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Cultivating greenhouse cut roses with bending system

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Abstract

In the light of the global financial crisis, inexpensive and easily applicable cultivation techniques are a necessity for the grower in order to maintain his profit, while old cultivation techniques resulting in low productivity and yield are gradually eliminated. In the present paper the bending cultivation system of greenhouse cut roses is described, with its two key modifications: the 'arching' and the 'high rack' practice. The advantages of this system, that can improve the quality of flower shoots and increase production of cut roses, are described along with the commercial and physiological characteristics of the cut flower shoots and the overall physiology of the rose plant. The impact of shoot bending on the sink-source relationship in rose plants is also assessed. Moreover, the cultivation technique of partially removing the first compound leaf below the harvest cut is described and according to this treatment, an early harvest up to 7-10 days (15-20%) can be achieved. Finally, the effect of the pruning height on the quality and yield is discussed. The above mentioned cultivation techniques can be very easily applied with minimum cost, especially in cases when harvest programming for high-demand seasons is important.

Key words: Arching, bending, cultivation, flower, high rack, hydroponics, Rosa, shoot

Introduction

Cut flower production is a very important section of the commercial greenhouse floriculture. It covers almost 25% of the floral industry with roses on the top of the list. World's leading flower trading centre is the Dutch flower auctions in Aalsmeer in The Netherlands, where only high quality flowers are sold (Steen, 2010). Usually, cut roses are of high demand during winter and especially on Valentine's day (14th February). High quality standards are applied during trading and even the slightest disorder (more than 5%) can result in lower category (UN/ECE, 1994), eventually leading to lower profit for the grower. During the last years, the global economic crisis reduced the demand for flowers, especially in Southern Europe. In these areas, there are still greenhouses applying old cultivation systems. In addition, expensive plant growth regulators are needed to extend the postharvest flower life of cut roses (Chamani *et al.*, 2005). Thus, there is a need now more than ever, for inexpensive and easy to apply cultivation techniques that can improve the quality and increase the yield of cut roses and help the grower to program harvesting, in order to maintain or even to increase its profit.

According to Mosher and Turner (2000), greenhouse roses have three distinct types of shoots: i) the flower shoots, that bear one or more terminal flowers and are the commercially important parts of the plant, ii) the canopy shoots, that form the photosynthetic canopy and the framework of the plant – these shoots sprout from axillary buds on the primary shoot (Kool and van de Pol, 1993) and provide with carbohydrates to the growing parts of the plant, and iii) the non-flowering blind or barren shoots that are flower shoots that dropped the terminal flower during the first stages of their formation. The blind shoots have no commercial value (Zieslin *et al.*, 1973; Zieslin and Halevy, 1975). The purpose of this review is to highlight the advantages of the bending cultivation system with its two key modifications (arching and high rack) and to promote inexpensive and easily applicable cultivation techniques such as the partial removal of the compound leaf, that can help the grower to maintain (and if possible to increase) its profit.

Bending rose shoots: the arching and the high rack cultivation systems: In the traditional cultivation system of roses, the plants are grown in rows (single, double or quadruple) across the greenhouse and a tall hedgerow foliage canopy is formed in order to capture light for photosynthesis. However, a part of the foliage canopy is sacrificed in the end, during harvesting. During the 80's the cultivation technique of bending the shoots in greenhouse cut roses was developed by Japanese growers (Gonzalez-Real *et al.*, 2007). This system is always combined with hydroponics (*e.g.* rockwool or coir as substrate in open or closed systems) so that high quality of cut flowers may be produced. In the bending cultivation system, rose plants are also planted in rows, but the canopy height is low. Main characteristic of this system is that the blind, weak or early flowering shoots are bent low to the ground. The bending of shoots is done all year round, towards the outside of the bed and these shoots form the photosynthetic, almost horizontal, canopy of the plant; while the stronger basal shoots arising subsequently from the crown will be harvested later as cut flowers. Thus, a heterogeneous canopy structure is formed by upright flower shoots and horizontally bent canopy shoots, which will fill the space between the plants and between the rows (Gonzalez-Real *et al.*, 2007). This way, no leaf area is sacrificed and the light is intercepted by basal shoots that emerge from or near the primary shoot (Kim and Lieth, 2004). In addition, the flowers from the bent shoots are removed, as they can affect the sink-source and the water relations in the plant and eventually the photosynthesis rate, transpiration and stomatal conductance (Kim *et al.*, 2004).

