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CANOPY MANAGEMENT PRACTICES IN MODERN PLUM (*PRUNUS DOMESTICA* L.) PRODUCTION ON VIGOROUS ROOTSTOCKS

Miljan CVETKOVIĆ[1], Gordana ĐURIĆ[1,2], Nikola MICIC[1,2]

[1]University of Banja Luka, Faculty of Agriculture, Bulevar Vojvode Petra Bojovića 1A, 78000 Banja Luka, Bosnia and Herzegovina
[2]University of Banja Luka, Genetic Resources Institute, Bulevar Vojvode Petra Bojovića 1A, 78000 Banja Luka, Bosnia and Herzegovina

Corresponding author email: miljan.cvetkovic@agrofabl.org

Abstract

Intensive high-density plantings (HDP) of plum trees in the Republika Srpska involve the use of Myrobalan (Prunus cerasifera Ehrh.) seedling as the predominant and, in most cases, the only rootstock. Using Myrobalan as a vigorous rootstock is a serious challenge in growing plums at higher planting densities. Although Myrobalan seedling rootstock increases the vigour of grafted cultivars, plum trees trained to the spindle system on Myrobalan rootstock can also be grown at very high plant densities ranging from 1,000 to 1,800 trees per hectare, depending on the cultivar/rootstock combination and central-leader inclination. The most common training system for plums in high density plantings is the slender spindle or the spindle bush system. Successful training and maintenance of spindle systems in intensive production on high-vigour rootstocks is not possible without the consistent use of canopy management practices, particularly during the first three years after planting, when these practices are most intensive for proper training of both the central leader and main lateral branches. Canopy management practices require a professional attitude and substantial manual labour. Particular importance in training spindle systems for plums as well as in maintaining the training system (replacement of spur-bearing branches) is given to the following specific canopy management practices: notching, shoot bending, shoot twisting, undercutting and replacement of spur-bearing branches. This paper outlines some important canopy management practices and their effect on plum growth and development, focusing on cultivar-specific responses to treatments.

Key words: *plum, canopy management practices, cultivar.*

INTRODUCTION

On an annual level, plum production in Bosnia and Herzegovina (during 2003 – 2013) showed an increase in total land area (+7.37%) and production (+4.80%) and a decline in average yield (–2.39%) (FAOSTAT, 2016). Although plum is the leading fruit crop in BiH (Statistics Agency, BiH), the intensity of production is rather low, which may be associated with the use of growing methods (Mićić et al., 2005) unadapted to the tendency to introduce new cultivars into production.

The most common training system for plum trees in high density plantings (HDPs) is the slender spindle or spindle bush (Grzyb and Rozpara, 1998; Hrotko et al., 1998; Meland, 2001; Čmelik et al., 2002; Gavrilescu et al., 2004) which uses low-vigour rootstocks. Establishing new highly intensive (high density) plum plantings in Bosnia and Herzegovina characteristically involves the use of Myrobolan (*Prunus cerasifera* Ehrh.) seedling as the predominant, and in most cases the only rootstock available for plum grafting. In modern highly intensive plantings under high density planting systems which use higher vigour rootstocks, practices designed for canopy management during dormancy and timely summer pruning operations are the preconditions for successful plum production (Mićić et al., 2005; Milošević et al., 2008; Glišić, 2012; Cvetković et al., 2015).

Shoot management operations aimed at creating the best crotch angle possible such as shoot bending (during the first part of the growing season) can have an important effect on generative bud differentiation and, hence, facilitate the control of growth and development processes.

The objective of this study was to analyze shoot bending in plum trees grown on vigorous rootstocks in highly intensive plum production systems.

MATERIALS AND METHODS

The analysis of shoot bending practices in plum trees was conducted in a plum planting at Gunjevci (44°35'33"; 18°56'38") near Kozarska Dubica (BiH) at an altitude of 155 m.

The planting was established in autumn 2009. The experimental plot has a north-western exposure, with a slight inclination (2%). Total land area of the planting is 1 ha.

