 1975 a; Bassi *et al*., 2003). Since some changes in shoot morphogenetic gradient during rest period were evident in response to dormancy and chilling (Guerriero and Scalabrelli 1982), any classification of branch habit should be strictly associated with a specific environment.

Depending on the type of bud (floral or vegetative) and shoot (sylleptic, long brindle, brindle or spur) the chilling requirement may be very different and, eventually, can be a factor in regulating branch habit and fruiting behavior (Guerriero and Xiloyannis 1975 b; Guerriero and Viti, 1997). To decide how to manage pruning, the shoot should be identified by its specific growth rate after bud break. For this purpose, its physiological behavior should be constantly monitored. There is some evidence that the emergence of sylleptic shoots is highly probable when a threshold level of growth rate is exceeded (Zucconi, 2003). This means that in some conditions apical dominance is not able to inhibit the growth of lateral meristems, which thus originate sylleptic (anticipated) shoots rather than buds (Fig. 1).

Generally, the buds (once formed) become rapidly dormant (Fig. 2) and will only grow in the following spring after a specific amount of chilling, and as a result they will originate proleptic shoots.

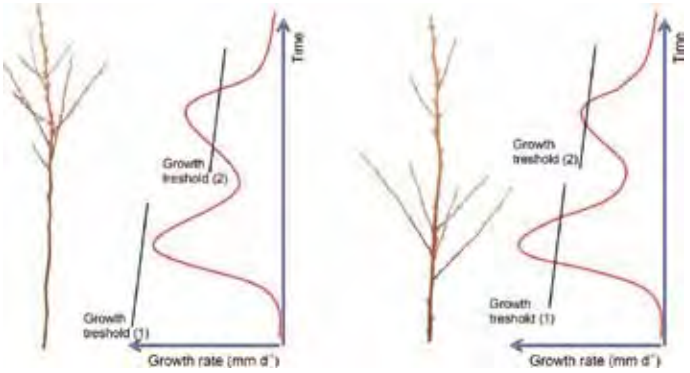


Fig. 1 - Shoot growth rate and sylleptic shoot formation in apricot. This model assumes that the growth rate threshold for inducing sylleptic growth decreases during the season. Left: the threshold was overcome only at the end of the season. Right: the critical growth rate was overcome twice in the season.

It is also possible that, depending on growing conditions, sylleptic shoot formation can take place more than once (Fig. 1) along the shoot growth. Thus buds that are formed on sylleptic shoots at different times compared to proleptic ones may have a different fruiting performance and time of flowering: this is frequently reported by growers.

Consequently the date of pruning, whether during the vegetative period (summer pruning, early or late) or during the winter before bud break, can have a strong influence in controlling the fruiting of different varieties. Moreover, the knowledge of how the shoots grow is very important

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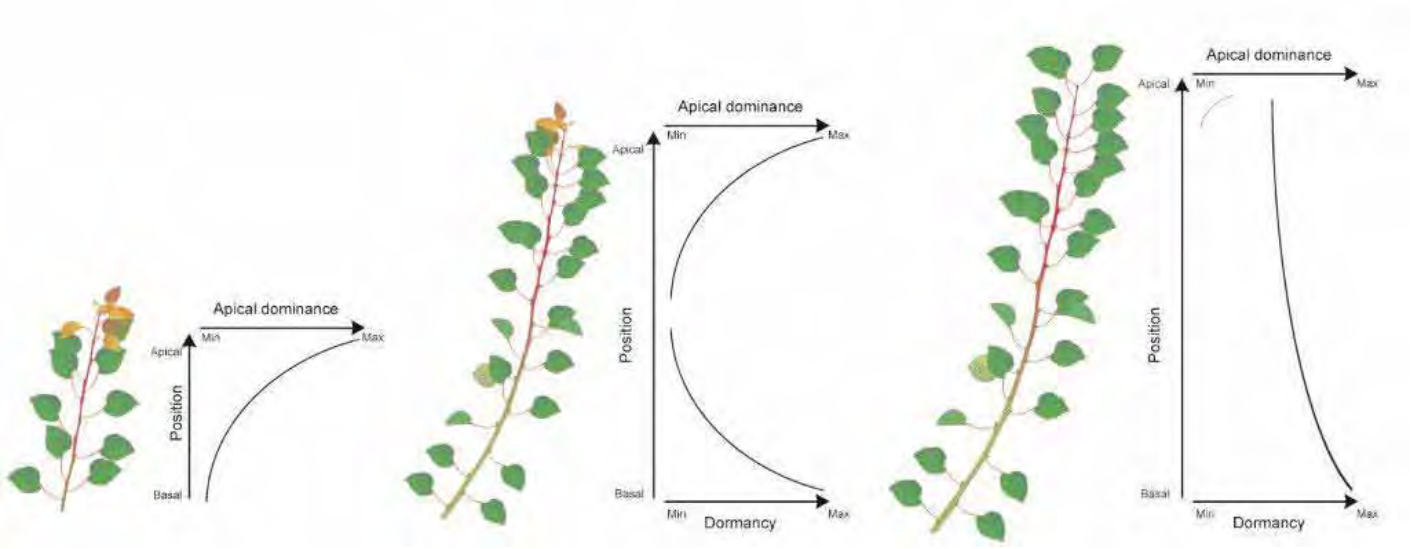


