Apple tree training in France: current concepts and practical implications

Pierre-Éric Lauri[a]*
Jean-Marie Lespinasse[b]

[a] Laboratoire d'Arboriculture fruitière, unité de recherche en Génétique et Amélioration des Plantes, Inra, 2, place Viala, 34060 Montpellier cedex 2, France

[b] Unité de recherche sur les Espèces Fruitières et la Vigne, Inra, BP 81, 33883 Villenave-d'Ornon cedex, France

* *Correspondence and reprints*

Received 11 December 1998
Accepted 22 March 1999

Fruits, 1999, vol. 54, p. 441–449

RESUMEN ESPAÑOL, *p. 449*

Apple tree training in France: current concepts and practical implications.

Abstract — Introduction. The article develops a reflection upon the conception of fruit tree training, based on scientific and technical papers already published in French and English. **Tree structure and fruiting**. Three concepts, which appear particularly important for the tree structure and fruiting, are developed: the autonomy of fruiting points, the fruiting branch and the fruiting distribution on points of growth. **For an integrated concept of the fruit tree**. Three lines of reflection are detailed. i) Bending of the branches is a natural phenomenon during the tree life. Its proper usage at the level of the whole tree, meaning the fruiting branches around the trunk as well as the extremity of the trunk itself, seems to be an efficient way of globally mastering tree growth and fruiting. ii) Fruiting can take place at the terminal position on vigorous shoots. Inflorescence thus no longer appears to be a substitute for weakened vegetative growth but rather as a motor for the architectural organisation of the tree. iii) The technical layout of the orchard and the training approach have a strong impact on light distribution throughout the canopy of the trees. Optimising light interception by the canopy is of crucial importance to modern orchards and their high density planting. The orchardist can act more directly at the level of the technical structure of the orchard or at that of the architectural organisation of the tree itself. **Conclusion and perspectives**. Research into new training approaches is focused on the needs of early yield, regularity of production and reductions in the cost of production. The present research aims at improving the mastery of fruit-bearing branch fruiting regularity. © Éditions scientifiques et médicales Elsevier SAS

France / Malus / plant training / cultivation / fruiting / light requirements

---

La conduite du pommier en France : concepts actuels et implications pratiques.

Résumé — Introduction. L'article propose une réflexion sur la conception de la conduite de l'arbre fruitier et s'appuie sur un certain nombre de documents déjà publiés en français et en anglais. **Structure de l'arbre et fructification**. Trois concepts, particulièrement importants pour la structure de l'arbre et sa fructification, sont développés : l'autonomie des points de fructification, la branche fruitière et la distribution de la fructification sur les points de croissance. **Pour une conception intégrée de l'arbre fruitier**. Trois lignes de réflexion sont détaillées. i) La courbure des branches est un phénomène qui se produit naturellement dans la vie de l'arbre. Son utilisation raisonnée au niveau de l'arbre entier, c'est-à-dire des branches fruitières autour du tronc et de l'extrémité du tronc lui-même, apparaît efficace pour maîtriser globalement la croissance et la fructification de l'arbre. ii) La fructification peut se réaliser en position terminale sur des rameaux vigoureux. L'inflorescence n'apparaît plus alors comme le substitut d'une croissance végétative affaiblie mais comme un élément moteur de l'organisation architecturale de l'arbre. iii) La structure technique du verger et le mode de conduite conditionnent étroitement la distribution de la lumière au sein de la couronne des arbres. L'optimisation de l'interception lumineuse par le couvert végétal est d'une importance cruciale pour les vergers modernes, à haute densité de plantation. L'agriculteur peut agir sur la structure technique du verger ou sur l'organisation architecturale de l'arbre lui-même. **Conclusion et perspectives**. Les recherches de nouveaux modes de conduite des arbres fruitiers sont focalisées autour du besoin d'une production précoce et régulière et de la réduction des coûts de production. Les travaux actuels visent à améliorer la maîtrise de la régularité de fructification sur les branches fruitières. © Éditions scientifiques et médicales Elsevier SAS

France / *Malus* / conduite de la plante / pratique culturale / fructification / besoin en lumière

1. introduction

The economic success of an orchard depends on a combination of economic and technical factors, "the orchard system puzzle" [1], among which tree training plays a major role. The apple grower has traditionally considered tree training to be a series of manipulations used to enhance tree fruiting by giving the tree a predetermined form (Y-trellis, Palmette, Tatura, etc.). These manipulations force trees to follow growth, branching and fruiting distribution rules which are often extremely different from their natural aptitudes. Such interventions are incompatible with present day economic constraints which require professionals to increase product quality while reducing costs. These orchard approaches delay the first yield, give no assurance of production regularity and result in high financial outlay, thus proving increasingly inappropriate to the economic context.

