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# THE IMPLICATION OF DIFFERENT PRUNING METHODS ON APPLE TRAINING SYSTEMS

## SUMMARY

A comparison between long (rich) and short (poor) pruning methods known as "Standard" and "Click" respectively, was performed on the cultivar Golden Delicious grafted on M9 rootstock. The cultivar was trained as Slender Spindle and Bi-axis systems. The experiment was conducted by using an integrated pest management system in the first two years followed by an organic method. Biometrical data in terms of trunk cross sectional area, height, width and depth of the trees and canopy volume were annually detected. Plants pruned with the Click method resulted more compact particularly in the Bi-axis, which had a significantly lower depth compared to the Slender Spindle training system. The increase of pruning severity in the Click method didn't affect fruit number and yield but led to increase mildly the fruit size. No differences were found between the training systems in terms of fruit size. Trees pruned with Click method resulted with a higher percentage of scab infection shoots after the primary infection even though this is a preliminary result because is related to one year only of observation.

**Keywords:** Slender Spindle, Bi-axis, Click, Yield and Fruit quality

## INTRODUCTION

The province of Trentino is an important apple growing area and represents 25% of the total apple production of Italy. Apple cultivars are grafted mainly on dwarfed M9 rootstock and trees are trained primarily with Spindle and Slender Spindle systems. The trees are formed by a vertical leader trunk and lateral horizontal weak branches which are much shorter at the top than at the bottom giving the plants a conical shape (Buler and Mika, 2009). Usually, the lateral branches are replaced over the years by pruning, but some of them, as scaffold basic branches, may remain permanent. Generally, these "laterals" have the same age as the trunk leader and bear a high number of fruits, which represent a high percentage of the total apple tree yield. This could be a limiting factor in the Spindle system especially where the limited space between branches

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might be filled quickly leading to increasing shade causing apple fruit quality decrease (Corelli and Sansavini, 1989).

Recently an alternative kind of tree has been introduced in the orchards patented under the trade name "Bibaum®" (Musacchi, 2008). This tree is formed by two axis which develop along the row giving the plant a flat shape. The lateral branches are shorter than those of the Spindle, thus providing apparently a better light canopy penetration and at the same time providing a good vigour control simplifying many cultural practices particularly winter pruning, limb bending in summer and harvesting (Dorigoni et al., 2006; 2011).

Both training systems are well adapted to high planting density (HPD) and full canopy can be achieved by the end of the third year (Robinson, 2011; Dorigoni et al., 2011). Normally, small trees show less shade within the canopy, but once the tree density increases, poor illumination could occur even in these planting systems (Robinson et al., 1991; Barritt, 2000).

Thus the adoption of an appropriate pruning method could solve or limit the problem (Robinson et al., 1997; Barritt, 2000) being one of the most important and immediate cultural management techniques to influence fruit quality and yield (Özkan and Kücüker, 2009). In fact, pruning might model the canopy allowing light interception, yield efficiency and fruit quality improvement without increasing vegetative growth potential (Robinson et al., 1991; Tustin, 2000). Branching renewal strategy through pruning was reported by Warrington et al. (1995) and Robinson et al. (1997) aiming to allow better light penetration in the canopy.

The "Long pruning" method, developed in France with the aim to better control plant vigour and yield (Lespinasse, 1977; 1980) has been adopted in these kind of HDP in Trentino province, obtaining good results in terms of production but decreasing fruit quality over the years due to the effect of shading particularly in the Slender Spindle training system.

The "Click", a short pruning method, could be one of the solutions to improve light penetration in the canopy allowing a better return bloom and improves fruit quality. This technique requires a continuous branch renovation with the final aim to improve fruit quality homogeneity within the canopy. The heading back cut of the leader and of the basic scaffold branches proposed in this method could promote better flower bud formation on one-year old branches as observed by Mohammadi et al. (2013). This technique was created in The Netherlands and Belgium apple growing areas to ameliorate light penetration in the canopy, essential in these latitude-growing areas. The renewal pruning increases photosynthesis, promotes shoot growth, and improves yield and fruit weight in apple (Tustin et al., 1988; Warrington et al., 1995; Li MingXia et al., 2011). Renovation of limbs promotes fruiting shoots for early cropping, and contemporarily to overcome alternate bearing (Ventura and Sansavini, 2005). On the other hand, Mitre et al. (2010) observed that fruit quality decreased in trees with branches of different ages. In addition, the cylindrical compact shape of the tree given by the click method forces the plant to stay in the established space

(Dallabetta et al., 2013). Nevertheless, the maintenance of a tall narrow tree in a proper space increases the fruit quality in the lower part of the canopy (Robinson et al., 2006).

The aim of this study is to verify the effect of "Click", an innovative pruning method, to ameliorate yield and fruit quality in apple HPD orchards trained as Slender Spindle and Bi-axis.