Fig. 2 - Left: apical dominance intensity along the growing shoot in early spring. Centre: apical dominance and bud dormancy intensity along the growing shoot in late spring. Right: apical dominance and bud dormancy intensity along the shoot in late summer.

for effective pruning, improving the chance of acclimatizing a cultivar that may be productive in a specific environment. Pruning for apricot should be modulated both in intensity and timing according to the interaction between the variety and its environment.

Finally, the specific shoot physiology and architectures of fruiting branches of apricot varieties will determine very dissimilar regimes for pruning. For this reason there should be in each growing area a classification of the varieties, according to their precise branch habit, fruiting behavior and need for pruning.

The most common classification in northern Italy is arranged into three groups: A - with very vigorous and spreading habit, and a tendency to fruit on spurs, brindles and sylleptic shoots; B - with less vigorous, assurgent, or semi-spreading habit, fruiting on spurs and vigorous shoots; C - with very vigorous, assurgent, or mixed spreading habit, and ability to fruit on all kinds of shoot (Neri, 2003; Pirazzini, 2004; Neri *et al*., 2010).

Therefore, for each apricot variety, it is important to predict the response (in terms of the number and type of lateral shoots) to head back pruning of shoots and branches in different periods of the spring and summer seasons. Pruning intensity and cultural techniques (fertilization, irrigation, soil management, and eventually forcing and protection conditions) play an extraordinary role in determining the final result and the possible optimal training system (Neri *et al*., 2011).

*Spring shoot heading back and thinning*

The intensity of head back pruning of growing shoots can be performed within these two extremes: short pruning (leaving half of the shoot or only the basal portion of it with three to five buds, as a spur) and long pruning (which reduces the apical portion of the shoot by pinching or cutting a few centimeters below the tip). Generally, these pruning techniques are limited to the spring with fast growing shoots. The time of pruning can be intended as early or late spring pruning, in which the early pruning induces the formation of long sylleptic shoots, while the latter induces nil growth or the formation of few, short, sylleptic brindles with, likely, a higher flower differentiation aptitude.

After spring heading back, shoot vigour is strongly reduced and the number of sylleptic shoots is generally increased. Short head back pruning was generally less effective than long heading back in inducing flowering brindles, with the exception of weak varieties which need to improve shoot growth. The response to pruning is always higher in fertile and irrigated soil. Apparentely the pruning in late spring induces a better response if it is limited to the terminal part of the long shoot (long pruning) (Fig. 3).

Delaying spring pruning (late spring pruning) reduces the number of sylleptic shoots per single cut and also the

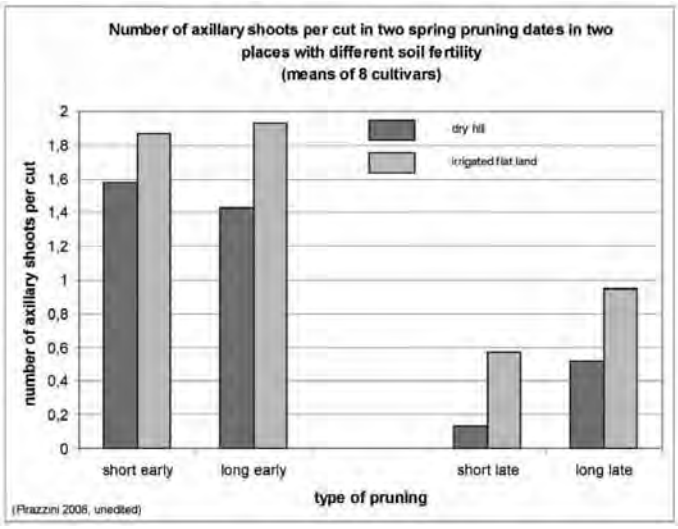


Fig. 3 - Number of sylleptic shoots per single cut in response to short and long pruning delaying the operations from early to late spring.

flowering intensity. Flowering intensity is higher when pruning is applied in early spring (May) in different varieties (Fig. 4), probably because more sylleptic brindles were produced. Apparently late pruning in June induces a better response if it is performed on the terminal part of the shoot (long pruning).