Four cultivars were planted: 'Stanley', 'Čačanska Lepotica', 'Čačanska Najbolja' and 'Čačanska Rana'. All cultivars were grafted on Myrobalan (*P. cerasifera* Ehrh.) seedling rootstock.

Trees were trained to the spindle system using all necessary canopy management practices. Spacing for all cultivars was 1.5 m within the row and 4.0 m between rows.

The planting received standard cultural practices. Soil management systems were grass mulch for the inter-row space, and bare fallow combined with herbicide band for the within-row space.

The research was carried out in 2010 - 2013. The trees of the tested cultivars were subjected to shoot bending, as follows:

a) initial spreading of the shoots to keep them at an angle subordinate to the central leader – at the beginning of the growing season, and

b) bending of the shoots to retain the desired position relative to the central leader – in the middle of the growing season.

Shoot management treatments were applied in the entire planting, but 30 trees per cultivar subjected to shoot bending operations were randomly selected for detailed analysis.

The shoots were initially spread out by wooden toothpicks, whereas in the second part of the growing season they were bent by plastic hooks, twine (aluminium wire and plastic wire spreaders) and twisting.

After the three–year experimental period, the shoot bending techniques used in the study were analysed for visual shown and integrated evaluation of their efficiency and effectiveness.

RESULTS AND DISCUSSIONS

Spreading of the shoots. The initial spreading of the shoots along the central leader by toothpicks in the tested cultivars (Figures 1a and 1b) favoured the formation of a proper crotch angle (about 90°) of the newly formed shoots which generally provide the basis for the spindle structure in plum trees (Lučić et al. 1996; Mićić et al., 2005; Gonda, 2006; Glišić, 2012).

Figure 1. Spreading of shoots by toothpicks - variety 'Čačanska Lepotica' (a) and 'Čačanska Rana' (b)

The spreading operation in the tested cultivars led to reduced apical dominance (Wilson, 2000). Importantly, spreading by toothpicks should be done successively in accordance with the shoot growth dynamics.

The shoots subjected to spreading exhibited a higher rate of generative bud differentiation (Mićić et al., 1998). The horizontal position of the shoot resulted in higher percent activation of growth points along the shoot during the same or following growing season, with shorter growth formed and much of this growth developing into fruiting wood. Such a response was effective in reducing growth vigour and producing a more favourable ratio of vegetative to generative growth on the tree, which is of particular importance in the first years of plum production on higher vigour rootstocks.

The spreading efficiency of toothpicks is dependent on the optimum time to use them. Spreading should be performed when the shoot has reached a length of 15 – 20 cm, which is, in part, a cultivar-specific trait.

In 'Čačanska Najbolja' and 'Čačanska Rana', spreading should be applied to shorter lengths of shoots. 'Čačanska Najbolja' exhibits intensive growth, and its shoots longer than 20 cm generally have a greater base diameter and are not spreadable. 'Čačanska Rana' showed a tendency to develop shorter shoots with a higher rate of lignification at the base, thus potentially creating spreading problems. 'Stanley' and, particularly, 'Čačanska Lepotica' show a positive response to shoot spreading by toothpicks even at a later developmental stage. Mitrović et al. (2005) and Glišić et al. (2007) agree that shoot bending is a mandatory practice in establishing dense plum plantings on vigorous rootstocks, but no precise shoot bending times are defined in their studies. Toothpicks should be used in succession – only shoots that have reached the required developmental stage are to be spread out.

Previous experience has shown a very positive effect of toothpicks (Mićić et al., 2005; Glišić et al. 2007; Glišić, 2012*)*. If the shoots are bent in the second part of the growing season without being previously spread at this early stage, the so–called "knee" is formed at the shoot base.

The use of toothpicks has a number of advantages: a high installation efficiency rate (a large number of toothpicks installed per unit time); good spreading performance; simple installation; causing minimum damage to the tissue which shows a high healing rate; the natural material they are made of has no negative effect on plants; they are available on the market and very affordable.