Works carried out by the *Institut National de la Recherche Agronomique* (Inra) at the centre of Bordeaux, France, over the past 30 years have considerably altered this "mechanistic" conception of fruit tree training: the emphasis is placed on accompanying the tree in its growth rather than imposing a prefixed form at the outset. The four types of apple fruiting studied by Bernhard and Marénaud, and published by Bernhard [2], represent an initial step in a more global study of natural growth, branching and fruiting characteristics for the main cultivars [3, 4]. Lespinasse [5] proposed the integration of these morphological results into the definition of four ideotypes. As of the first studies, it was possible to draw links between this global typology and the beginning of production on the one hand, and alternate bearing on the other [2]. These studies, as well as others on the size of fruit from Golden Delicious cultivar [6], reinforced the idea that progress in the field of tree training would have to be based on a more in-depth knowledge of cultivar behaviour, notably as concerns:

– branching organisation around the trunk,

– fruiting distribution throughout the canopy of the tree and its development in time,

– the influence of fruit position on its quality.

Taking these elements into account was the starting point for developments concerning tree training approaches, from the "Vertical Axis" in the 1970s [3, 7] to "Solaxe" [8–10].

Although the main works have been carried out on apple trees, the same approaches seem to be applicable on other species such as cherry trees [11, 12].

It would seem interesting to give an overview of the concepts at the basis of these proposals. Their interest lies as much in their proven operational value as in the research perspectives they open up at the level of fruit tree physiology.

Three concepts appear particularly important:

– autonomy of fruiting points,

– the fruiting branch,

– fruiting distribution on points of growth.

Over and above the terms used, it is the set of underlying ideas which will be the centre of attention in the text which follows. Moreover, the article develops a reflection based on scientific and technical articles published in French and English. The reader will be directed towards these source documents for more precise information on the analytic approach.

2. tree structure and fruiting

2.1. autonomy of fruiting points

In the adult phase of apple tree development, inflorescence appears in different situations on the shoots: in the "lateral" position or in the "terminal" position on shoots of varying lengths [13] (*figure 1*). In all cases, flowering corresponds to a transformation of the terminal meristem of an axis. Any further growth can only take place from a secondary axis called a "bourse-shoot" (*figure 1*). The "return-bloom" phenomenon on a bourse-shoot (*figure 1*) is particularly interesting as it indicates, for the cultivar under question, a propensity for regular fruiting. Certain cultivars, such as Granny Smith, have a strong propensity for return-blooming on bourse-shoots, that is to say, they produce one fruit after another on the same axillary shoot. Works run on a large range of cultivars show a positive relationship between, on the one hand, this return-bloom aptitude on bourse-shoots and, on the other hand, bourse volume and the length of the bearing axis [14]. The notion of fruiting point autonomy is based on these results. It covers both the bourse-shoot return-bloom aptitude and the set of morphological traits which are associated with it, notably bourse volume and carrier length. It suggests the involvement of metabolic processes, especially resource allocation characteristics which vary from one cultivar to another. Orchard observations, furthermore, show that if, in a given training context, return-blooming is a discriminating criterion between cultivars, it changes in time and can be considerably modified depending on the training approach. It is known, for example, that a cultivar which is characterised by alternate bearing can be brought to produce more regularly, bourse after bourse, as soon as the number of axillary shoots is reduced along the branches.

2.2. the fruiting branch

The new fruit tree training concepts of the Bordeaux Inra centre resulting from reflections on the vertical axis [15] are based on the fruiting branch notion. This term is defined as a branched set growing directly on the trunk or a scaffold branch and the principal axis of which is allowed to develop freely over several years. Depending on the cultivar, its natural habit can be erect or drooping [16], only slightly branched in the case of cultivars like Granny Smith or more heavily branched for cultivars like Reine des Reinettes (*figure 2*). In all cases, the fruiting branch constitutes the work unit of which the apple grower will optimise positioning in the tree, controlling its development from year to year.