## MATERIAL AND METHODS

The trial was carried out in Trentino-Alto Adige region, Northern Italy in the experimental farm of Fondazione Edmund Mach (San Michele all'Adige, Italy) at 210 ma.s.l.. Golden Delicious B clone was the cultivar selected for the trial grafted on M9 rootstock. The trees were trained as Slender Spindle (SS) and Bi-axis and pruned according to two methods: "long cut standard" and "short cut Click". The SS only was pruned with another method which consists in a mix of standard and Click pruning techniques. The orchard was established in 2009 at 3317 trees/Ha planting density (3.35 x 0.90 m) for the SS training system and at 2488 trees/Ha (3.35 x 1.20 m) for the Bi-axis trees one. Twelve trees of similar vigour and crop load were chosen for each treatments positioned in 4 blocks (3 trees/block). The trees were managed according to commercial practices as integrated crop and pest management in 2009 and 2010 and later with organic farming conduction.

The "standard" pruning method consists in growing a central leader and lateral branches without heading cuts. From the lateral branches small secondary shoots develop forming complex branches. Branches are renewed periodically if they become too vigorous, while basic scaffold lateral branches are permanent. The "Click" pruning technique consists in heading back the leader and the basic scaffold branches on new wood at the second-third-bud level. The lateral branches are continuously renewed in order to obtain fruiting branches of 2-3-4 years only. Old lateral branches are removed when too old or too big (> 1/3 or ½ of the diameter of the central leader) by cutting the head leaving a stub to facilitate shoot renovation. The "mixed" method is similar to the Click method but with a difference that the leader is grown naturally without heading back. Biometrical data such as trunk cross sectional area (TCSA) 20 cm above graft union, height, breadth and depth of the trees were recorded after harvest. The canopy volume was calculated by a formula using the biometrical data. At harvest the fruits were annually graded using Greefa equipment measuring weight (g) and size (mm) of each fruit. At the end of the primary infection (end of May 2014) Scab shoot infection were detected. Hundred shoots for Click and standard pruning methods were chosen divided in 4 blocks (25 shoots / block).

Statistical analyses were carried out using R, version 3.0.2.. The package nlme (Pinheiro et al., 2013) was used to fit a Linear Mixed Model; the variables "Blocks" and "Trees" were used to take into account the possible sources of correlation in the data. The p-values for the comparison of interest were corrected to control the false discovery rate.

## RESULTS AND DISCUSSION

Trees pruned according to the pruning methods and trained with both training systems resulted similar in crop load and yield efficiency at harvest (data not shown). The similar crop load was also imposed tuning up the chemical and hand thinning intensity in order to avoid the effect of crop load on fruit quality.

Bi-axis trees resulted with a significant lower depth compared to the SS trees even though the canopy volumes were similar comparing the two training systems (Fig.1a and b). In fact Bi-axis trees have a higher number of lateral branches which are shorter than those in the SS trees and develop mainly along the row giving to the tree a flat shape tree (Dorigoni et al., 2006 and 2011).

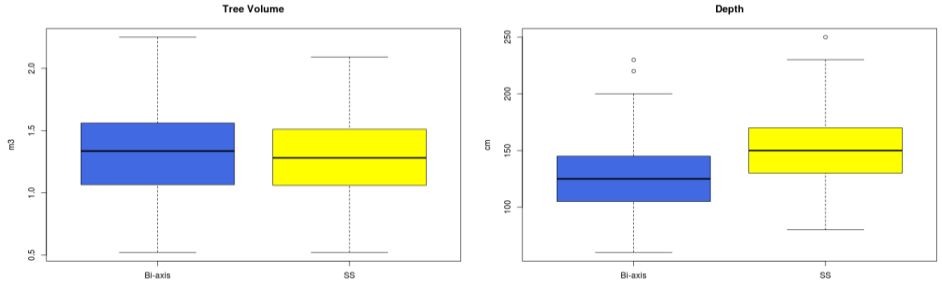


Figure 1a & b. Tree volume ($m^3$) in the two different training systems (left). The adjusted p-value for the comparison is not significant (ns). Tree canopy depth (cm) in the two different training systems (right). The adjusted p-value for the comparison is: $<10^{-7}$.

Trees pruned with the "Click" method resulted more compact compared to trees in the standard method (Fig. 2a and b). The depth and the tree volume were significantly lower in the "Click" pruned tree due to increasing of the pruning severity which forced the trees to stay in proper space distances (Dallabetta et al., 2013). The trees trained with SS system and pruned with the mixed method resulted similar in term of tree volume and size compared both the trees pruned with the Click and standard method.

