Scientia Horticulturae 229 (2018) 193–200

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Review Article

Intensive sweet cherry production on dwarfing rootstocks revisited

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A R T I C L E I N F O

Keywords:
Prunus avium L
'GiSelA 5'
Pruning
Microirrigation
Fertigation
Research imperatives

A B S T R A C T

The long lasting process of intensification of the sweet cherry production has slowed down during the last decades. According to the widespread opinion, this is because the available dwarfing and productive rootstocks, essential for intensification, do not perform well in relatively dry conditions, on poor and light soils: cherry trees tend to overset, stunt and even die. But is this statement correct? The perusal of the available literature cogently shows that the inadequate results come after disregarding the extremely high requirements concerning carbon nutrition, water regime and mineral nutrition of the intensively grown trees. Crucial for success is the reconsideration of traditional management practices. Modern equipment, high and multivalent grower qualification, and strict execution of each operation are imperative. Microirrigation and fertigation are indispensable elements of intensive sweet cherry production. Such technology requires that growers reconsider familiar irrigation and fertilization regimes according to the ecological conditions, the stages of the trees' development, and the scion/rootstock combination. In order to scrutinize all elements of such a precise-agriculture technology, the research should be carried out by large teams of scientists with diverse expertise complementing one another.

1. Introduction

It is generally accepted that the productivity and the economic efficiency of sweet cherry production can be enhanced solely by its intensification with small-size trees and denser orchards (Bujdosó and Hrotkó, 2009; Lang, 2000, 2001b, 2008; Long, 2004, 2009; Predieri et al., 2003; Trefois, 1981). Sweet cherry orchard management has evolved from 1) minimal inputs and very large trees to 2) extensive efforts to contain excessive vigor and promote earlier, heavier cropping to 3) intensive efforts to promote more vigor and to reduce cropping levels on dwarfing rootstocks (Lang, 2008). Weber (2001) and Lang (2001a) defined tree dwarfing as critical for improving labor efficiency for such a labor-intensive fruit crop as fresh market sweet cherries. Whiting (2006) pointed that the next generation sweet cherry orchard can and must yield high quality fruit on a precocious, productive, dwarfing rootstock. According to Ayala and Lang (2017), today's worldwide trends are driven towards controlling tree vigor with dwarfing rootstocks and/or training systems.

For all the rootstock-related high expectations, however, the process of intensification apparently slows down. Many researchers and farmers find the available dwarfing rootstocks inappropriate for relatively dry conditions, on poor and light soils. In that context, present review critically reconsiders the accumulated evidence with regard to an unjust disregarding of existing dwarfing rootstocks, which may delay the progress in cherry production for decades.

2. Potential and holdbacks

Precocity, high yields, fruit quality and efficient resource management (labor, water, fertilizers, pesticides, etc.) are the distinguishing features of the intensive cherry production (Ayala and Lang, 2017; Børve et al., 2017; Lang, 2000; Lang, 2001a,b; Long, 2004, 2009; Long and Kaiser, 2010; Papadopoulos et al., 2017; Whiting, 2006). High-density pedestrian orchards have the potential to double labor efficiency concerning pruning and harvesting. Small trees facilitate the air circulation and the even distribution of light throughout the canopy, which conduce to alleviate biotic stress and to improve fruit quality. Chemical protective sprays are performed with reduced volumes and increased efficiency. The costs of orchard covering systems are lowered. The ability of dwarfing rootstocks to induce significant cropping by the third-fourth year after planting (West et al., 2012) helps to recover orchard establishment costs several years earlier.

However, the benefits of intensive sweet cherry production (ISCP) are accompanied by the risk of larger initial investments and the need for considerable expertise, which is intrinsic to technologically complex production systems (Long, 2009; Robinson et al., 2007; Seavert and Long, 2007). Crucial for success are selection of rootstock and training system to ensure proper balance between fruit and leaves (carbon

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https://doi.org/10.1016/j.scienta.2017.11.009
Received 18 August 2017; Received in revised form 26 October 2017; Accepted 3 November 2017
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nutrition), water supply and mineral nutrition of the trees.

2.1. The rootstock

According to Lang (2001a,b), the potential for genetic control of sweet cherry tree vigor by rootstock selection is more promising than any alternatives. One challenge of the dwarfing rootstocks is their strong tendency to overcrop, resulting in much lower leaf-to-fruit ratio, and subsequently smaller fruit size and suppressed vegetative growth (Andersen et al., 1999; Godini et al., 2008; Lang, 2001a,b; Lang, 2008; Long, 2009; Robinson et al., 2008; Whiting, 2006; Whiting and Lang, 2004; Whiting et al., 2005). Lang (2000), however, notes that this does not appear to be a genetic limitation of the rootstock, but rather a challenge to develop new ways to manage cherry orchards. The results of Whiting and Lang (2004) and Ayala and Lang (2008) demonstrate that large fruit can be grown on small trees through appropriate horticultural management techniques (Ayala and Lang, 2017).

2.2. The carbon nutrition

Canopy establishment, tree training and pruning are key tree fruit management tools governing photoassimilate availability and distribution. Generally, a typical balanced sweet cherry canopy should have about 5.5 leaves per fruit to achieve optimal fruit size and quality. Because of the leaf size variability, however, a source-to-sink ratio of 200 cm^2 leaf area per fruit is thought to be the standard lower limit providing fruit mass of 10–12 g. This is the equivalent of two to three average shoot leaves or nearly an entire set of average spur leaves (Ayala and Lang, 2017; Whiting and Lang, 2004).

