ABSTRACT
Mango blossom malformation (MM) is a serious disease in South Africa (SA), causing severe economic losses annually. Current recommendations are to break out the malformed inflorescences as well as three additional nodes of the branch when malformed flowers are clearly visible, but before sporulation occurs. Despite these recommendations, a high incidence of MM was reported during the past two seasons. The aim of this study was to investigate and evaluate the influence of various management practices by producers on the incidence of malformation and to develop an integrated strategy for optimum control. In the Hoedspruit production area, the incidence of MM was monitored on different cultivars at four producer sites. In the Nelspruit production area, in a 36 year old ‘Sensation’ orchard, the effect of inflorescence removal combined with chemical control was investigated. Malformed branches were removed at 300 mm to 500 mm distance behind malformed blossoms during November. After harvest in January, three treatments were applied, being 1) a control treatment (no further removal of malformed branches), 2) further removal of malformed branches, and 3) further removal of malformed branches followed by a spray of benomyl WP at 0.75 g/L. At all sites the number of healthy and malformed inflorescences was counted before inflorescences were removed. Records of all husbandry practices were kept. In the Hoedspruit area removal of the malformed inflorescences lead to a 44% to 80% decrease in the prevalence of malformation. It was established that branches were not always broken out by producers according to recommendations, leading to poor control of malformation in certain instances. Results of the incidence of malformation at each of the trial sites are presented. The study will continue for a further two years and the results will be used to develop a strategy to minimise MM in SA.

INTRODUCTION
Since the 2010/11 season the Agricultural Research Council – Institute for Tropical and Subtropical Crops (ARC-ITSC) has conducted research to find solutions for the mango malformation problem in the Hoedspruit area. Current control recommendations are to break out the malformed panicles when these can be easily distinguished, but before the flowers have dried out and sporulation occurs. They should be broken out three nodes (growth flushes) back or at least 200 mm to 300 mm, whichever is greatest. During the past two seasons a 20% reduction in annual yield was reported in the Hoedspruit area. Questions arise as to whether this management practice is still effective, but not applied correctly or whether recommendations should be adjusted to achieve more effective control. The aim of this study was 1) to investigate and evaluate the influence of various management practices by producers on the incidence of mango malformation in the Hoedspruit area and 2) to develop an integrated strategy for optimum control of MM at the Nelspruit trial site.

MATERIALS AND METHODS
Hoedspruit
In the 2011 season an orchard with a history of MM was selected at each of four producers in the Hoedspruit area. Producers are referred to as producer A, B, C and D. Thirty branches were marked at each site except at producer B were only 20 branches were marked. The total number of healthy and malformed inflorescences was counted before and after removal of malformed inflorescences by the respective producers during the 2011 and 2012 seasons. Records were kept of all husbandry practices followed.

Nelspruit
In a 36 year old ‘Sensation’ orchard at ARC – ITSC, Nelspruit, the following treatments were applied in the 2012 season. In October/November malformed flowers and branches were removed 300 mm to 500 mm behind malformed flowers by hand and secateurs connected to long poles. Fruit were not saved where malformation was observed close to fruit. In certain instances large branches were removed and in three
instances the whole tree was cut down to soil level as malformation was too severe to remove branches alone. After harvest in January, the following treatments were applied.

Treatment 1. Nil (no further removal of malformed branches after harvest) (Control)

Treatment 2. Further removal of malformed branches after harvest.

Treatment 3. Further removal of malformed branches after harvest and spray with benomyl @ 75 g/100 L.

The total number of healthy and malformed inflorescences was counted on 24 randomly selected branches in each treatment before removal of malformed flowers in October/November. Treatments have been applied for one season only, but the trial will continue for three consecutive years.

Laboratory trial

A small laboratory trial was also conducted to determine when major spore release from flowers occurs. Two different selective media, original Nash & Snyder medium (Burgess et al., 1994), but with increased Neomycin sulphate of 0.175 g/L and Van Wyk agar (Van Wyk et al., 1986), was used to detect spore release. Each week, starting from 31 July, a malformed flower and a few leaves were collected in the 36 year old ‘Sensation’ orchard at ARC – ITSC, Nelspruit. Photographs were taken each week of the development stage of the collected flower. The small individual flowers on the malformed inflorescence were removed and 40 g weighed off and suspended in 250 ml of water to which 50 µl of Abamectin, a miticide was added to kill all mites present. The leaves were cut into small pieces and 4 g suspended in 250 ml water. After an hour, 100 µl of the suspensions were transferred to 90 mm petri dishes containing the selective media and spread evenly over the surface using a glass rod. The first few weeks only full strength suspensions were tested, but when the number of colonies increased, the suspensions were diluted 1:10 and later further diluted to 1:100. Five replicate plates were used for the 1: 10 dilution, two for the full strength and 3 for the 1:100 dilution. Plates were incubated at 25°C for 7 days when colonies were counted.

