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Effect of hydrogen cyanamide, mineral oil and thidiazuron in combination with tip pruning on bud break, shoot growth and yield in 'Bourjasotte Noire', 'Col de Damme Noire' and 'Noire de Caromb' figs

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ABSTRACT

Commercial fig production is relatively new to the Mediterranean-type climate Western Cape Province of South Africa. A lack of lateral branch development impedes tree structure development and therefore adequate yields of quality fruit. The chemical rest breaking agents, Lift® (thidiazuron 3 g L^{-1}) at 6%, Dormex® (hydrogen cyanamide, 520 g L^{-1}) at 4%, mineral oil at 4% and a combination of mineral oil and Dormex® at 2% each were evaluated in a split plot design in combination with tip-pruning vs. no-pruning to overcome apical dominance and increase complexity (Experiment 1). During the 2008/2009 season, an additional investigation was conducted to evaluate the use of thidiazuron and hydrogen cyanamide for harvest scheduling (Experiment 2). Dormex® at 3% and Lift® at 6%, were applied to dormant trees on 30 June 2008, 3 August 2008, 15 August 2008 or 30 August 2008. In general, Lift® can be used to increase the number of buds breaking in 'Bourjasotte Noire' and 'Col de Damme Noire', while tip pruning decreased bud break with a resultant increase in shoot length. Dormex® and oil combined decreased bud break in these two cultivars but was effective on 'Noire de Caromb'. Where bud break was increased the resultant $N+1$ shoot length was decreased. RBAs increased the number of fruit in both the breba and main crop of 'Noire de Caromb', but decreased fruit size of the breba crop. Our data are not conclusive as to what the reason for low lateral bud break might be but leans towards strong AD in seasons with 400 Utah CU or more, but might include some delayed foliation response in seasons with less than 200 Utah CH.

1. Introduction

Commercial fig production is relatively new to the Mediterranean-type climate Western Cape Province of South Africa. Local producers ascribe inadequate yields of high-quality fruit to a lack of lateral branch development that impedes tree structure development and decreases the number of potential bearing units. Poor lateral branch development could be due to a lack of winter chilling to overcome endodormancy and therefore low bud break percentages or it could be due to strong apical dominance (AD) inhibiting lateral bud break or a combination of both.

Fruit tree cultivars have specific genetic chilling requirements to break endodormancy (Erez, 1995). The most characteristic growth response of trees that received insufficient chilling to overcome endodormancy is a marked reduction in lateral bud break, as is well documented for temperate fruit trees grown in warm winter regions (Erez, 1987). Fig cultivars generally have low chilling requirements (Flaishman et al., 2008; Aksoy, personal communication), but it is unknown what the chill requirement of the three fig cultivars Bourjasotte Noire, Col de Damme Noire and Noire de Caromb is that were introduced to South Africa. Figs can be grown in regions with little winter chilling, but bud break might be erratic and thereby compromise yield (Flaishman et al., 2008).

Terminal buds inhibit the sprouting of lateral buds through apical dominance (AD) (Saure, 1985; Naor et al., 2003). After alleviation of endodormancy by exposure to chilling, cytokinins (CKs) have the ability to induce bud break (Faust et al., 1997) resulting either in uniform outgrowth of all buds or in acrotony (Crabbe, 1994), depending on the strength of the AD generated by the terminal bud and the receptiveness of lateral buds to the dominance effect (Faust et al., 1995). According to Aksoy (personal communication), many fig cultivars display strong AD in that only the terminal bud and the adjacent 1–2 buds break. Of the three cultivars planted in South Africa, two ('Bourjasotte Noire' and 'Col de Damme Noire') display strong AD, while 'Noire de Caromb' displays moderate AD (Gerber et al., 2010).

Various methods have been used to supplement chilling and to decrease AD in fruit trees. Hydrogen cyanamide (HC), mineral oil and thidiazuron (TDZ) are the restbreaking agents that are most

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commonly used to induce bud break in various deciduous fruit crops (Erez, 1987). Although no reports were found for the use of mineral oil and TDZ, HC has been used to manipulate bud break in fig. Rates of 0.5–2.5% HC caused early, uniform bud break in fig (Shulman et al., 1986). In Israel, a rate of 3% Dormex® has been successfully used in fig to force bud break and schedule fruit ripening over the season (Yablowitz et al., 1998). This could therefore potentially enable growers to schedule harvest during more lucrative marketing windows. The earliest treatment date was 15 December (NH), which resulted in bud break from 1 to 10 January. Lateral bud break can also be stimulated by heading cuts (Oosthuyse et al., 1992).

The first aim of this research was to establish whether RBAs in combination with tip-pruning can increase bud break in 'Bourjasotte Noire', 'Col de Damme Noire' and 'Noire de Caromb'. Whether the increased complexity due to increased lateral bud break would translate into an increase in yield, was established in 'Bourjasotte Noire'. The second aim of this research was to evaluate the effect of timing of RBA application and the potential effect on harvest scheduling by using RBAs to advance bud break.