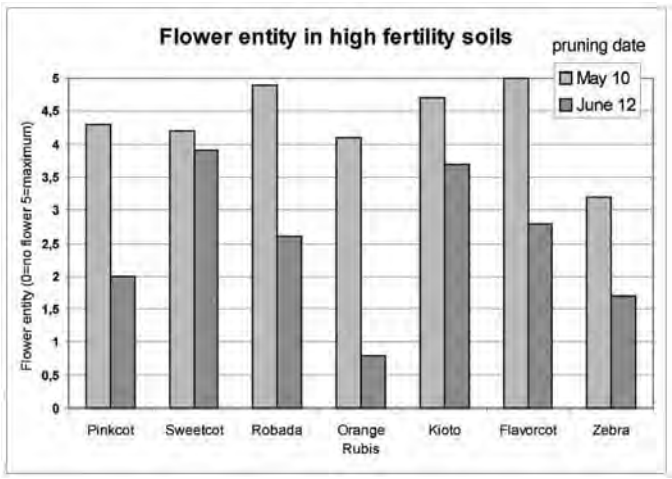


Fig. 4 - Flowering estimated entity in 8 varieties in response to pruning applied in May (early pruning), or in June.

Shoot thinning is generally carried out a few weeks before harvest to improve fruit quality in very vigorous trees. It is devoted to eliminating overcrowded and malpositioned shoots. The final goal is to have better light distribution inside the canopy and less carbon directed to water sprouts and suckers which cannot be used for fruit production in the future management of the branches.

*Summer shoot heading back and thinning*

Summer shoot head back pruning aims to increase flower differentiation but in apricot this is possible only if there is new shoot growth, which can be induced by water supply after summer drought or by heavy cuts such as late summer heading back.

Summer shoot thinning can be performed with the aim of improving the quality of shoots as a consequence of better light penetration and carbon allocation. This practice reduces the need for winter pruning and can be useful in areas where frost damage may challenge flowering and therefore winter pruning must be delayed until after fruit set.

Different pruning intensity is meant to stimulate more vegetative vigour when the shoot is suddenly cut very short, but to induce the formation of flowering brindles when it remains quite long (Fig. 5). Under northern Italian continental climate, the vegetative response to pruning is always greater in fertile and irrigated soils, resulting in greater shoot vigour. Finally, sylleptic shoots tended to bloom later than the rest of the plant (a very important advantage in climates where late frost is common) but to bear fruits of small size, at least in some varieties (Pirazzini, personal communication).

*Varietal differences in response to spring heading back*

*Pinkcot*. Early short heading back induces numerous, equally balanced and productive sylleptic shoots. Sylleptic shoot growth is very active when it is stimulated on vigorous shoots (water sprouts), which by the end of the season are well ramified. At blooming the number of flowers on sylleptic shoots is higher with long heading back than with short. Short heading back resulted in more uniform distribution of brindles and spurs along the original branch.

*Sweetcot*. Growth is greater after early shoot heading back: nevertheless only few sylleptic shoots were formed, they are not too long and the flower number is increased. In non-irrigated soils late pruning does not improve shoot ramification, while growth is short and rich in flowers.

*Robada*. In fertile soil, early pruning generally induces a few sylleptic shoots, often only one as an extension growth from the terminal bud, even though the number of flowers on all type of shoots is high. With late pruning there is a certain number of sylleptic shoots (brindles and

