Scientia Horticulturae 225 (2017) 204–212

Contents lists available at ScienceDirect

Scientia Horticulturae

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

# Effects of cutting position of rose rootstock cultivars on rooting and its relationship with mineral nutrient content and endogenous carbohydrates

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ARTICLE INFO

*Keywords:*
Mineral nutrient
Carbohydrates
Natal briar
Rosa progress
Position

ABSTRACT

The stem cuttings for propagating rose rootstocks are usually obtained from the shoots on the mother stock irrespective of the position. However, adventitious root formation may be influenced by the cutting position. We therefore determined the effects of cutting position of rose rootstocks on rooting and its relationship with endogenous mineral nutrient (Nitrogen, zinc, manganese and iron) and carbohydrate (glucose, fructose, sucrose and total soluble sugars) contents. Cuttings were obtained from three positions; top, middle and bottom, from two rootstocks, 'Rosa progress' and 'Natal briar' and planted under greenhouse conditions in a randomized complete block design replicated 3 times. Carbohydrates and mineral nutrient content in the cuttings were determined at 0, 3 and 7 days after planting (DAP). The root number, total root length, shoot height, leaf number and percentage survival increased acropetally. The zinc and manganese content was higher in top position of 'Natal briar' and middle position in 'Rosa progress' than in bottom position cuttings of both rootstocks and this positively correlated to root number in both rootstocks. The nitrogen content increased acropetally in 'Natal briar' and was positively correlated to root number. Top position cuttings recorded higher sucrose content in both rootstocks. There was a positive correlation between sucrose content and the number of roots at 7 DAP in 'Natal briar' and in 'Rosa progress' at 3 and 7 DAP. There was also a positive correlation between root number and total sugar at 0 and 7 DAP in 'Rosa progress' and 7 DAP in 'Natal briar'. The results of this study demonstrate the importance of endogenous mineral nutrient and soluble sugar contents of the stem cutting for the rooting process in *Rosa hybrida* rootstocks and apical cuttings should be used to multiply the two rootstocks.

## 1. Introduction

Rose rootstocks vary in terms of rooting, yield and quality of grafted scion. Studies have shown that the total number of harvestable stems/m$^2$ of rose variety 'Inca' grafted on the rootstock 'Rosa progress' was higher than on 'Natal briar' (Otiende et al., 2015). However, the rootstock 'Rosa progress' is rarely used due to its low rooting ability compared to 'Natal briar' that represents 60–70% of the world-wide cultivated surface of grafted roses (Gerardo, 2007) due to its faster rooting ability. The stem cuttings for propagating rose rootstocks are obtained from either the horizontal or vertical shoots on the mother stock (Gudin and Crespel, 2008) irrespective of the position. Higher flower yields have been obtained from vertical cuttings than horizontal cuttings due to better ratio of plants/m$^2$ to the number of axillary buds breaking per plant (Gudin and Crespel, 2008). Adventitious root formation may be influenced by the cutting position on the shoot (Bredmose et al., 2004; Hambrick et al., 1991; Hansen and Kristensen, 2006) due to a number of endogenous and exogenous factors (Hartmann et al., 2011). Some of these factors include changes in physiological and biochemical quality of mother plants, in addition to their genetic make-up (Osterc, 2009). Endogenous auxins, carbohydrate content, mineral nutrients and other biochemical components, such as phenolics that could act as rooting cofactors or auxin transport modulators, are transferred from the stock plants to the propagules when the cutting is severed. Mineral nutrient content, especially nitrogen, and carbohydrate status of the cuttings have a great impact on post harvest performance of plants (Druege et al., 2000), especially in the formation of adventitious roots. Carbohydrates contribute to the formation of adventitious roots by supplying energy and carbon necessary for cell division, establishment of the new root meristems and root formation itself (da Costa et al., 2013). Several studies have shown that the initial carbohydrate content of the cutting can be enough to supply the energy reserves throughout the rooting period (Husen, 2008). Druege et al. (2004) and Rapaka et al. (2005) reported that sugar, particularly the sucrose level in the leaves at the

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http://dx.doi.org/10.1016/j.scienta.2017.07.009
Received 3 March 2017; Received in revised form 2 July 2017; Accepted 5 July 2017
Available online 13 July 2017
0304-4238/ 

time of planting has an important role for subsequent adventitious root formation in pelargonium cuttings by supplying the sugars to the stem bases where rooting occurs. However, there is evidence that carbohydrate allocation and distribution within the cutting could be more important than the content itself (Druege et al., 2000; Druege, 2009; Ruedell et al., 2013). The supply of leaf derived carbohydrates may also provide co-delivery of other components required for rooting (Druege et al., 2000) especially with regard to the vascular transport of auxins (Baker, 2000).