Advantages of bending: Bending has many benefits for the cut rose production. With this cultivation system better quality of cut flowers is achieved, since longer, healthier and upright vigorous flower shoots are formed. Also, the rose plants are smaller and harvesting is much easier (Kool and Lenssen, 1997). The bending cultivation system may alter the structure of the plant canopy by the selective removal of short shoots during harvests (Kim and Lieth, 2004). In addition, it may affect the water relationships inside the plant by obstructing water transportation and modify the sink-source relations between leaves and flower buds on bent shoots which may further lead to changes in gas exchange rates *e.g.* photosynthesis and transpiration (Kim *et al.*, 2004). By bending rose shoots the growth and development of the healthy long shoots is enhanced. These shoots play a key role in the structure of the plant and eventually in flower formation (Zieslin and Mor, 1981a,b; Marcelis-van Acker, 1994; Kool and Lenssen, 1997; Le Bris *et al.*, 1998). A carbohydrate movement from canopy leaves to flower shoots is initiated, which improves the quality and increases the longevity of the cut flowers (Markelis van Acker, 1994; Kool *et al.*, 1997; Sarkka and Rita, 1999; Van Labeke *et al.*, 2001). Another advantage of the bending system is that better cooling of the glasshouse is achieved due to the greater leaf surface formed. This is very important, especially under hot summer conditions, where rose plants may be under stress that negatively affects the growth and quality of the flower shoots formed (Cline, 1991; Gonzalez-Real *et al.*, 2007). Finally, bending can increase flower development rate, stem diameter and weight, leaf area index (LAI), cross-sectional area of basal shoots and dry matter of the formed shoots (Kool and Lenssen, 1997; Kim and Lieth, 2004). After the harvest, the canopy foliage will be the main source of assimilates for the new growing shoots (Matloobi *et al.*, 2008).

Restrictions: However, with the shoot-bending technique the period up to the first harvest is longer, more time is needed between successive harvests, fewer flower shoots per plant are formed and the plant density is smaller, compared with the traditional technique, since more space is needed inside the greenhouse (Ohkawa and Suematsu, 1999; Sarkka and Rita, 1999; Van Labeke *et al.*, 2001; Sarkka and Eriksson, 2003; Kim and Lieth, 2004). Nevertheless, increasing plant density may alleviate the problem, since more plants per m^2 can lead to higher yield (De Vries and Dubois, 1983; Sarkka and Rita, 1999; Mortensen *et al.*, 2001; Doi *et al.*, 2009). Though the use of supplementary light may boost the number of flower shoots by up to 60% and at the same time reduce the blind shoots (Bredmose, 1993), the extra cost renders its use economically feasible only at northern latitudes where the dailylight increment is inadequate.