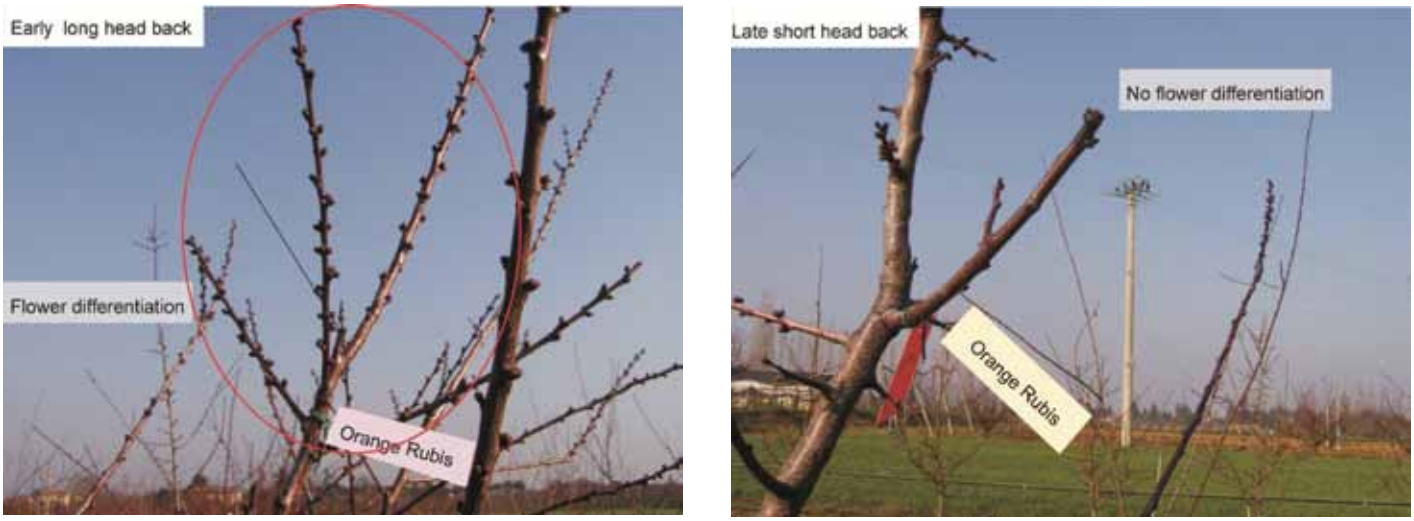


Fig. 5 - Orange Rubis forms shoots after early long-heading back (left): a high number of sylleptic shoot with good flower differentiation is formed. Shoot after late short-heading back (right): sylleptic growth and flower differentiation is visible.

spurs) but fewer flowers per shoot. In non-irrigated soil, short heading back does not induce any good growth, neither for shoots nor flowers.

*Orange Rubis*. Long early shoot heading back is very effective in stimulating sylleptic growth with high flower differentiation, while short heading back is useful only with weak shoots. Heading back of water sprouts, especially when late, does not favor flowering formation.

*Kioto*. The number of brindles and spurs is dramatically increased by early pruning, with very high flower differentiation along the old wood. Late pruning is positive only on vigorous lateral shoots. Flower differentiation is good in all the shoots after early pruning, and intermediate in sylleptic brindles in vigorous shoots after late pruning.

*Flavorcot*. Both short and long early pruning induce weak growth in comparison with the vigorous cultivars; the sylleptic shoots are limited in number and growth even in water sprouts. Late pruning does not induce good sylleptic ramification, but the flower induction is enhanced in brindles and spurs in all the plants. After early pruning, flowers are scarce in all the sylleptic shoots; after late pruning, flower production is much better in the old wood and in sylleptic brindles.

*Zebra*. Early long head back pruning induces positive sylleptic shoot growth; short heading back is less effective even in water sprouts; flower differentiation confirmed this result. Late heading back was negative and induced only few flowers.

*Pieve*. Early heading back is generally positive and, especially with long pruning, the number of sylleptic brindles is higher and flower differentiation is good. Late pruning reduces the branching of shoots, and induces a very limited number of flowers.

*Pisana*. For this low fertile variety, it is worth noting that the terminal shoot on the intact branch showed less growth than the second one below, as opposed to the heading back causing the terminal shoot to become the most vigorous of the branch. This means that in low fertility conditions the varieties of this group need to be stimulated by winter pruning instead of weakened by summer pruning.

*Bella di Imola*. This variety shows very high productivity on the one-year shoot, the terminal portion being the most productive. Growth was greater at the terminal position of the branch as well, revealing a much stronger acrotony than Pisana, and greater vigor. For this reason it is important to avoid any pruning which induces a vegetative response which is too strong. In fact in orchards with low fertilization, growth was not excessive even with winter pruning; flower differentiation was high in any case. It can be hypothesized that in more fertile soils vigor can be too strong, and so late summer pruning can be widely utilized (Neri *et al*., 2010).

*Pruning in different training systems for apricot*

Actual training systems for apricot are specific for each production area. The two most widely diffused training systems in the northern part of Italy are free open vase (with several variations, from delayed open vase to bush) for low density, hilly orchards and spindle for high density systems in flat fertile lands with low vigorous rootstocks.

The date and intensity of pruning effectively determines the branch architecture and fruiting potential of each cultivar. These observations lead us to conclude that for apricot, summer pruning is a basic practice in modern orchards but it must be adapted to local conditions and genetic material. Shoot physiology, theoretically modeled on the basis of growth rate, can help in choosing the best period and most effective intensity for the pruning of each new cultivar in the different training systems of a particular growing area.

We can generalize that summer pruning reduces vigor and induces greater flower production. Early long shoot heading back is more effective with high vigor varieties and fertile soil conditions, whereas short shoot and branch head back pruning is favorable for weak and spreading varieties, although the latter habit could be more easily controlled by winter pruning than the former.

