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The effects of different tip-pruning times on flowering, yield, and maturity of two mango cultivars in subtropical climate of Northern Territory (Katherine region) from Australia

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ABSTRACT

The present study aimed to take advantage of the progressively cooler weather in the Katherine regions (Northern Australia) that occurs from April to July to investigate the effects of night temperatures on developing mango buds. The experiment was conducted using seven-year-old commercial mango cultivars Honey Gold and Calypso (B74) grown in separate location sites. Tip-pruning treatments were applied to three replicate single trees at four weekly intervals for five months. All branches around the canopy were pruned 10 cm approximately above the last internode. The length of new vegetative flush growth for 20 randomly selected pruned branches on each tree was recorded on a weekly basis. During experiment from April to November (harvesting time) climate data including temperature (mean, max, min), chill and heat sums, chill and heat cumulative (cum), and relative humidity (RH %) were recorded hourly to find their impact on growth characteristics such as vegetative bud growth, flowering time, canopy flowering (%), inflorescence length, number of fruits/tree, and fruit maturity. Pruned trees produced more inflorescence when the axillary bud below cutting point received over 300 h chill cum < 20 °C over the first three to four weeks after tip pruning. Fruit maturity data indicated that tip pruning could be used as an agrotechnical tool to delay harvesting time for the studied mango cultivars. The result showed that the combination of cool weather (< 20 °C) and tip pruning is a promising alternative strategy for sustainable mango production in the region, when is applied in May, June, and the first two weeks of July.

1. Introduction

Controlling growth and stimulating the formation of vegetative and reproductive buds is a common task in fruit trees management achieved through canopy pruning. In mango tree, removing diseased branches, defining tree structure, inducing early flowering, increasing second-cycle yield, and improving fruit quality have been associated by pruning (Yeshitela et al., 2004; Davenport, 2006). As well as, the flower manipulating produce out-of-season fruits, manage production line, and improve productivity in mango tree (Ramírez and Davenport, 2010).

In tropical conditions, old slushes respond to floral stimulators through sending signal to buds. Experiments in Colombia indicated that the age of the last flush is the primary factor regulating flowering in mango in the tropics (Ramírez and Davenport, 2010; Ramírez et al., 2010). Tip pruning is an ideal way to synchronize vegetative flush events in mango. In the same way, potassium nitrate (KNO_3) has been applied to stimulate flowering in adequate mature stems (Davenport, 2000, 2003, 2006, and 2007). In Colombia, tip pruning and foliar KNO_3 are two practical methodologies that are applied to induce synchronous flowering (Ramírez et al., 2010).

Cold temperatures are one of the main factors in mango flower induction under subtropical conditions, where flower development happens after or during exposure to floral inductive cool temperatures (Davenport, 2009). In this sense, mango grown in subtropics rely on low temperature for floral induction than trees grown in tropical climates (Davenport, 2009). Removing of the apical bud on terminal shoots in mango just prior or during the flowering period induces the development of normally reserved axillary buds adjacent to the point of cutting (Reece et al., 1946). These buds typically develop as inflorescences, if pruning is performed during cool weather (Issarakraisila et al., 1991).

Katherine is a well-known area in Northern Territory of Australia for mango production, and around 20% of mango with a value over $40 million (AUD) in Australia are produced in Katherine region.

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Kensington Pride (KP), Calypso (B74), Honey Gold, and R2E2 are the most common mango varieties that are grown in this region (NT Farmers, 2015). Katherine has a sub-tropical climate, with the distinct wet season (December to March) and dry season (April to November). Annual rainfall is around 1000 mm and mainly received in December to March. Average temperatures range from 25 °C to 35 °C, with an occasional 40 °C during November and December usually accompanied by very high humidity. During April to July, temperature regularly drop down below 20 °C overnight. Cold weather and synchronization of vegetative growth are two main key factors of mango flowering in subtropics. Synchronization allows all the stems in the canopy to be at the same physiological stage of maturity (Davenport, 2000). Synchronized growth is achieved by tip-pruning of all terminal stems on trees (Davenport, 2003, 2006). However, tip-pruning not only produces a uniform flush of vegetative growth through the canopy, but also eliminates flower-inhibiting factors in stems resulting from the previous season's flowering and fruiting panicles (Davenport, 2000, 2009).

Researches have indicated that environmental factors play an influential role to induce flowering and fruiting in mango trees. When the mango trees are grown under subtropical conditions, cool temperatures are key features in flowering occurrence. However, the cold temperatures described as affecting mango flower induction are much higher than those causing flower induction in other fruit plants (Shu and Sheen, 1987; Whiley et al., 1989; Chaikiattiyos et al., 1994; Nunez-Elisea and Davenport, 1994; Batten and McConchie, 1995; Wilkie et al., 2008).

In addition, flower induction in response to cold temperature has been reported to be different among mango cultivars and genotypes. In this way, the aim of this study was to evaluate six different period of tip-pruning from April to July on two commercial mango cultivars including Honey Gold and B74 applying every four weeks. Taking advantage of cold weather from April to July during the dry season, associated to the tip-pruning, is promising to develop agro-technical alternative strategies for growing mango in the Katherine region to maintain the production sustainably.