RESULTS AND DISCUSSION

Hoedspruit

At Producer A the incidence of malformation decreased from 16.7% to 6.33% in the 2011 season. At first, monitoring in the 2012 season at mid-August, the incidence was 2.6%. Incidence increased to 9.3% due to late flowers developing malformation at the end of September. At the end of October after two removals in the 2012 season, incidence was 0% (Fig. 1). Overall there was a 44.3% decrease in malformation from the previous season (16.7% to 9.3%). Flowering during the 2012 season on the marked branches and overall in all orchards were 30% less than the 2011 season. Many of the marked branches had only flushed.

At Producer B the incidence of malformation decreased from 10.8% to 0.38% in the 2011 season. In the 2012 season the incidence at the beginning of September was 5.8% and did not increase further. The malformed inflorescences were removed once at the end of October. Overall there was a 46.3% decrease (10.8% to 5.8%) in malformation from previous season (Fig. 2). Flowering on marked branches was also very poor this season. On the marked branches 35% of the branches only flushed and did not flower.
At Producer C the incidence of malformation was 4.6% in the 2011 season. At the beginning of the 2012 flowering season malformation was 0%, but due to late flowering malformation increased to 5% at the end of October 2012 (Fig. 3). Malformation was not removed at this stage. Very poor flowering occurred on marked branches.

At Producer D the incidence of malformation decreased from 17.7% to 0.3% in the 2011 season. At the beginning of the 2012 season incidence was 3.5% and at the end of the 2012 flowering season 0%. Malformed flowers were removed once at the end of September. Overall there was an 80.2% decrease (17.7% to 3.5%) in malformation from the previous season (Fig. 4).

Monitoring will continue for another season and only then will it be possible to determine if current recommendations are still effective, but not applied correctly or whether recommendations should be adjusted to achieve more effective control.

Nelspruit
In the ‘Sensation’ orchard at Nelspruit, malformed inflorescences were removed in October 2012. The total number of healthy and malformed inflorescences was counted on 24 randomly selected branches in each treatment before removal of malformed inflorescences in October 2012. In January 2013 fruit were harvested for achar and yield records kept. After harvest, malformed inflorescences and branches missed in October or newly develop malformed inflorescences and branches were further removed in treatments 2 and 3 and benomyl @ 75 g/100 L applied to treatment 3. The percentage malformation in the orchard before the first removal of malformation in the orchard in October was between 17.5% and 23%. The yield data per treatment was between 729.14 kg and 1 200 kg. This data will be used as a baseline to determine the effect of each treatment on percentage malformation and yield over three consecutive years. The incidence of malformation on some trees before and after removal of malformed flowers is presented in Fig. 5.

Treatments have been applied for one season only, but the trial will continue for three consecutive years and the number of healthy and malformed inflorescences will be counted each year before removal of malformed inflorescences in October/November.

The 2013 seasons monitoring will commence in July. Only when this data is available will it be possible to determine if the treatments had any positive effect on the incidence of malformation.

Laboratory trial
The average number of colonies which developed on the Nash & Snyder medium (1:10 dilution) is presented in Fig. 6 and on the Van Wyks medium in Fig. 7.

Colony growth was better on the Nash & Snyder selective medium than on the Van Wyks selective medium and the Nash & Snyder medium will be used in future studies. On the Nash and Snyder selective medium the largest peak in spore release occurred on 9 October. Smaller peaks of 50 and above colonies per plate also occurred on 23 and 30 October and 6 November. On the Van Wyks medium colony growth was less and only small colonies developed and grew very slowly. A peak in spore release was observed in September. Another peak in spore release of more than 50 colonies per plate was also observed on 9 October. This was only a small laboratory trial.
and the technique will be refined the next season. More flowers will be evaluated and a 1:10 dilution will be used from the beginning and the 1:100 dilution when colonies become too many to count. The

**Fusarium** colonies observed on the plates were purified and representative colonies were sent to Pretoria Technichon to be identified using PCR techniques. The colonies observed on both media corresponded to the **Fusarium** sp. isolated from malformed flowers. Few spores were washed from the leaves on both media (data not shown). On the Nash and Snyder medium peaks were observed on 4 September and 2 October and on the Van Wyks medium on 18 September, 2 October and 9 October. The highest number of colonies counted when full strength suspension was used was 17 on Van Wyks medium on 18 September and 10 on Nash & Snyder medium on 2 October.

The development stage of the flowers on 9 October when a peak in spore release was detected on the Nash and Snyder medium is presented in Fig. 8a. Many of the florets on the inflorescence have dried out and were starting to fall off. The development stage before any spores were detected is presented in Fig. 8b. None of the florets has dried out at this stage and no spores were detected on any of the media used.

Although these are only preliminary results and the technique should be refined, indications are there that spore release starts to occur and to increase when the florets on the malformed inflorescence starts drying out. Malformed inflorescences should be removed from the orchards before the individual flowers on the inflorescence have dried out and spore release occurs. By refining this technique it will be possible to established more closely when spore release occurs in order to optimise the time of spraying when an effective fungicide is found.

**REFERENCES**


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**Figure 6.** Spore release from malformed inflorescences during the 2012 monitoring season on Nash & Snyder selective medium.

**Figure 7.** Spore release from malformed inflorescences during the 2012 monitoring season on Van Wyks selective medium.

**Figure 8.** a) Development stage of inflorescences with dried out flowers which are starting to fall off and b) Development stage with no dried out flowers.