Problems with toothpick use generally include their post-installation instability, which may be due to low toothpick quality, improper installation or adverse weather conditions (heavy rain, wind) after installation. If improperly installed, toothpicks soon fall off, and the treatment must be repeated for satisfactory spreading performance.

Spreading requires intensive manual labour continuously throughout the growing season (until mid-July), which may be a constraint to the use of this practice in large plantations. Upon use of toothpicks to spread out shoots during the initial stage of shoot development and crotch angle formation in the tested cultivars, most of the shoots exhibiting high growth vigour continue their intensive growth in the middle of the growing season. In order to hold the shoots in position, they were further spread by plastic hooks (hereinafter referred to as hooks), aluminium wire and plastic twine shortly before shoot lignification at the base (Figure 2 a,b,c).

The use of hooks to spread shoots during the growing season showed a range of practical advantages: relatively easy installation; hooks can also be used to spread shoots that show strong growth; relatively easy removal after use; hooks can remain on the tree for use in the following growing season (which might cause their partial deformation); they cause no damage to either the leader or the shoot.

Although they increase production costs to some extent, these types of hooks have also been manufactured in the domestic market in the last years at a relatively affordable price.

When purchasing hooks, it is advisable to pay attention to their resistance to UV radiation.

The use of aluminium wire (and plastic twine) for shoot bending in this research showed the following disadvantages: relatively low spreading efficiency per unit time (the wire cannot be cut to a required length far in advance of the spreading operation, but rather shortly before the treatment; this slows down the operation and the process of finding a suitable position on both the shoot and the leader or some other type of growth to which the wire is to be fastened – this was a problem especially with plastic twine which was fastened to two positions; a crotch angle of 90^o is difficult to establish by wiring and twining in shoots being spread at the base (unless previously done by toothpicks); wires can often fall off after installation, especially at the point of contact with the shoot, and the operation requires correction (which was not the case with the plastic twine); during the growing season, wires must be removed from vigorous shoots to prevent them from cutting into the shoot tissue (in more extreme situations, this can lead to breakage of the shoot and, later on, the year–old branch), which is also a problem with plastic twine.

Wires are given priority in spreading strong shoots that are unspreadable by hooks, if no twisting is used.

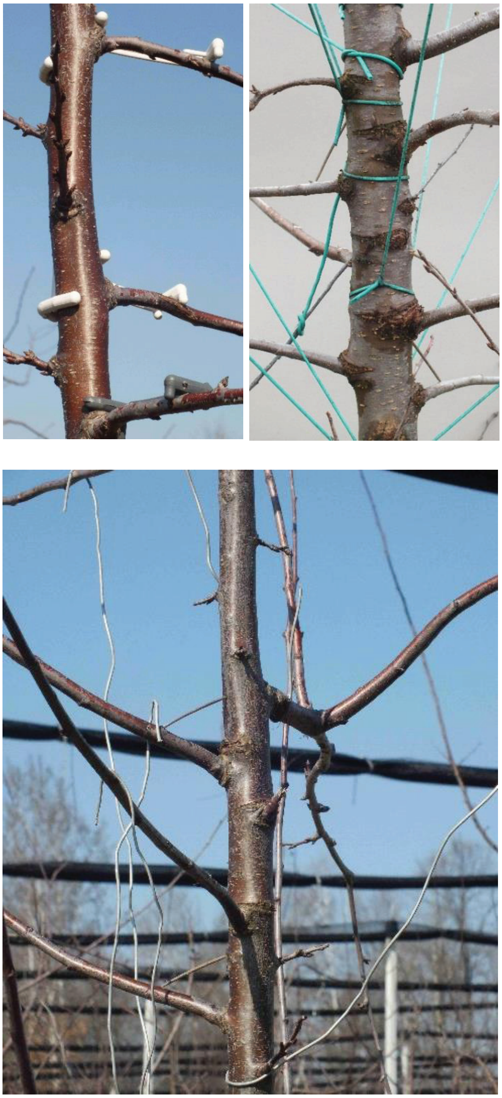

Figure 2. Spreading of shoots by plastic hook (a -variety ’Čačanska Lepotica’), plastic twine (b - variety ’Stanley’) and aluminium wire (c - variety ’Čačanska Rodna’)

Shoots that have been timely brought to a proper position in relation to the central leader will by the end of the growing season acquire the character of the fruiting wood i.e. mixed–type fruiting branch or, rarely, long vegetative growth.