Works have been carried out on fruiting branches of cultivars belonging to four types of fruiting. All of the branches were bent, either artificially in the case of naturally erect cultivars (Oregon Spur, Reine des Reinettes), or naturally for drooping habit cultivars (Granny Smith, Red Winter). Studies focused on the individual development of axillary branches over a 5 year period: vegetative or flowering function, latency, death (scarring). The studies showed that each cultivar can be characterised by a specific "strategy" associating a set of phenomena [16, 17]. The contrastive examples of Reine des Reinettes and Granny Smith seem particularly interesting. The former cultivar is characterised by a rate of axillary development which remains quite steady over time. It has, in fact, a low propensity for bourse-shoot return-bloom. The latter cultivar, Granny Smith, is characterised by extensive abatement in the number of functional axillary branches over time: over 50% of the functional axillary branches present on 1 year-old wood are no longer functional on 2 year-old wood (*figure 3*). This

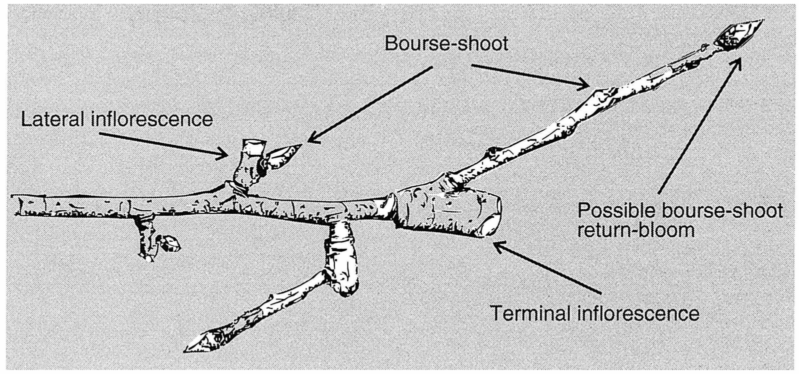


Figure 1.
Shoot bearing both "lateral" and "terminal" inflorescences. Bourse-shoots issuing from such inflorescences can be of varying lengths.

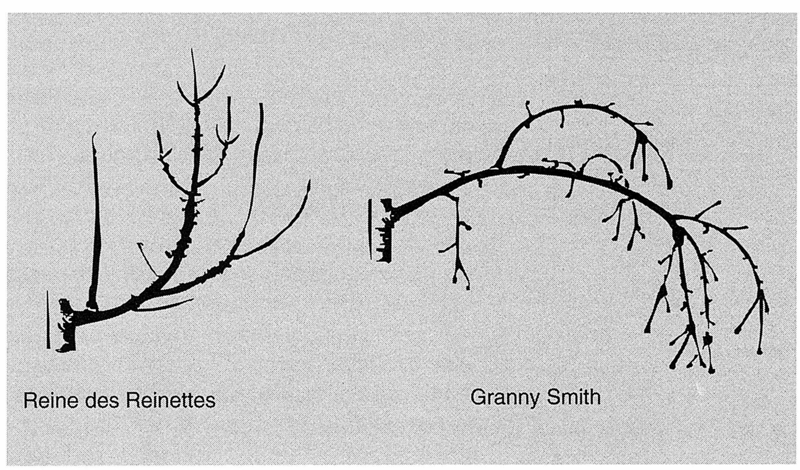
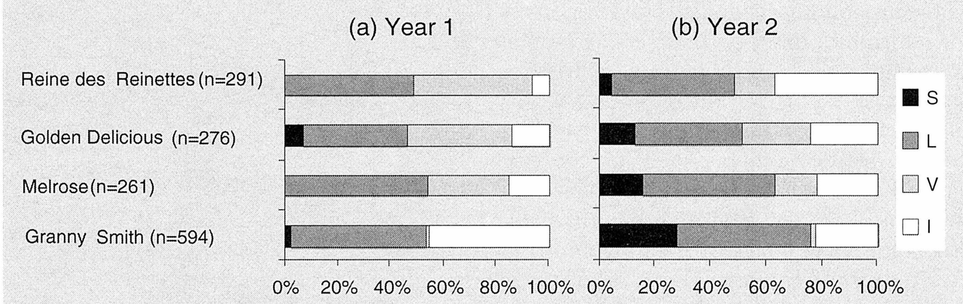


Figure 2.
Unpruned 5 year-old 'Reine des Reinettes' and 'Granny Smith' fruiting branches in natural habit.



(c) Change in the functioning points between year 1 and year 2

	Year 1	Year 2
Reine des Reinettes (n=291)	51%	51%
Golden Delicious (n=276)	54%	49%
Melrose (n=261)	46%	37%
Granny Smith (n=594)	46%	24%

Figure 3.
Proportional presentation of the four types of axillary productions, scarred (S), latent (L), vegetative (V) and inflorescent (I), carried on (a) a 1 year-old shoot and (b) a 2 year-old shoot for four cultivars: Reine des Reinettes, Golden Delicious, Melrose and Granny Smith. One can see the percentage shift in functional axillary shoots (V, I) with relation to the full set of axillary types (S, L, V, I) between the 2 years (c). "n" represents the total number of axillary productions for each cultivar.

phenomenon is called "extinction" [16, 17]. On this cultivar there is a high rate of return-blooming on bourse-shoots.