Sink-source relationship: Shinjii *et al.* (2009) found that the bending practice in roses is so productive because of the favorable sink-source relationship at the bent area of the shoot, where carbohydrates accumulate, and are attracted and consumed by the terminal flower (Kohl and Smith, 1970; Mor and Halevy, 1979; Jiao *et al.*, 1989). However, the various cultivation techniques applied to the greenhouse rose production, such as pruning, pinching, bending, may affect the sink-source relationship and the gas exchange status of the canopy unfavorable (Heichel and Turner, 1983; Kim *et al.*, 2004; Medhurst *et al.*, 2006; Matloobi *et al.*, 2009). Pinching, in particular, affects the final length of the flower shoot and can break the dormancy of the lower axillary buds, releasing them from the inhibitory effect of apical dominance (Zieslin *et al.*, 1976; Sae *et al.*, 2009). These buds during development will also attract carbohydrates from the lower parts and act as sink at the expense of the flower shoots (Zieslin *et al.*, 1975; Matloobi *et al.*, 2009). Nevertheless, the most important changes in the sink-source relationship take place after the harvest of the flower shoots, when the leaves of the canopy turn into a very strong source of carbohydrates and the newly formed flower shoots a very strong sink, as 97% of the photosyntetic producs are transported; while when their leaves are fully developed they also photosynthesize and produce carbohydrates (Mor and Halevy, 1979; Baille *et al.*, 2006; Matloobi *et al.*, 2009).

Bending shoots according to the arching and the high rack techniques: Bending the non productive shoots is an innovative cultivation method preferred in the greenhouse cut rose production (Getachew *et al.*, 2012). It can be applied with two main modifications: the 'arching' and the 'high rack' technique. The main difference between them is the height at witch that bending will take place: in the arching system, the bent shoots are located at the base of the plant (Fig. 1), while in the high rack system they are located at a height of about 10-50 cm from the base (Fig. 2 and Fig. 3), causing the formation of vigorous long and healthy new shoots. This way, commercially acceptable flower shoots will come up from the center of the plant and get harvested (Sarkka and Eriksson, 2003; Shinjii *et al.*, 2009). The

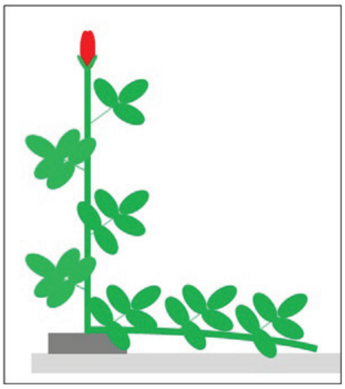

Fig. 1. According to the arching cultivation system, the shoots are bent at the base of the rose plant.

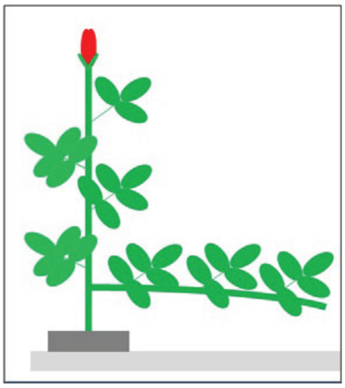

Fig. 2. According to the high rack cultivation system, the shoots are bent at a height of 10-50cm from the base of the rose plant.

Fig. 3. Bending a rose shoot according to the high rack cultivation system. The bending was done about 10 cm from the base of the plant.

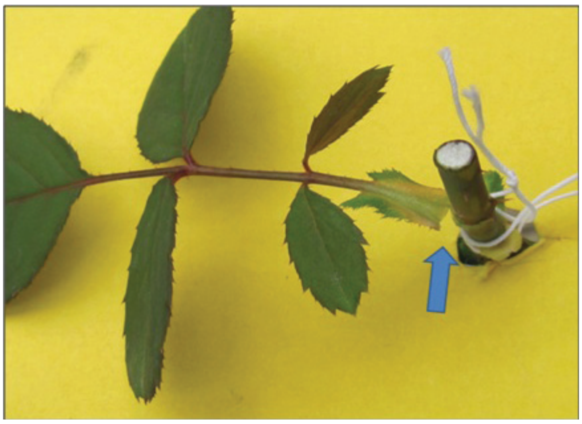

Fig. 4. Partial removal of the compound leaf after harvesting. Arrow indicate the compound leaf that is still semi-attached to the shoot.