Shoot twisting. The vigour of a plum tree, especially when Myrobolan is used as a rootstock, very often induces intensive shoot growth in the second part of the growing season, showing the tendency for apical growth, even if hooks or wire spreaders are previously used. In order to keep the shoots subordinate to the central leader and prevent apical dominance, shoot twisting was performed on the tested cultivars in early July.

The operation was aimed at reducing the vegetative growth activity of the shoots and inducing flower bud differentiation. Shoot twisting was done in accordance with the principles set down by Mićić et al. (2005), which ensure satisfactory operation and adequate performance: at twisting, the shoots had active tip growth; twisting involved holding the shoot base in one hand, while twisting the shoot over a wide area with the other hand, to prevent breakage; twisting was repeated if it failed to produce the desired effect in the first twisting treatment. In shoots exhibiting lower growth vigour and smaller base diameter, twisting entails smaller spacing between the hands i.e. the portion of the shoot subjected to the twisting pressure is shorter.

When twisting stronger shoots with greater base diameter, the spacing between the hands is wider, and the portion of the shoot subject to the twisting pressure is longer. This is common in shoots subjected to twisting later than considered optimum (degree of lignification of the shoot base) or which are not spread out in initial developmental stages (by either toothpicks or hooks). The twisting pressure was applied until creases appeared on the bark, and in certain cases until the bark was damaged or cracked. So far, research on the use of twisting has shown that bark damage due to twisting does not have an adverse effect on further growth and development (resin flow, shoot dieback) although this may be an open question from the viewpoint of the ecological and health situation of the trees (Figure 3 a,b,c).

The present research has confirmed that the damaged portion of the shoot shows very good healing in biological terms, and does not differ from the rest of the shoot. The position of the shoot when released speaks of the twisting performance.

The return of the shoot to its original position is a reliable sign of improper twisting. Strong twisting pressure which brings down the shoot completely results in complete crushing of growth vigour and fruit bud formation along the shoot.

Figure 3. Results of shoot twisting (a - variety ’Čačanska Lepotica’, b - variety ’Stanley’) and aluminium wire (c - variety ’Čačanska Rodna’).

This is in favour of the conclusion that greater efficiency is always achieved by strong twisting. Twisting plays an important role in controlling vegetative growth and initiating cropping in initial years of spindle formation. Glišić (2012) observed that the combined use of canopy management practices, with twisting included, leads to trees coming into bearing very early and reaching full productivity at an earlier date in a considerable number of plum cultivars grown under high density system.

Twisting in other stone fruit crops is not so efficient (sour cherry) as in plums or it leads to excessive shoot damage or dieback (sweet cherry).

CONCLUSIONS

Plum production on Myrobalan (*Prunus cerasifera* Ehr.) seedling rootstock under spindle training and high density planting systems requires proper and timely tree management practices during the growing season, along with the need to follow the rest of intensive production principles.

Shoot management operations during summer pruning are designed to bring the shoots at their initial developmental stages to the best position possible in relation to the central leader and enable crushing of apical dominance and vegetative vigour.

Initial spreading by toothpicks at the beginning of the growing season and subsequent bending in the second part of the season provide optimum spreading performance.

Under intensive growth conditions in the second part of the growing season, high efficiency is achieved by shoot bending as well.

Cultivar-specific response to these treatments can influence the date, effectiveness and efficiency of the treatments.

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