Field trials using Surround™ to reduce fruit fly damage on mango in West Africa.
Introduction

Fruit flies, particularly the invasive species *Bactrocera invadens*, have very damaging effects on productivity in many ACP countries. The pest is thought to have originated in Sri Lanka, and first appeared in Africa ten years ago, in Kenya. *B. invadens* is highly successful because it can infest many cultivated and wild fruits, and the pest has now spread into at least 20 African countries.

Significantly for the important trade in mango, the presence of fruit flies in fruit is a barrier to the movement of produce, both regionally and internationally, and the pest is hampering trade. *Bactrocera* is currently considered the most important threat to exports of mango, and is having devastating effects on those who depend on the crop for their livelihood.

Due to this serious situation, COLEACP/PIP has responded urgently to requests for help from several countries in the Sahel region, in developing ways to manage and control fruit flies on mango. Research trials have been carried out in three countries in West Africa (Senegal, Gambia and Mali) using different potential control methods, with a view to generating recommendations for growers on how to reduce the impact of *B. invadens* in particular.

Previous work on fruit fly control indicates that methods such as quarantine, use of insecticidal sprays, field hygiene, and post-harvest treatment of fruit are insufficient when used in isolation. Several methods need to be used simultaneously to achieve useful levels of control. Countries that wish to maintain market access are therefore forced into adopting integrated pest management (IPM), trade is only possible when producing countries can convince their trading partners that effective measures are in place.

The range of pest management technologies available in the Sahel has been limited, which led to the demand for field trials to assess different tactics to manage fruit flies. The methods assessed in recent COLEACP/PIP trials include the use of a calcined kaolin-based product (Surround) sprayed onto developing fruits; and an odour-baited trap technique with parapheromone and feed attractant to attract adult flies towards a lethal treatment. This can be a surface treated with insecticide or a plastic trap that retains the flies.

Field trials to assess the kaolin spray were carried out in Gambia, Mali and Senegal.
1. Mali trial

1.1. Methods

In Mali, where mango is an important crop, trials were carried out in June and July 2013 by the Centre Régional de la Recherche Agronomique de Sotuba to determine the efficacy of a commercial powdered calcined kaolin product (Surround WP) applied at three different rates (25, 50 and 75 g/l water). These rates were 0.5× recommended dose; actual recommended dose; and 1.5× recommended dose, and equate to around 3, 6 and 9 kg/ha Surround.

These kaolin treatments were compared with the level of fruit fly control achieved by an insecticide containing the pyrethroid deltamethrin (Decis 12.5) applied at a rate of 2 l/ha. There was an untreated control, and the treatments were replicated four times.

Each week, before the treatments were applied, fruit were sampled to determine the proportion infested with fruit flies.

1.2. Results

Egg-laying - More than 50% of mangoes harvested from the half-dose Surround plots after the second application had signs of egg-laying on the skin (had been oviposited). There was a similar percentage of oviposition signs in both the plots treated with deltamethrin and the control (untreated) plots. In plots treated with kaolin at the higher rates of 50 and 75 g/l, the percentage of fruits showing evidence of egg-laying was only 30%. This reduced level of egg-laying continued with subsequent applications. By the end of the trial, almost 100% of untreated fruit showed evidence of attack, whereas only one in three fruits treated with the two higher doses of Surround showed oviposition marks.

Emergence - Fruit retained to study the emergence of maggots from infested fruits (the pests pupate in the soil after emerging from the fruit) had approximately 50% each of Bactrocera invadens and Ceratitis sp. The emergence of the maggots from deltamethrin treatments was much lower than from kaolin treatments, indicating a much reduced rate of survival in fruit treated with the pyrethroid insecticide.

The results indicate that the presence of kaolin on the skin deterred females from laying eggs on the fruit when the recommended dose or the higher dose had been applied to the fruit. However, the reduced number of eggs laid in the fruit treated with kaolin had a good chance of surviving and living to emerge as adult flies. In contrast, deltamethrin did not significantly reduce egg-laying, but a much smaller proportion emerged from the fruit.