2.3. fruiting distribution on points of growth

This third concept relates to the general organisation of the tree and is based on observations of trees in natural habit. Certain cultivars in free habit and on weak rootstock (M9) quickly develop an architecture composed of middle length branches and occasionally strong erect shoots with, in all cases, regular "terminal" fruiting year after year. Granny Smith is a good example of such a cultivar (*figure 4*). Under the same conditions, other cultivars, with late terminal fruiting, maintain a more powerful trunk around which extensive branching develops carrying short lateral alternate-bearing shoots. This is the case for Reine des Reinettes (*figure 4*). In accordance with Edelin [18], we have proposed terms for a polyarchical organisational plan to designate the first type of behaviour and for a hierarchical organisational plan to designate the second [16]. These two notions are both morphological (homogeneity versus heterogeneity of shoot types throughout the canopy of the tree) and functional (autonomous shoots versus short alternating spurs). They illustrate what man can bring about artificially through choices in training approaches.

The classical training concept is based on a very hierarchical view of trees. The orchardist first seeks to establish a strong vegetative structure (for classical goblets: trunk, scaffold branches, secondary branches, fruiting branches) upon which he distributes the points of fruiting. From a deeper point of view, one could say that this conception is based on the idea of an antagonism between vegetative growth and fruiting [19]. In practice, the propositions of traditional training thus lead to paradoxical manipulations. The forming of the tree structure will require repeated pruning which will maintain a population of vigorous, non-fruiting shoots. In such a context, fruiting can only be maintained on "less vigorous" shoots which form a separate population from the first group. Man's actions thus constantly maintain, especially through winter pruning, a spatial separation between the vegetative development zones, mostly at the extremity of the canopy and so in an environment which is favourable but naturally of low fruiting, and fruit-bearing zones at the interior of the tree which are disadvantaged in comparison to the rest

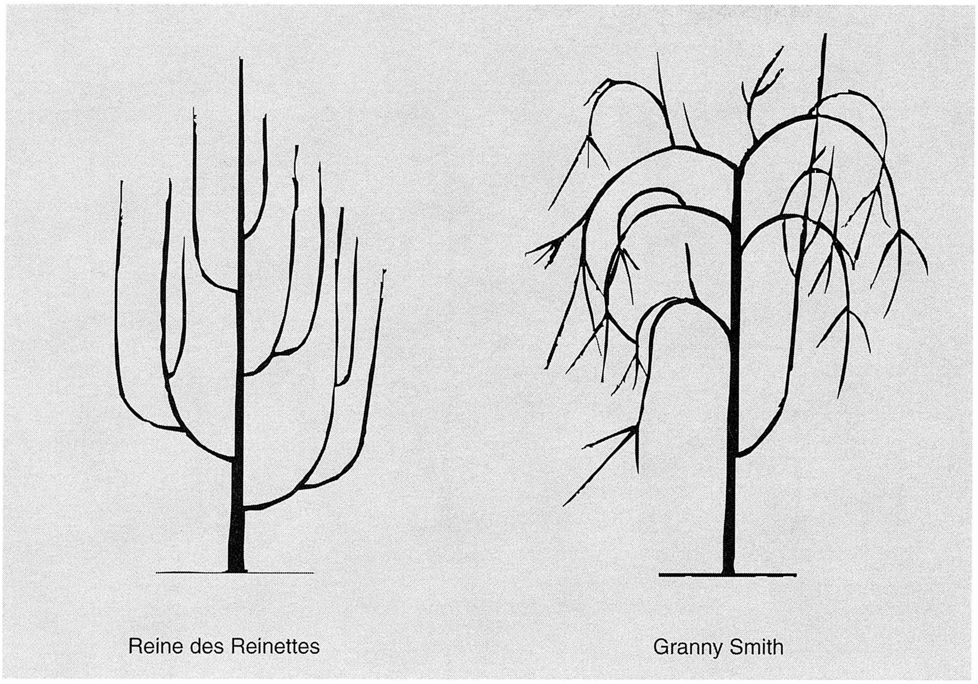


Figure 4.
'Reine des Reinettes' and 'Granny Smith' silhouettes.

of the tree. The negative effects of training systems based on these principles (Lincoln Canopy, Palmette) are well described in the literature [19]: vigorous branches near the tops of trees, heavy shading lower down. This artificially maintained dissociation of growth from fruiting has negative effects on the fruit. Tustin et al. [20] show how the "pyramid-shaped central leader" training of Granny Smith cultivars results in a negative effect on fruit weight due to the hanging position of the bearing shoots as well as their interior position inside the structure of the tree.