The goal for all orchard canopy architectures is to maintain a structure that balances vegetative growth with reproductive potential (Lang, 2005). In vigorous trees the leaf-to-fruit ratio is high and the excessive vegetative growth tends to create shade, thus reducing both precocity and productivity. In that case, summer pruning (after terminal bud set) using thinning cuts will limit the building of storage reserves and reduce the canopy leaf area without stimulating vigorous replacement-shoot development (Ayala and Lang, 2017; Lang, 2008; Long, 2007; Whiting, 2006). Conversely, low-vigor trees are characterized by low leaf-to-fruit ratios, i.e. leaf area is insufficient to provide the reproductive and vegetative growth with adequate photoassimilates. Hence, proper leaf-to-fruit ratio has to be maintained annually by strong, sometimes aggressive dormant season pruning, focused on reducing crop load and increasing vigor (Andersen et al., 1999; Ayala and Lang, 2017; Lang, 2000; Long, 2004, 2007; Robinson et al., 2007). Pruning strategies for trees on productive rootstocks have been developed and described in detail in the specialized literature (Andersen et al., 1999; Lang, 2001a; Lang, 2005; Lang and Ophardt, 2000; Long, 2007; Long et al., 2015; Robinson et al., 2007; Whiting et al., 2005). It is worth noting that, in the case of dwarfing rootstocks, general pruning and crop load management techniques are completely counter to pruning vigorous trees, where the aim is to encourage precocity and productivity in the tree (Lang, 2008; Long, 2007; Whiting, 2006).In many cases, productive rootstocks are associated with alternative training systems: instead of the traditional multiple-leader, open center vase architecture, sweet cherry trees are being trained to Spanish bush, central leader, vertical axis, slender spindle and other high-density production systems (Long, 2009; Long and Kaiser, 2010; Long et al., 2015; Robinson et al., 2007; Whiting et al., 2005).

2.3. The water supply

Proper water regime and adequate mineral nutrition of the trees are indispensable for intensive sweet cherry production. Microirrigation systems are most suitable for that purpose. They are efficient delivery systems in the irrigated orchard and even for a single tree. Irrigation management should be based on solid knowledge of the biological traits of the crop as well as the soil and climatological characteristics of the site. Any failure in managing the agrobiological, agrochemical or engineering aspects may eliminate any advantages of microirrigation or discredit it thoroughly (Bar-Yosef et al., 1988; Koumanov, 2007; Koumanov et al., 1998; Neilsen et al., 1998).

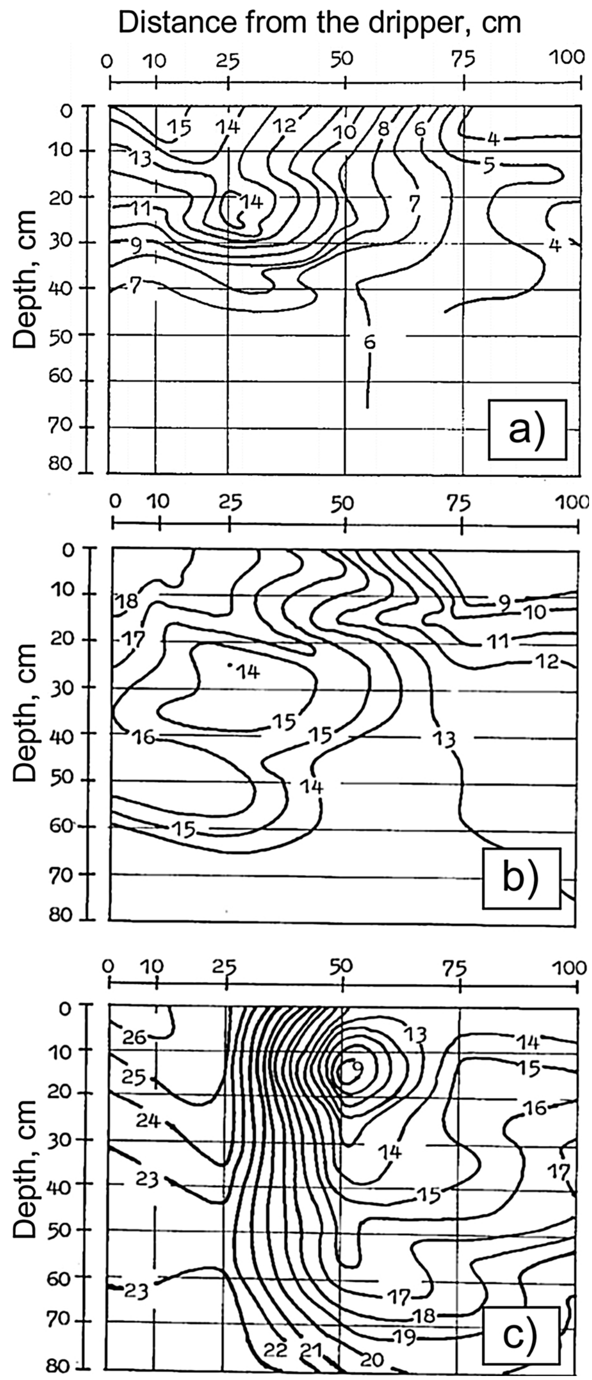

Fig. 1. Fields of soil moisture (kg kg^{-1} × 100) 20 h after same water application rate by drip irrigation in: a) Fluvisol, b) Luvisol, and c) Vertisol; zero denotes dripper position. (Koumanov et al., 1998).

It should be underlined that the microirrigation scheduling and management thoroughly differ from the conventions in the surface irrigation and the sprinkling. According to the widely spread concept, the good irrigation regime should provide maximum utilization of the soil water storage: irrigation is applied when the easily available soil water is depleted in the root zone and the application rate recovers water storage to the field capacity (FC). Microirrigation, however, is realized

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