Fig. 5. Partial removal of the compound leaf after harvesting. Arrow indicate the axillary bud that is visible after the removal (white circle).

technique of shoot bending according to the arching cultivation system results in longer flower shoots of higher quality and fewer blind shoots (Ohkawa and Suematsu, 1999; Sarkka and Rita, 1999; Kim and Lieth, 2004). However, comparing the two systems, the high rack system should be preferred instead. With the arching system, flower shoots with higher stem length, stem weight and weight/length ratio than the high rack are formed. On the contrary, with the high rack the length and the weight of the flower shoots that are formed is smaller, but there are more

Fig. 6. The axillary bud after the partial removal of the compound leaf. Sprouting of the bud takes place about 7-10 days (15-20 %) earlier than the untreated.

flower shoots per plant. These flower shoots are commercially acceptable and hence higher yield may be achieved. (Kajihara and Katsutani, 2003; Kajihara and Katsutani, 2008; Szmagara *et al.*, 2016).

Speed up harvest- the partial removal of the compound leaf: The next important step after the removal of the flower shoot during harvest is its replacement with a new shoot sprouting from the uppermost axillary bud below the cut. Since, this bud is under the inhibitory influence of the subtending compound leaf (Le Bris *et al.*, 1999), a technique of the partial removal of that leaf is being applied so that the bud is partly relieved from the inhibition although at the same time retains part of the photosynthates coming from the leaflet blades (Figs. 4-6).

In order to provide carbohydrates to the leaf-bud, the compound leaf is not fully removed. This technique forces the axillary bud to grow 7-10 days (15-20 %) earlier, allowing less time between harvests and has no impact on quality and postharvest life of the cut flower shoots (Tsanakas, 2010). The technique of partially removing the compound leaf can be applied easily in order to program the harvest for high demand periods or in order to reduce the time between harvests and eventually to reduce the cost of production. However, this technique is not applicable to all rose cultivars and sometimes it is substituted by the application of benzyladenine-lanonin paste (up to 0.25 %) to the cut surface in order to break the dormancy of the axillary bud, as in the case of 'Blue Moon' (Ohkawa, 1984; Bredmose *et al.*, 2005).

Pruning in the bending system: Roses are pruned with harvesting, to program the next harvests or in order to control the growth of the canopy and to allow other cultivation practices (Zieslin *et al.*, 1975). The pruning height affects the production, as it controls the length of the flower shoot and the number of the cut roses per plant (Zieslin, 1981). In particular, it has been found that harvesting right above the 2nd compound (five-leaflet) leaf from the base, leads to the formation of more and longer flower shoots compared with harvesting at a higher point or from the base of the flower shoot (Zieslin, 1981; Shimomura *et al.*, 2003). Moreover, harvesting lower than the second leaf reduces flower shoot production because greater potentially photosynthetic surface is removed (Zieslin and Mor, 1981c). Finally, pruning allows plants to use light more efficiently, which affects favorably the quantum yield of Photosystem II (PII) as chlorophyll fluorescence measurements have shown (Calatayud *et al.*, 2008).

Expanding the cultivation of cut roses with modern inexpensive cultivation techniques is essential for the grower in order to maintain or even to increase his income. Further research is needed in order to fully elucidate the hormonal, biochemical and molecular pathways behind the sink-source relationship and how they affect and are affected by the shoot bending technique. The investigation of the mechanics and physiological principles involved in the partial removal of the compound leaf and pruning height would be of equal interest. A systems biology approach (*e.g.* transcriptomics) could also be attempted in order to highlight the genes that are differentially expressed and the gene networks formed; while proteomic analyses can help to identify proteins that play key roles in the hormonal biosynthesis and are responsible for the control and regulation of the sink-source ratio in the plant. All the above could lead to the development of new products that can affect the hormonal status of the plant and potentially to increase yield. Finally, the establishment of a targeted breeding program, based on research results, as outlined above, elucidating molecular and biological pathways, could lead to the development of new cultivars with desirable commercial qualitative characteristics and increased yield.

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