Varieties of group A, such as some of the new varieties, benefit from early summer pruning (early heavy shoot heading back) in order to induce the formation of sylleptic shoots; and summer pruning (without heading back but possibly with shoot thinning) to encourage shoots to be more lignified. Group B performs best after winter pruning (shoot thinning and heading back of two- to three-year-old branches). Group C may be pruned in late summer or at the end of winter (shoot thinning, heading back the branches), depending on local growing conditions. In order to limit the development of sylleptic shoots, which only bear small fruits, it is better to carry out heading back in late summer instead of in the winter.

In any case, every pruning strategy must be tested on each variety before it is adopted throughout commercial orchards. This is due to the possible very specific influence of varietal differences in chilling requirements, and specific shoot and flower differentiation physiology.

## 2. Peach

In modern peach orchards, application of spring and summer pruning is increasing (from 20% up to 60% of the total amount of pruning), depending on the training system, production area and farm management (Giovannini *et al*., 2010). Peach shows good ability to form sylleptic shoots and strong epinastic control that makes the sylleptic shoot insertion angles wider moving from the top to the basal part of the shoot. These features require an appropriate shoot pruning technique and finally, if well managed, lead to dwarf the tree with the open habit of mature peach plants.

During training of modern intensive orchards, spring pruning is therefore applied more than summer pruning (and obviously of winter pruning), in order to address the inclination of vigorous growing shoots and to anticipate formation of the skeleton structure of the canopy. The re-

moval of mal-positioned water sprouts and stimulation of a higher number of well positioned shoots (Ferree *et al*., 1984; Lanzellotti *et al*., 1998) finally dwarf the trees (Kappel and Bouthillier, 1995; Hossain and Mizutani, 2008).

The second goal of a greater use of spring and summer pruning is to reduce the vegetative unproductive phase and enhance early bearing in all new training systems (Giovannini *et al*., 2010; Neri *et al*., 2010). Summer pruning is applied to shorten the not-fruiting initial phase, improve light distribution on fruiting shoots and strengthen the future scaffold branches with a higher number of fruiting shoots (Miller, 1987).

Nevertheless, pruning time in less intensive orchards is often determined by farm organization, depending on the availability of labor and arrangement of the working schedule, rather than on the plant physiology (Chalmers *et al*., 1981; Marini and Barden, 1987; Sansavini and Neri, 2005).

Pruning can be also applied in the spring for biological reasons. In fact for some cultivars pruning intensity can be adjusted near blooming time, when flower buds enlarge and become more visible, depending on the quantity of buds that were damaged by frost during the winter. This kind of spring pruning can thus augment fruit set per tree.

If the risk of frost damage is extended to blooming time, pruning can be carried out precisely during the fruit set period. In this case "winter pruning" is completely substituted by an early spring pruning which eliminates the excess shoots, based on the rate of fruit set, by heading back two-year-old branches.

Late spring pruning is commonly used for training, but in modern orchards it is not very common to control production if trees are mature and equilibrated. Also early summer pruning, before harvest time, is used only to thin the water sprouts and to improve light distribution in the canopy, whenever the vigor is too high, to increase fruit color and quality and to prevent diseases. However when this pruning is too heavy or too early it can negatively affect fruit development.

Summer pruning after harvest can better manage excess vegetative growth and change the distribution of assimilates (Rom and Ferree, 1984; Marini, 1985; Mizutani *et al*., 1997; Hossain *et al*., 2004). It improves bud differentiation and branch hierarchy organization. During summer, shortening branches results in a more regular sprouting in the following spring, with less vigorous shoots and high quality flower buds. In some cultivars, when it is necessary to cut big branches, the summer period is useful also because it induces a more rapid and efficient wound healing. This sort of pruning can also be considered when it is necessary to mitigate severe water stress (Lopez *et al*., 2006; Marsal *et al*., 2006).

Late summer pruning in August-September is important and widespread in all environments because it contributes to reduce canopy volume and allows shoot hardening. It partially prevents winter pruning (therefore it is called pre-winter pruning) and strongly reduces the need for it. Furthermore, it is more selective than winter pruning as the best buds for fruit set are chosen in advance.

*Summer pruning for peach training systems in Mediterranean climate*

Depending on the training system, both spring and summer pruning are applied to favor the branch inclination of shoots through pinching or cutting the upper part of the shoot to induce sylleptic ramification (Fig. 6), also more than once per season as is done for the Catalonian vase (Monserrat and Iglesias, 2011).

Removal of excess and mal-positioned shoots is also practiced to give a regular shape to the spindle and to the small open vase (Neri *et al*., 2010). In any case, the pruning intensity is minimal and eventually some spring interventions are postponed from the first to the second year, and/or continued in the third if tree vigor is too weak.