2. Materials and methods

2.1. Plant materials

The experiment was conducted on the cultivar Honey Gold at Piñata Farm (Fox Road, 14°32′44.2″S 132°28′21.9″E) and the cultivar B74 (Calypso) at NT Land Development Farm (Florina Road, 14°35′31.0″S 131°58′53.4″E) in the Katherine region. A total of 24 trees of each cultivar on Kensington Pride (KP) rootstock was selected from seven year-old trees for each cultivar. All trees were subjected to pruning after fruit harvesting in the 01 January (standard industry practice). A complete randomized block with six pruning times, was used for each cultivar to prune three trees every four weeks for each pruning time based on week of the year; time 1 (week 13), time 2 (week 17), time 3 (week 21), time 4 (week 25), time 5 (week 29), and time 6 (week 33). All terminal stems around the canopy were pruned by secateurs pruner above 10 cm (approximately) of the last internode for each branch on each tree. For each pruning time, 20 branches were randomly selected and tagged around the canopy on each tree to monitor vegetative growth.

2.2. Measuring variables

For each experimental site, two data loggers (Tinytag Plus 2, Hastings Data Loggers, NSW, Australia) were installed to measure temperature (mean, max, min) and relative humidity (RH %) hourly from week 13 to week 46 (harvesting time) of the year. During this period temperature < 20 °C was calculated as chill sums as well as heat sums calculated as follow [(max temp + min temp)/2] – 12 (Moore, 2013). The heat sums calculator is a tool used to predict mango fruit maturity in Australia. Different mango varieties have slightly different heat units requirement, generally growers count heat sums from flowering at stage 6 of panicle emergence (the first time the bud can be seen) to the time that dry matter reaches to a certain percentage (DM%) for each variety, *e.g.* the DM% for both cultivar Honey Gold and B74 is approximately 15% to 16% at harvest.

One week after pruning, axillary flushes length below the point of cutting for each 20 new shoots selected was recorded on weekly vegetative growth based on millimeter (mm). For all treatments, flowering time (week of the year), canopy flowering (%), the number of panicle emerging the cutting point, and the number of fruits/tree were recorded. For each pruning time, 20 fruits/tree (60/treatment) were harvested in week 46 of the year (the second week of November) for both cultivars.

The fruits were transferred to the lab for measuring of the following variable: Brix°(reflectometer, two times/fruit from both side), fruit weight (g), and dry matter (DM%). The dry matter has been used as maturity indicator by most of the growers for harvesting mango in Australia. Therefore, in this study, we measured the maturity using traditional and infrared spectroscopy methods used by farmers. To measure DM% based on destructive prediction (traditional method) for each harvested fruit, a sample from both sides (center) of the fruit were taken using the apple corer (1 cm thick). The samples then were peeled and weighed. Samples then were dried in the oven at 65 °C for 48 h and weighed. Dry matter was calculated by following formula; DM% = (Dry weight/Wet weight) × 100% (Owens and Moore, 2013). Non-destructive prediction of DM% also performed using pre-collaborated near infrared spectroscopy F-750 NIR unit (Felix Instruments, WA, USA) for both cultivars (Subedi et al., 2007).

2.3. Statistical analysis

The experiment was arranged as a complete randomized block design with three replications. Data were subjected to ANOVA analysis using SAS version 9.3 statistical software (SAS Institute, Cary, NC, USA) and Excel (2013), and analyzed separately for each cultivar.

3. Results and discussion

In many studies, weather conditions have been reported to have a key role on mango vegetative and flower bud induction, the results of climate data collected from both mango plantation sites in this study including: temperature (mean, max, min), day/night temperature fluctuation, chill and heat sums, chill and heat cumulative (cum), and RH%, was presented for 'Honey Gold' (Fig. 1 and Table 1) (Piñata Farm, Fox Road, 14°32'44.2"S 132°28'21.9"E) and 'B74' (Fig. 2 and Table 2), (NT Land Development Farm, Florina Road, 14°35'31.0"S 131°58'53.4"E). Whiley et al. (1989) showed that at the temperature regime of 15/10 °C flower indication happened in some mango cultivars, while some varieties produced flower buds at 20/15 °C. Shu and Sheen (1987) reported that 100% of 'Haden' mango trees flowered at 19/13 °C, 60% at 25/19 °C and 0% at 31/25 °C. Surprisingly, some cultivars that failed to flower at 20/15 °C in the earlier study carried out by Whiley et al. (1989) flowered at 30/20 °C in the study that was done years later by Sukhvibul et al., 2000. Also, the duration of cold temperature that needed for floral initiation in mango has been reported to vary from one week to two weeks in cultivar 'Haden' (Reece et al., 1946; Shu and Sheen, 1987), and up to five weeks in 'Tommy Atkins' and 'Keitt' (Yeshitela et al., 2004).

Growth characteristics af fected by different pruning times is presented in Tables 1 and 2. First growth was observed 2–3 weeks after tip-pruning for the buds close to the cutting point regardless of treatments, which are in agreement with results reported by García De Niz et al. (2014) on mango. For the tip-pruning times 1 and 6, the vigor (length) of the first and second growth cycle were not statistically different to the unpruned tree (control) in both cultivars Honey Gold and B74. The