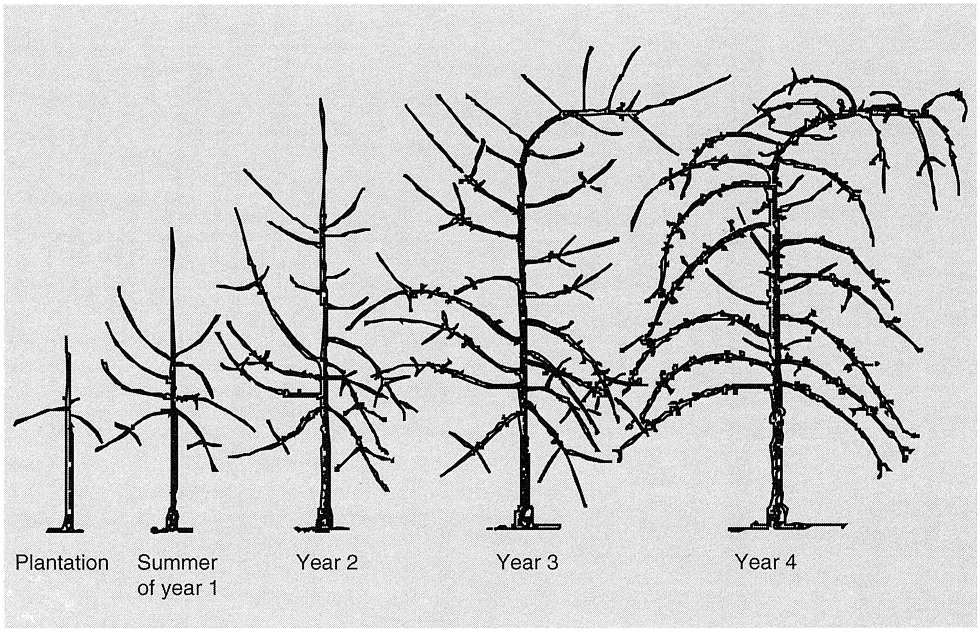
Comparing these results with our own observations of systems such as the Solaxe (*figure 5*), in which fruits are very rapidly in a hanging position, brings to light a fundamental point: at the scale of tree canopy, the homogeneity of fruit quality depends in large part on the homogeneity of growth distribution and fruiting. These considerations have led us to develop a more polyarchical training concept, radically different from the preceding approach. Any consideration of flowering quality, that is to say, the ability of an inflorescence or a flower to develop fruit [21, 22], or of fruit quality must integrate not only the local environment, but also the global vegetative context. It is on the basis of this principle that the "fruiting branch" notion has been elaborated.

3. for an integrated concept of the fruit tree

These concepts correspond to levels of integration ranging from the fruit-bearing organ to that of the tree. Implementation of training systems based on these concepts, Solaxe in particular [23, 24], over the past few years have stimulated the following three lines of reflection.

(i) The bending of fruiting branches, be it natural or man-made, is a classical method of controlling the balance between vegetative growth and fruiting at the level of individual shoots or groups of shoots [25–27]. This approach is used widely in other training systems, such as the slender spindle system [28–30] or the super spindle system [31]. Observations of trees in natural habit show that, except for a few rare exceptions ('Stark Spur McIntosh Wijcik', a columnar habit cultivar), bending of the branches is

Figure 5.
The five steps in Solaxe apple tree training.



a natural phenomenon during their lives, taking place at an age which depends on the cultivar. It thus appears that the practice of bending branches is not the same kind of method as pruning: it simply anticipates a natural situation which would normally develop later on. Proper usage of the approach at the level of the whole tree, meaning the fruiting branches around the trunk as well as the extremity of the trunk itself, seems to be an efficient way of globally mastering tree growth and fruiting. In fact, we consider that the training of the fruiting branch cannot be isolated from the training of the whole tree. Non-respect of this principle inevitably leads to the architectural heterogeneity of the tree through the juxtaposition of vegetative and fruit-bearing zones and explain, in our opinion, the previously mentioned results of Tustin et al. [20].