In Mediterranean areas, with long growing season and early ripening cultivars, also vase training systems (i.e. low open vase) are commonly managed with the application of spring-summer pruning. In fact small vase formation can be improved using summer shoot cuts to direct vegetative growth to the well displaced lateral sylleptic and proleptic shoots. Modern systems derived from the vase are characterized by a low scaffold (0.5 m above ground), low tree height (2.5 m), and free growth during the first years (bush type to enhance early bearing).

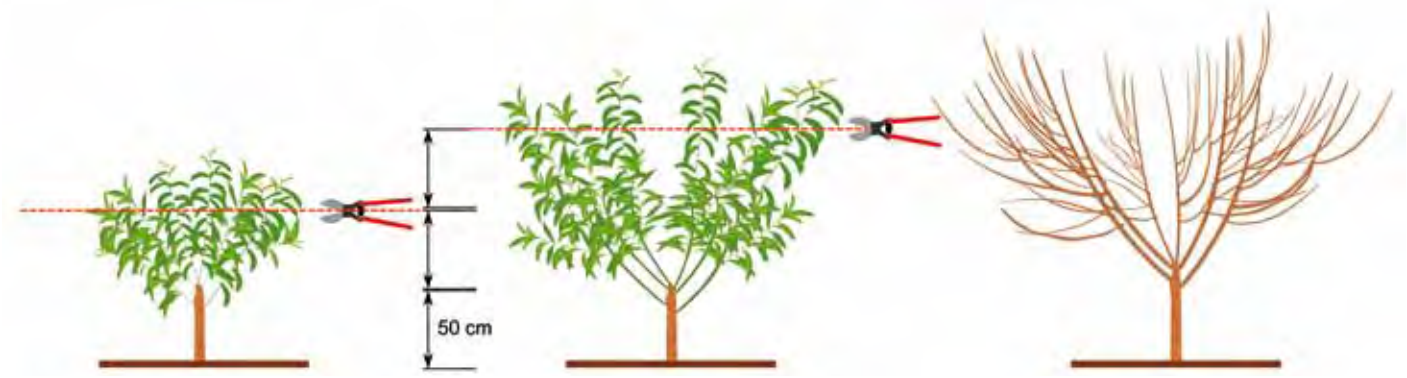


Fig. 6 - Catalonian vase during the first growing season. Left: first manual topping when the shoot exceeds 100 cm from the soil. Centre: second topping (manual or mechanical) when the shoots exceeds 150 cm from the soil. Right: the final growth at the end of the first year (redrawn from Monserrat and Iglesias, 2011).

The Catalonian vase, which originated in Spain, is the most recent and wide-spreading vase system. Spring-summer pruning is repeatedly employed to form and dwarf the trees during the first two years of training. Mechanical topping is applied every 50 cm till the final size of the plant is reached (2.5 m) at the end of second year (Figs. 6 and 7). Topping involves removing a few apical buds per shoot, thus inducing suppression of apical dominance and increasing the possibility for growth of the external sylleptic shoots. This sets off a temporary strong competition among all growing shoots, but in peach the external shoots are privileged, and thus the main shoots are naturally oriented toward the external direction. Finally, the whole plant height is lower but several shoots are well positioned to become the future branches of the vase.

During the second year, or third in the case of low fruiting cultivars, the vase shape can be completed by thinning the primary branches and cleaning the central part, mainly in late summer. In mature orchards, pruning labor in this system can require less than 100 hr/ha (60% during vegetative season), and the fruiting winter pruning (the remaining 40%) completes the late summer pre-winter pruning (Fig. 8).

Specific summer pruning is required also in the "Y" trellis system. Inclined branches with angles wider than 40-45° promote the growth of vertical shoots in the internal portion of the canopy and late spring and early summer pruning are necessary to remove them during the initial years. The high density planting of this system, the possibility to use long pruning, without eliminating shoot apex of primary branches, and the reliability of pruning during the vegetative season provide early fruiting. Nevertheless, the "Y" system is well performing only where climate conditions provide a high level of light, allowing the reduction of branch angles close to 30°, and thus reducing water sprout formation. This angle promotes a balanced vegetative growth and fruit production in all the lateral and basal portions of the two fruiting walls. "V" systems with double tree density and less vigorous rootstocks can be used to reduce further the need for spring and summer pruning. In this case, defining the two oblique productive planes is easier and more rapid but the cost of planting is very high and there is risk for overcrowding in the internal part of the canopy, which could induce an exponential increase in the need for pruning.