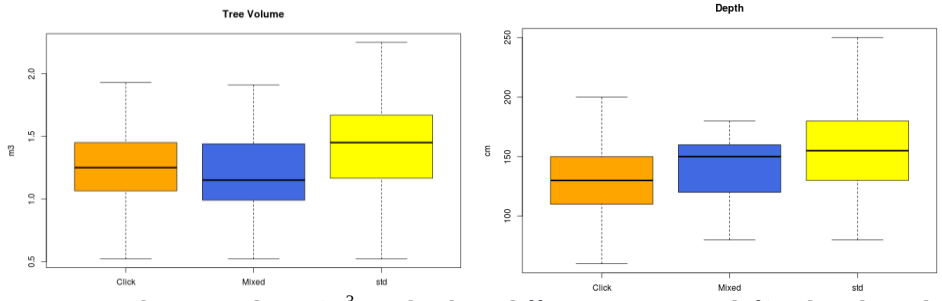


Figure 2a & b. Tree volume ($m^3$) in the three different treatments (left). The adjusted p-value for the comparison between the Click and standard pruning method is:<0.0017 and is not significant (ns) for the comparison between the Click and the mixed pruning method. Tree canopy depth (cm) in the three different treatments (right). The adjusted p-value for the comparison between the Click and standard pruning method is: $<10^{-5}$ and is not significant (ns) for the comparison between the Click and the mixed pruning method.

No differences on fruit size were found between the two training systems (Fig. 3a). This may be due to the fact that both training systems had similar tree volume and fruit number. It is known that yield is related to surface area (Winter, 1981) and the total number of leaves supplying carbohydrates to the fruits or the fruit/leaf ratio influence the carbohydrates content of the fruits as observed by Corelli-Grappadelli et al. (1994) and Poll et al. (1996).

The increase of pruning severity adopting the Click technique mildly increased the fruit size comparing the fruits in the trees pruned with the standard method (Fig. 3b). The fruits in the mixed method resulted in similar size with those of the Click. This is probably due to the fact that Click technique promotes a continue branch renovation which leads to an increase in fruit size. In fact, Warrington et al. (1995) found a 8% increase in fruit size renewing branches. The trees pruned with the Click method resulted with a higher percentage of shoot scab infection after the primary infection (data not shown) even though these are preliminary results. No differences were found for the infection on fruits.

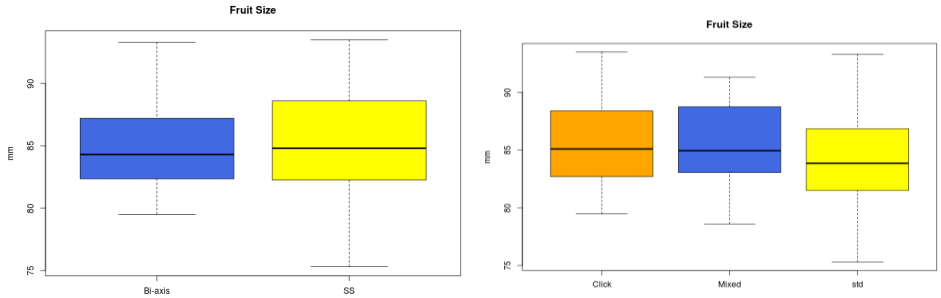


Figure 3a & b. Average size (Ø mm) of fruits carried out by the two different training systems (left). The adjusted p-value for the comparison is not significant (ns). Average size (Ø mm) of fruits carried out by the three different pruning methods (right). The adjusted p-value for the comparison between the Click and standard pruning method is: <0.0566 and is not significant (ns) for the comparison between the Click and the mixed pruning method.

## CONCLUSIONS

The objective of this work was to study the effect of pruning methods ("standard" and "Click") in two different training systems (SS and Bi-axis). The Click was introduced particularly to improve fruit quality in an HPD. Branch renovation, adopted by using the Click method, improved slightly the fruit size, one of the most important parameters for the market without reducing fruit number. Modern HPD systems need to renew periodically their lateral branches to promote new fruiting limbs and to improve light penetration within the canopy trees to maintain a standard fruit quality in the orchard over the years.

The continuous branch renovation can help to produce fruits on similar age branches improving fruit quality homogeneity within the canopy thus avoiding many picks at harvest.

The growth of complex branches by using the standard pruning method increased the tree volume in both training systems. This increases shade within the canopy promoting yield in the external part of the tree extending into the space distances of the planting system.

The innovative Bi-axis confirmed to be a valuable training system for HPD obtaining a similar fruit quality and yield compared to the more known SS system. The Bi-axis resulted more compact than the SS system and may facilitate the maintenance of the tree in the appropriate space distances. Nevertheless, the Click method resulted to promote more speed vigour which could lead to an increase of scab infection danger due to the fast growth of the vegetation. These are still preliminary results and a further analysis is required to confirm the result.

In conclusion this paper recommends the Click pruning method or at least promotes the branch renovation strategies for HPD to maintain the trees in the appropriate space distances and a high percentage of marketable fruit size.

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