(ii) Observations carried out on hybrid plots and commercial orchards over approximately 30 years show that fruiting can take place at the terminal position on vigorous shoots. It then induces a substantial reorganisation of both growth and branching. Inflorescence thus no longer appears to be a substitute for weakened vegetative growth but rather as a motor for the architectural organisation of the tree. The observation of naturally erect trees for which the natural habit has been modified by Solaxe training lends credence to the idea that fruit distribution within the canopy has a feedback effect on vegetative growth, organising it to the advantage of fruiting.

(iii) The technical layout of the orchard (space within and between rows, tree height) and the training approach have a strong impact on light distribution throughout the canopy of the trees. The same level of irradiance will, therefore, have different effects on vegetative growth and flowering / fruiting phenomena depending on the orchard design and training system choices [32–35]. Optimising light interception by the canopy is of crucial importance to modern orchards and their high density planting. Two avenues of improvement can be envisaged, depending on whether one wishes to act more directly at the level of the technical structure of the orchard or at that of the architectural organisation of the tree itself.

In the first case, increasing the distance within the row makes it possible to create discontinuities between trees and avoid the development of continuous vegetal covering which inhibits light penetration [36]. This proposal is developed on narrow-topped cone-shaped trees over 5 m in height where light distribution at basal and interior zones is quite limited [20, 36].

Training approach research into crowns with light openings represents another avenue of improvement as such crowns would make it possible to reduce the effect of self-shading [37–39]. From an architectural point of view, our observations of different training systems [40] have shown that one of the deciding criteria on light porosity is the homogeneity of vegetative growth and fruiting distribution throughout the canopy. In this context, the concept of a free fruiting branch developed according to the Solaxe system represents an interesting alternative for semi-pedestrian orchards (heights of 2.5 to 3 m) on M9 rootstock, with 1 to 2 m separation within rows.

4. conclusion and perspectives

Research into new training approaches has the goal of meeting the following needs:

- early yield,
- regularity of production,
- reductions in the cost of production.

Our present research aims at improving the mastery of fruit-bearing branch fruiting regularity. It appears, in fact, that the Solaxe system induces an early yield which, if not sufficiently controlled, can lead to alternate bearing.

Information gathered for certain cultivars (Granny Smith, for instance), indicating a natural self-regulation of the number of functioning points along fruiting spurs through "extinction" along with its link to a strong propensity towards bourse-shoot return-bloom [17, 41], leads us to believe that carrying out "artificial extinction" on naturally biennial cultivars would stimulate return-bloom on their remaining axillary branches [8, 41, 42]. At the agronomic level, the basic idea is to concentrate training techniques during the first years of a tree's life (notably reasonable bending and "artificial extinction") in order to limit the manipulations necessary later on.

Preliminary trials indicate that such interventions must begin with the first strong flowering, generally between the second and fourth years in the orchard, depending on the cultivar and growth conditions. One observes an increase in fruit diameter the same year (linked to the reduced number of fruits brought about by the intervention) as well as return-bloom the following year.

In contrast to simple thinning of young fruits, this manipulation permanently removes the axillary shoot and thereby precociously modifies axillary branching density along the branch and, consequently, the balance between growth, branching and fruiting.

Works are presently underway within the framework of the MAFCOT (Maîtrise de la Fructification – Concepts et Techniques / Mastery of Fruiting – Concepts and Techniques) applied research network with the aim of validating these observations on different cultivars in a variety of cultural contexts. These studies should, as well, make it possible to master the usage of these manipulations within a global technical itinerary including trellising, bending, pruning and thinning [43].

references

[1] Barritt B.H., Intensive orchard management, Good Fruit Grower, Washington State Fruit Commission, Yakima, Washington, USA, 1992.

[2] Bernhard R., Mise à fleur et alternance chez les arbres fruitiers, In: Congrès pomologiques, Inra, Paris,1961, pp. 91–116.

[3] Lespinasse J.M., La conduite du pommier. I – Types de fructification. Incidence sur la conduite de l'arbre, Invuflec, Paris, France, 1977, 80 p.

[4] Lespinasse J.M., Delort F., Apple tree management in vertical axis: appraisal after ten years of experiments, Acta Hortic. 160 (1986) 120–155.

[5] Lespinasse Y., Breeding apple tree: aims and methods, In: Proceedings of the joint conference of the EAPR breeding and varietal assessment section and the Eucarpia potato section, janvier 1992, Landerneau, France, Rousselle-Bourgeois F., Rousselle P. (Eds), Inra, Ploudaniel, France, 1992, pp. 103–110.