Untreated control fruits were heavily oviposited and emergence was highest, so that virtually none of the fruit was of marketable quality.
1.3. Conclusion

The recommended dose and the 1.5x recommended dose of Surround reduced the number of egg-laying holes and hence improved the visual appearance of fruits, but eggs that were laid in fruits had a good chance of completing their development and emerging to pupate. In contrast, deltamethrin treatment did not reduce oviposition, but eggs laid in fruits treated with deltamethrin had less chance of developing and emerging from the fruit.
2. Senegal trial

2.1. Methods

In Senegal, a trial was carried out by the Université Cheikh Anta Diop, Facultés des Sciences et Techniques. As described above, calcined kaolin (Surround WP) was sprayed onto mango fruits to assess its effectiveness in limiting fruit fly damage. The effect of a surfactant additive (Aquacon) added to the spray mixture at a rate of 5%, with the intention of improving the adherence to the crop, was also examined.

As with the Mali trial, the dose rate of Surround was 25, 50 and 75 g/l water (50 g being the recommended dose), but the trial took place slightly later, in July and August, with four treatment applications. Instead of deltamethrin, a formulation of spinosad with a bait (Success Appat), sprayed in a band around the tree, was used as a comparison with the treatment. There was also an untreated control.

Number of fruit with egg holes, emerging individuals, and proportion of marketable fruit were used to judge the beneficial effects of treatments.

2.2. Results

Egg-laying - Results showed that all kaolin treatments reduced egg-laying. In the untreated control, 78% of fruit showed evidence of egg-laying, compared with approximately 35% with the spinosad bait treatment. This compared with a mean of approximately 15% for the recommended dose of Surround, and 24% for the half dose. Increasing the recommended dose by an additional half dose gave a mean of around 18%. There was no significant difference between different doses of kaolin, but all were significantly better than the spinosad bait (Success Appat) treatment and the untreated control.

Emergence - When infested fruits were observed in the laboratory, the number of emerging larvae reflected the data from the observations on the number of oviposition holes on fruits, with all kaolin treatments giving lower emergence than either the bait treatment or the control. Almost all flies emerging from fruits were the species B. invadens (98%) and only a few (2%) Ceratitis cosyra.
2.3. Conclusion

In conclusion, the kaolin (Surround) treatments applied four times reduced the incidence of infestation by fruit flies in mangoes. However, significant infestation still occurred, particularly early in the harvesting period. The bait (Success Appat) treatments were less effective, but reduced the level of infestation compared with the untreated control.

3. Gambia trial

3.1. Methods

A trial in The Gambia was carried out by the National Agricultural Research Institute during 2013. Similarly, the study aimed to evaluate the efficacy of a calcined kaolin-based crop protectant (Surround WP) against the pesticide bait Success Appat against the invasive fruit fly (Bactrocera invadens). Another species (Ceratitis cosyra) was also present on the mango trees.

As with the trials in Mali and Senegal, the dose rate of Surround was 25, 50 and 75 g/l water (50 g being the recommended dose). The trials took place in July and August.

3.2. Results

The results of the four treatments, the three Surround sprays and Success Appat, were not significantly different, although the lowest fruit drop was observed at the higher (75 g/l) rate, which is 1.5 times the dose recommended by the manufacturer.

3.3. Conclusion

All treatments were significantly better than the untreated control in terms of fruit drop.
4. Overall conclusions

In terms of an IPM strategy for fruit flies, these trials demonstrate that sprays containing calcined kaolin (in this case, Surround WP) produce a significant reduction in the rate of oviposition and infestation of mango fruit.

Surround sprays applied four times during the period when mangoes are approaching harvest do have beneficial effects on the level of infestation. However, used alone, Surround sprays would be insufficient to provide adequate control – although levels of oviposition are reduced by the treatment, they are not halted.

Unfortunately, kaolin does not appear to affect the development of eggs laid in the fruit, so any female flies that overcome the repellent effect are likely to produce a new generation of flies.

For a more effective strategy to mitigate the effect of fruit flies on mango, in particular the invasive species *Bactrocera invadens*, an integrated approach is necessary, consisting of trapping, use of baits, quarantine measures, post-harvest treatments, and use of biological and chemical control measures.

Application of sprays containing kaolin could play an important role as part of an integrated approach to the management and control of fruit flies.