2. Materials and methods

2.1. Plant material and site description

'Bourjasotte Noire', 'Col de Damme Noire' and 'Noire de Caromb' in commercial orchards in the Breede River valley (Mediterranean-type climate; 33°34′S, 19°16′E, 217 m) near Worcester in the Western Cape, South Africa were used in these experiments. The area accumulated 400.5 Utah chill units from 1 May 2007 until 31 August 2007 and 171.0 Utah chill units from 1 May 2008 until 31 August 2008 (Richardson et al., 1974). The trees, on own roots, were planted in October 2004 at a spacing of 4 m × 3 m. Experiment 1 was conducted on 'Bourjasotte Noire' and 'Col de Damme Noire' during the 2007/2008 season while in the 2008/2009 season all three cultivars were included. Experiment 2 was conducted on all three cultivars during the 2008/2009 season.

2.2. Experimental design and treatments

Experiment 1 consisted of a split-plot design with 5 × 2 treatments, replicated five times on 'Bourjasotte Noire' and ten times on 'Col de Damme Noire' during 2007/2008 and six times on all three cultivars during 2008/2009 in randomised, complete blocks. The main treatments were as follows: (1) an untreated control; (2) 4% Dormex® (HC); (3) 2% Dormex® plus 2% BudBreak® (mineral oil); (4) 4% BudBreak®; and (5) 6% Lift® (TDZ). The sub-treatments were a pruning treatment that entailed removing the apical ±2.5 cm of shoots (tip-pruning) or an unpruned control and was randomly applied to all shoots on one of the two trees in each subplot. Treatments were applied when terminal buds reached green tip (7/09/2007 and 11/09/2008, respectively).

Experiment 2 was conducted during the 2008/2009 season as an augmented factorial, randomised complete block design using nine treatments, replicated six times, using single tree plots. Treatments consisted of an untreated control and two RBAs, TDZ (Lift®, 6%) and HC (Dormex®, 3%), that were applied on four different dates ((30/06/2008 (mid winter), 3/08/2008, 15/08/2008 or 30/08/2008 (bud swell)).

In both trials, RBAs were applied with a motorised spray gun until run-off. Three relatively uniform dormant shoots per tree were selected, tagged and evaluated as described in Section 2.3. These shoots varied in length between cultivars as tree vigour varied.

2.3. Data collection

2.3.1. Experiment 1

The initial number of buds breaking on tagged shoots was counted on 5/10/2007 and 10/10/2008 in both 'Bourjasotte Noire' and 'Col de Damme Noire', and 10/10/2008 on 'Noire de Caromb'. After shoot growth cessation in autumn and commercial harvest the following data were collected: final bud break, number and length of new ($N+1$) shoots, basal diameter of N tagged shoots, number of fruit and fruit diameter.

2.3.2. Experiment 2

The three selected one-year-old shoots (N shoots) per tree were evaluated in terms of the following parameters: bud break percentage, shoot length and basal diameter, total number of vegetative buds, bud break over time, number of new shoots, new shoot length, number of fruit, and the weight, diameter and harvest dates of individual fruit.

2.4. Statistical analysis

Date were analysed using the general linear models procedure of SAS version 9.1.3 SP2 (SAS Institute, Cary, N.C., 2004). Where appropriate, single degree of freedom, orthogonal, polynomial contrasts were fitted and/or covariate analysis performed.

3. Results

3.1. Experiment 1

3.1.1. Bourjasotte Noire

In 'Bourjasotte Noire' there were significant differences between rest breaking treatments in the initial number of buds breaking per N shoot during the 2007/2008 and 2008/2009 seasons, with Lift® inducing a higher number of buds to break when compared to the control and all other RBA treatments (Tables 1 and 2). In both seasons Dormex® in combination with oil decreased initial bud break compared to the control. Oil and Dormex/oil decreased bud break compared to all other treatments during 2008/2009. A higher number of buds broke initially on shoots that were left unpruned during both seasons. There were no significant differences in the final number of buds breaking in 'Bourjasotte Noire' during the 2007/2008 season, yet during the 2008/2009 season, both the Lift® and no-tipping resulted in higher numbers of buds breaking whereas Dormex® in combination with oil decreased final bud break, similar to the initial bud break results (Tables 1 and 2).

RBAs had no effect on the average $N+1$ shoot length in 'Bourjasotte Noire' during the first season, while the combination of Dormex® and oil resulted in a higher average $N+1$ shoot length than the other RBAs during the second season, although not significantly different from the control. Lift® decreased the average $N+1$ shoot length compared to the control and the Dormex® and oil combination. During both seasons, tip-pruning caused an increase in the average $N+1$ shoot length. There were no significant differences in total new shoot growth or the number of $N+1$ shoots longer than 5 cm in either season (Tables 1 and 2).

During the 2007/2008 season, there were no significant differences in 'Bourjasotte Noire' between treatments in the number of fruit produced per N shoot, while during the 2008/2009 season, tip-pruning decreased the number of fruit per N shoot (Tables 1 and 2). There were no significant differences in the number of fruit per $N+1$ shoot in the first season (Table 1), whereas the combination of Dormex® and oil produced $N+1$ shoots with more fruit in comparison to the other treatments in 2008/2009, while the pruning treatment again had no significant effect on yield (Table 2). None of