[6] Lespinasse J.M., Variation du calibre des fruits de Golden Delicious en fonction des caractéristiques et de la position des inflorescences dans l'arbre, Bulletin Technique Interprofessionnel 250 (1970) 365–381.

[7] Lespinasse J.M., La conduite du pommier. II – L'axe vertical. La rénovation des vergers, Invuflec, Paris, France, 1980, 120 p.

[8] Lauri P.É., Lespinasse J.M., The vertical axis and Solaxe systems in France, Acta Hortic., (to be published).

[9] Lespinasse J.M., Lauri P.É., Pommier : 5 points essentiels pour le contrôle de la fructification, Fruits & Légumes 147 (1996).

[10] Steigmeyer R., Sorting out the Solaxe, Fruit Grower June (1996) 22–23.

[11] Claverie J., Lespinasse J.M., Lauri P.É., Arcina® Fercer + Tabel® Edabriz + Solaxe – Pour un nouveau type de verger, Fruits & Légumes n° 155 (1997).

[12] Lauri P.É., Claverie J., Lespinasse J.M.,The effects of bending on the growth and fruit production of sweet cherry spurs, Acta Hortic. 468 (1997) 411–417.

[13] Pratt C., Apple flower and fruit: morphology and anatomy, Hortic. Rev. 10 (1988) 273–308.

[14] Lespinasse J.M., Delort F., Regulation of fruiting in apple. Role of the bourse and crowned brindles, Acta Hortic. 349 (1993) 229–246.

[15] Lespinasse J.M., Réflexions sur la conduite du pommier. Une nouvelle forme : le Solen, L'Arboriculture Fruitière 399 (1987) 45–48.

[16] Lauri P.É., Térouanne É., Lespinasse J.M., Regnard J.L., Kelner J.J., Genotypic differences in the axillary bud growth and fruiting pattern of apple fruiting branches over several years – An approach to regulation of fruit bearing, Scientia Hortic. 64 (4) (1995) 265–281.

[17] Lauri P.É., Lespinasse J.M., Térouanne É., Relationship between the early development of apple fruiting branches and the regularity of bearing – An approach to the strategies of various cultivars, J. Hortic. Sci. 72 (4) (1997) 519–530.

[18] Edelin C., Nouvelles données sur l'architecture des arbres sympodiaux : le concept de Plan d'organisation, In: L'arbre, biologie et développement, C. Edelin (Éd.), Naturalia monspeliensia, Montpellier, Actes du 2e Colloque international sur l'Arbre, Montpellier, France, hors-série A7, 1991, pp. 127–154.

[19] Forshey C.G., Elfving D.C., Stebbins R.L., Training and pruning of apple and pear trees, Alexandria, Virginia, USA, Am. Soc. Hortic. Sci., 1997.

[20] Tustin D.S., Hirst P.M., Warrington I.J., Influence of orientation and position of fruiting laterals on canopy light penetration, yield, and fruit quality of 'Granny Smith' apple, J. Am. Soc. Hortic. Sci. 113 (5) (1988) 693–699.

[21] Buszard D., Schwabe W.W., Effect of previous crop load on stigmatic morphology of apple flowers, J. Am. Soc. Hortic. Sci. 120 (4) (1995) 566–570.

[22] Lauri P.É., Térouanne É., Lespinasse J.M., Quantitative analysis of relationships between inflorescence size, bearing-axis size and fruit-set – An apple tree case study, Ann. Bot. 77 (1996) 277–286.

[23] Lespinasse J.M., Apple orchard management practices in France. From the vertical axis to the Solaxe, Compact Fruit Tree 29 (1996) 83–88.

[24] Lespinasse J.M., Lauri P.É., Influence of fruiting habit on the pruning and training of fruit trees, Compact Fruit Tree 29 (1996) 75–82.

[25] Dennis Jr. F.G., Factors affecting yield in apple, with emphasis on 'Delicious', Hortic. Rev. 1 (1979) 395–422.

[26] Tromp J., Shoot orientation effects on growth and flower bud formation in apple, Acta Bot. Neerl. 19 (1970) 535–538.

[27] Wareing P.F., Growth and its coordination in trees, In: Physiology of tree crops, Luckwill L.C., Cutting C. (Eds), New-York, Academic Press, 1970, pp. 1–21.

[28] Balkhoven-Baart J.M.T., Bootsma J.H., Groot M.J., Wagenmakers P.S., Wertheim S.J., Development in Dutch apple plantings, Acta Hortic., 1999 (to be published).

[29] Mika A., Trends in fruit tree training and pruning systems in Europe, Acta Hortic. 322 (1992) 29–35.