*Spring and summer pruning in peach training systems for continental climate*

In the northern part of Italy, where there are short growing seasons and high risk of frost in the spring, with midseason varieties high hedgerow systems (palmette and central leader, 4 m high) are still popular. This is because late spring frost may dramatically damage the production in the bottom part of the tree (first 2 m from the ground). In this condition pruning may be delayed after blooming (when fruit set is already complete). Thus winter pruning becomes an early spring pruning, while early summer

Fig. 8 - Catalonian vase during the fourth growing season at blooming in the Sibari area. The skeleton is completed and the plant is dwarf and equilibrated.

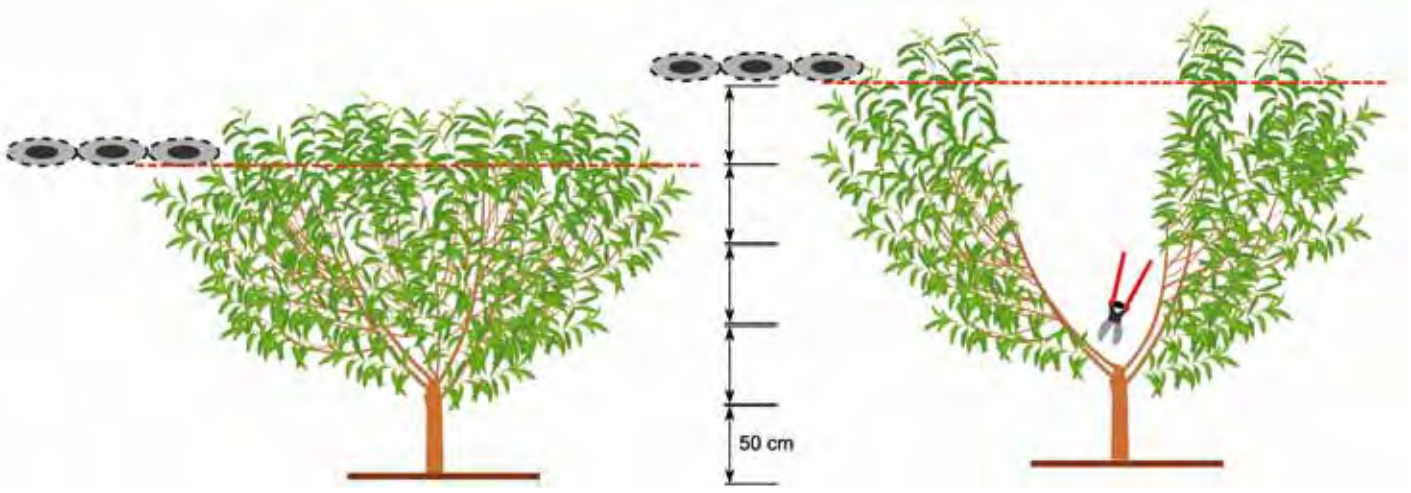


Fig. 7 - Catalonian vase during the second growing season. Left: first mechanical topping when the shoots exceed 200 cm from the soil. Right: second mechanical topping when the shoots exceed 250 cm from the soil, and manual pruning to thin the main branches down to four to five in number, opening the centre in very late summer. This last pruning is done only if the variety has a very high productivity (redrawn from Monserrat and Iglesias, 2011).

pruning is not frequent and limited to lightening the upper part of the canopy (if necessary).

During the training period to reduce shoot vigor of the mal-positioned water sprouts, turning and partially crashing them can improve their fruiting aptitude. Late summer pruning is used to maintain the shape of the trees and to increase lignification of the shoots that otherwise would be too shaded. The hedgerow made by trees trained as "U" or candelabras along the row requires less green pruning than palmette or central leaders because of less vigor of each vertical branch.

For training high density peach orchards, well feathered scions from the nursery must be used to obtain fruit production in the second year. In mature orchards, green pruning is mandatory in two specific seasons: i) in early spring before harvest to eliminate water sprouts and to induce a higher number of productive shoots in well defined positions; after fruit set it is also possible to thin the shoots proportionally to the amount of fruit set; and ii) in late summer after harvest to anticipate the winter pruning (pre-pruning). In this case the water sprouts are eliminated and the vigorous shoots on the main branches are cut only if there is excess flower differentiation; the top part of the branches can be reduced to better permit light distribution in the canopy. If the pre-pruning in late summer is well executed with light shoot thinning, winter pruning can be avoided. In this way labor can be saved and/or better organized.

In low bush open vase (delayed open vase) (Sansavini and Neri, 2005), for the first three-four years the training of the trees is free with only a few pruning cuts; green pruning is not important. Late summer pruning becomes important in the third to fourth year to cut the central leader and to open the centre of the vase. In the fourth to fifth year, the main branches are headed back and the tree is completely formed as a vase. Finally, pre-winter pruning is necessary to manage fruit shoot quality and quantity when production becomes important (starting from the third year).