Mineral nutrient composition of the cuttings, especially micronutrients such as zinc, iron, manganese and boron, play key positive roles in determining root morphogenesis (Assis, 2001; Rejman et al., 2002). Zinc is required for the biosynthesis of the amino acid tryptophan, main auxin precursor (Marschner, 1995). Zinc stimulation on rooting has been reported in mother vines of Dog ridge rootstock (Somkuwar et al., 2013). Manganese and iron are co-factors and structural components of peroxidases and can therefore affect auxin (Indole-acetic acid) catabolism enzymes (Campa, 1991; Fang and Kao, 2000). Although nitrogen is thought to be necessary for root initiation because it is essential in synthesis of nucleic acid and protein which are necessary for root differentiation (Blazich, 1988), the relationship between nitrogen and adventitious root formation remains controversial. For instance, work on *Rosa multiflora* (Hambrick et al., 1991) and bitter almond (Kasim et al., 2009) showed a negative relationship between nitrogen concentration and rooting percentage with hardwood cuttings. On the other hand, high nitrogen supply to stock plants in herbaceous cuttings has been shown to strongly promote adventitious root formation (Zerche and Druege, 2009). The mineral nutrients may act synergistically or additively with hormones, especially auxins by protecting them against oxidation. They may also affect certain enzymes that are active during root formation or stimulate the transport of exogenous auxins in plant tissues. These mechanisms may differ, even within the same species depending on the differences in the mineral nutrient content in plant parts at the time they are harvested for propagation (Szydło and Pacholczak, 2004).

The endogenous factors of the nodal shoot of the parent shoot and variation along the shoot from the base to the apex have been shown to influence root formation. For instance, Hambrick et al. (1991), Keeley et al. (2004) and Soonhuae and Limpiyaprapant (1996) attributed the higher rooting percentage from the bottom position cuttings of *Rosa multiflora,* 'Norton' grape vine rootstock and *Dipterocarpus alatus,* respectively, to high content of storage carbohydrates. However, apical cuttings may have low storage carbohydrates that could limit rooting of such cuttings (Lyon and Kimuin, 1997). High concentration of endogenous root promoting substances, such as auxins in the apical cuttings which arise from the terminal buds, increases rooting ability (Tchoundjeu and Leakey, 2001; Choummaravong, 1998; Hartman and Kester 1983).

There is however paucity of information on rooting of rose rootstocks in relation to endogenous factors of the cutting position. The objective of this study was therefore to evaluate the rooting of *Rosa hybrida* rootstocks and its relation to endogenous mineral nutrient and carbohydrate contents of different stem cutting positions.

## 2. Material and methods

### 2.1. Experimental material and treatments

The experiment was laid out in a randomized complete block design and replicated 3 times. The treatments consisted of 3 cutting positions (top, middle and bottom) in a factorial combination with 2 rootstock cultivars ('Natal briar' and 'Rosa progress'). Cuttings of *Rosa hybrida* 'Rosa progress' and 'Natal briar' were harvested from 3 month-old mother stock plants maintained at Finlays Flowers Company in Kericho, Kenya. The vertical shoots, each measuring 150 cm long, were divided into three equal positions of top, middle and bottom (Fig. 1). Stem


**Fig. 1.** Cutting positions of *Rosa hybrida* rootstock.

cuttings each measuring 5 cm with one 5- 7 leaflet leaves and an auxillary bud were obtained from each position. The excess leaflets on each stem cutting were removed to leave only 5-leaflets in order to reduce water loss. Each treatment combination had 40 stem cuttings each planted in a pot (7 cm × 7 cm × 6.5 cm) per replicate. Clean sterile coccus (SL (PVT), Sri Lanka, supplied by Hardi Kenya) with a pH of 6.5-7.5 and electrical conductivity of 0.18–0.24 mS/cm was used as a media. 20 plants were used for the determination of growth parameters and the remaining 20 plants for analysis of soluble sugars and mineral nutrients. The media had the following initial mineral content; 15 μg/g of iron, 5 μg/g of manganese, 6 μg/g of zinc and 6 mg/g of nitrogen.

### 2.2. Greenhouse conditions

The following conditions were maintained in the greenhouse in the first 2 weeks after planting and then gradually reduced to harden the plants: a relative humidity of ≥90%, temperatures of 30–35 °C at day time and 22–24 °C at night and misting cycles of 10–30 min at day time and 1–2 h at night. The minimum light intensity was maintained at 300 W/$m^2$ throughout the growing period. A thermal screen was applied to control the light intensity. Fertigation started 14 DAP and every 4 days thereafter depending on measured EC. The fertilizers used were $Ca(NO_3)_2$, $KNO_3$, $MgSO_4$, iron chelates, $MnSO_4$, $ZnSO_4$,$BNa_3O_3$, $Na_2MoO_4$ and $CuSO_4$ from Amiran, Kenya. The EC of the media before fertigation was 0.3 mS/cm and that of fertilizer 1.3–1.5 mS/cm.

### 2.3. Data collection

Ten plants per treatment combination were sampled to determine the shoot height and leaf number, while 6 plants were sampled for determination of shoot weights and root parameters (root number, total root length and root dry weight (RDW)). Rooting and percentage survival were determined at 30 DAP. The rooting percentage was determined by counting the number of plants that had formed roots with respect to the total number of cuttings planted per treatment combination. Percentage survival was determined by counting the number of plants having both roots and shoot with respect to the total number of cuttings planted per treatment combination.

### 2.4. Analysis of mineral nutrients and carbohydrates

Twenty stem cuttings planted alongside each treatment combination were used for the determination of chemical constituents at the rooting zone of cuttings. The stem bases (1 cm) of six unrooted and rooted cuttings were randomly collected on the day of planting (day 0), 3 and 7 DAP then stored at −20 °C to preclude enzymatic reactions. The samples per treatment combination were ground to fine particles in a Wiley mill (Moullnex AR II, China) to homogenize them and then 5 g of each sample used for determination of soluble carbohydrates (fructose, glucose and sucrose), nitrogen, zinc, iron and manganese contents.

Nitrogen was analysed by Kjeldahl procedure (Cline et al., 1986)