[30] Wertheim S.J., High-density planting: development and current achievements in the Netherlands, Belgium, and West Germany, Acta Hortic. 114 (1980) 318–327.

[31] Weber M., The super spindle system, Acta Hortic., (to be published).

[32] Robinson T.L., Seeley E.J., Barritt B.H., Effect of light environment and spur age on 'Delicious' apple fruit size and quality, J. Am. Soc. Hortic. Sci. 108 (5) (1983) 855–861.

[33] Robinson T.L., Lakso A.N., Bases of yield and production efficiency in apple orchard systems, J. Am. Soc. Hortic. Sci. 116 (2) (1991) 188–194.

[34] Rom C.R., Light thresholds for apple tree canopy growth and development, HortScience 26 (8) (1991) 989–992.

[35] Rom C.R., Ferree D.C., The influence of fruiting and shading of spurs and shoots on spur performance, J. Am. Soc. Hortic. Sci. 111 (3) (1986) 352–356.

[36] Tustin D.S., Cashmore W.M., Bensley R.B., The influence of orchard row canopy discontinuity on irradiance and leaf area distribution in apple trees, J. Hortic. Sci. & Biotechnol. 73 (3) (1998) 289–297.

[37] Lakso A.N., Apple, In: Handbook of environmental physiology of fruit crops. Vol. 1: Temperate crops, Schaffer B., Andersen P.C. (Eds), CRC Press Inc., Boca Raton, Florida, USA, 1994, pp. 3–42.

[38] Palmer J.W., Computed effects of spacing on light interception and distribution within hedgerow trees in relation to productivity, Acta Hortic. 114 (1980) 80–88.

[39] Tustin D.S., The slender pyramid tree management system. In pursuit of higher standards of apple fruit quality, Acta Hortic., (to be published).

[40] Lespinasse J.M., Delort F., Carbonneau A., Conduite de Royal Gala. Étude comparative de différents systèmes. L'Arboriculture Fruitière 449 (1992) 30–36.

[41] Lauri P.E., Lespinasse J.M., Térouanne É., Vegetative growth and reproductive strategies in apple fruiting branches – An investigation into various cultivars, Acta Hortic. 451 (1997) 717–724.

[42] Lauri P.É., Térouanne É., Effects of inflorescence removal on the fruit set of the remaining inflorescences and development of the laterals on one year old apple (*Malus domestica* Borkh) branches, J. Hortic. Sci. & Biotechnol. 74 (2) (1999) 110–117.

[43] Lauri P.E., Lespinasse J.M., Fouilhaux L., Conduite du Pommier – Vers un meilleur contrôle de la fructification, L'arboriculture Fruitière 510 (1997) 37–42.

El manejo del manzano en Francia: conceptos corrientes e implicaciones prácticas.

Resumen — **Introducción**. El artículo propone una reflexión sobre el diseño del manejo del árbol frutal y se apoya en unos cuantos documentos ya publicados en francés e inglés. **Estructura del árbol y fructificación**. Se desarrollan tres conceptos, particularmente importante para la estructura del árbol y su fructificación: la autonomía de los puntos de fructificación, la rama frutal y la distribución de la fructificación en los puntos de crecimiento. **Para un diseño integrado del árbol frutal**. Se detallan tres lineas de reflexión. i) La curvatura de las ramas es un fenómeno que se produce naturalmente en la vida del árbol. Su utilización raciocinada al nivel del árbol entero, ramas frutales alrededor del tronco y extremidad del tronco mismo, resulta eficaz para dominar globalmente el crecimiento y la fructificación del árbol. ii) La fructificación puede realizarse en posición terminal en ramas vigorosas. La inflorescencia no aparece ya entonces como el substituto de un crecimiento vegetativo debilitado pero como un elemento motor de la organización arquitectural del árbol. iii) La estructura técnica del vergel y el modo de manejo condicionan estrechamente la distribución de la luz dentro de la corona de los árboles. La optimización de la intercepción luminosa por la cubierta vegetal es de una importancia crucial para los vergeles modernos, en alta densidad de siembra. El agricultor puede actuar sobre la estructura técnica del vergel o sobre la organización arquitectural del árbol mismo. **Conclusión y perspectivas**. Las investigaciones de nuevos modos de manejo de los árboles frutales se focalizan alrededor de una necesidad de una producción precoz y regular y de la reducción de los costos de producción. Los trabajos actuales intentan mejorar el dominio de la regularidad de fructificación en las ramas frutales.

Francia / *Malus* / formación de la planta / cultivo / fructificación / necesidades de luz