*Production pruning*

When the tree is well mature and fully formed, spring pruning is less important and must be carried out only in very specific cases when excess vigor of the growing shoots can compete with the growing fruits, interfering with the fruit quality and flower induction for the next year.

Peach production is located on one-year shoots (brindles, fruiting shoots and in some varieties also in water sprouts) and in a very limited quantity on the spurs (these are important only in clingstone peaches and in some nectarines with low fertile shoots). Because of this specific fruiting behavior, it is very important to control shoot growth to form highly specific shoots in each variety (Day *et al*., 1989).

If the vigor is very high (generally in early ripening varieties) it is necessary to execute the first pruning before harvest in late spring in order to eliminate mal-positioned water sprouts and to improve light distribution in the canopy. Whereas pruning in late summer is very helpful both in early and late ripening varieties to improve the quality of the fruiting shoots, favoring shoot hardening and carbon allocation. To improve light distribution in the canopy it is important to thin the shoots and to head back the branches. This pruning in late summer anticipates winter pruning, which consequently can be delayed at blooming to determine the final number of flowers per plant. Winter pruning can even be eliminated and early spring pruning after fruit set can be applied to determine more precisely the number of fruits per plant.

It is important to remember that avoiding heavy shading is important to obtain homogeneous distribution of the shoots along a branch. In fact when the shoots are shaded they can be damaged during winter and necrotize. Because peach trees do not produce adventitious meristems and do not maintain latent buds for long, winter pruning is not able to recover new adventitious shoot growth and finally the shaded area of the canopy is lost.

To avoid this dramatic loss of efficiency of the internal part of the canopy, spring- summer pruning is mandatory in modern orchards. This problem is even more accentuated in high density planting systems in which early spring pruning can be associated with fruit thinning to reduce the impact of self shading and inter shading on shoot and fruit quality. Traditional low density orchards under continental conditions are mainly pruned using precise winter pruning because once the open vase is well formed it provides high quality and constant fruit production.

## 3. Conclusions

In apricot each group of varieties has its own optimum season and intensity for pruning, according to fruiting aptitude and branch habit. For high density orchards, heavy late spring pruning may be used to reduce vigor and improve flower differentiation during the summer. For free open vase, use of late summer pruning only can be suggested to obtain a better carbon partitioning towards the fruiting shoots and a more uniform light distribution in the canopy.

The higher the flower differentiation aptitude, the greater the possibility to use different seasons for pruning. With low aptitude, manipulation of spring growth of the shoots and light distribution in the canopy through spring-summer pruning is mandatory.

Apricot varieties can be classified into groups characterized for different vegetative and reproductive habits, accordingly and depending on the fertility of the soil, they can be pruned in summer (if soil fertility is high) or in winter (if soil fertility is low).

Some of the new low productive varieties benefit from early summer pruning (early or late spring shoot heading back) to induce the formation of sylleptic shoots and to obtain good flower differentiation. Weak varieties perform the best after winter pruning (branch heading back). Other, very productive varieties may be pruned in late summer or at the end of winter (shoot or branch heading back) depending on local growing conditions (Pirazzini, 2004).

In peach, habit is mainly influenced by assurgent growth in low chilling varieties that are well adapted to the mild Mediterranean climate with low chill in winter, and by the widespread habit of the varieties, suitable for more continental climatic conditions with cold winters and tolerant to late frost in the spring.

Among these groups of varieties, flower aptitude is another factor which influences the type and intensity of spring and summer pruning. In modern peach orchards, late summer pruning is widely diffused as a common practice to manage light distribution and carbon allocation and finally shoot quality. This technique is applied in substitution or to reduce the amount of the winter pruning.

Late spring pruning is applied only if necessary when tree vigor is too high, while early spring pruning is used less and limited only to cases of unpredictable fruit set due to erratic climatic conditions. In any case, the labor for all kinds of pruning (spring, summer, and winter pruning) takes not more than 100 hours per hectare per year.

With some very productive varieties and appropriate training systems (delayed open vase and free spindle) it is possible to reach an amount of labor for all the manual operations during the season of about 15 hours per ton of fruit (Giovannini *et al*., 2010; Neri *et al*., 2010).

During training of Catalonian vase in the first two years, spring and summer pruning can be mechanized with a moving machine to further reduce labor. Late summer pruning may start in the second year for heavy producing varieties and in the third year for the less productive ones.

In conclusion, spring and summer pruning increase the efficiency of labor (both for the ease and speed of the work and for the capability of the tree to rapidly compensate for errors and incorrect interventions) and improve fruit quality. Late summer pruning can particularly improve modern orchard management efficiency.

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