# Studies on the cassava fruit fly *Anastrepha* spp.



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**Abstract**

Two species of fruit flies have been identified as attacking cassava in Colombia: *Anastrepha pickeli* in the Valle del Cauca (altitude 1000 m) and *M. manihoti* in the coffee-growing regions (1200 m). When this insect attacks the fruit of cassava, it does not cause economic losses; but when it attacks the stem, it bores tunnels where a bacterial pathogen *Erwinia carotovora* var. *carotovora* can be found causing severe stem rot. When environmental conditions are favorable, the cassava plants can recover rapidly from this damage even when growing terminals have rotted or died. Severest fruit fly damage is observed in planting material; the use of infested cuttings results in losses in germination as well as yield. Environmental conditions favorable to fruit fly development and aspects of its biology are discussed. *Opius* sp. is a parasite of larvae in the cassava fruit but has not been observed in the stems. The use of systemic insecticides is discussed, and results are given of field experiments designed to determine which baits or attractants would trap fruit flies or increase the effectiveness of insecticides.

The fruit fly has been reported as a pest of cassava only in the Americas. When it attacks the fruit, it causes no economic losses (3-4). In recent years we have also observed fruit flies causing damage to cassava stems in several countries of Central and South America. Two species of fruit flies have been identified as attacking cassava in Colombia: *Anastrepha pickeli* (Tephritidae), collected at the CIAT farm in the Valle del Cauca (altitude 1000 m), and *M. manihoti*, found in the coffee-growing regions (1200 m) where in recent years it has become a serious pest of cassava.

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## Type of damage caused

When oviposition occurs in the fruit, the larvae bore throughout the fruit, destroying the developing seed. The infested fruit shrivels and becomes soft, turning yellow green in color (1).

Larval tunneling in the stem results in brown galeries in the pith area. A bacterial pathogen (*Erwinia carotovora* var. *carotovora*), often found in association with fruit fly larvae, can cause severe rotting of stem tissue (2). The presence of the larvae within the stem can often be noted by the white liquid exudate that flows from the larval tunnel and exit holes. In severe attacks, growing points may collapse and die, retarding plant growth and encouraging growth of lateral buds. Buds located along infected stem portions are first invaded and necrosed. Younger plants (2-5 months) suffer more from damage than older ones.

Field observations have shown that damage in cassava plantations can be extensive. On one field 84 percent of the plants were observed with fruit fly/bacteria damage while in another field about 75 percent of the plants had collapsed, 20 to 30 cm below the growing points.

The effect of this damage on cassava production *is not known.* In one study 100 plants damaged by fruit flies were harvested, root yield recorded and compared to the yield of 100 undamaged plants. There was a 5 percent reduction in root yield of the damaged plants. Affected plants were stunted and may have been shaded by their healthy neighbors; hence yield losses may have been overestimated. It is also suspected that this secondary rotting may cause a reduction in germination when infested stems are used as planting material and that yields from damaged planting material may be reduced.

This paper will discuss the biology and ecology of the fruit fly, the economic damage it causes, and possible control methods.

## Biology and ecology

The yellow- to tan-colored female inserts the egg in the succulent part of the stem, about 10 to 20 cm from the tip, so that about one third of the egg with a slender white rod protrudes. After hatching, the white to yellow larvae bore up- or downwards in the stem pith region. Since numerous eggs may be deposited in one stem, several larvae may be found per stem. This provides an entrance for the bacterial pathogen that causes stem rotting.

The fruit fly/bacterium association is not fully understood. It appears that the bacterium is present on the stem, where it can live epiphytically. Rain is probably the principal means of dissemination. Investigations have not definitely concluded that the fruit fly is a vector of the pathogen; however, observations indicate that the fruitfly/pathogen association exists naturally and that the insect can disseminate the causal organism.

The boring action of the larvae under high humidity conditions provides the wound needed for bacterial entrance into the stem. Under favorable environmental conditions of adequate rainfall and high humidity, rotting develops. The rotten stem is not a favorable environment for the larvae; inspection of rotting stems showed 40 percent larval mortality. This also indicates that the fruit fly may result from infestations of the cassava fruit or alternate hosts rather than from stem infestations. The fruit of several other plants commonly found in areas of high fruit fly populations have been examined, but no additional hosts to these species have been identified yet.

Mature larvae leave the stem or fruit and pupate on the ground. The larval exit hole is clearly visible in the stem. Adults emerge in about 17 days. In some areas high fruit fly populations occur year-round, but extensive damage is usually associated with the rainy season. Damaged stems have been observed in cassava-growing areas ranging from coastal areas where there is minimal and sporadic rainfall to mountainous areas where rainfall is well dispersed throughout the year; however, observations indicate that high fruit fly populations correspond to areas of high humidity and dispersed rainfall.

Fruit fly larvae in cassava fruit are attacked by the parasite *Opius* sp. (Hymenoptera: Braconidae). A study on the CIAT farm showed a 4.9 percent level of parasitism; whereas in the coffee regions of Colombia, where fruit fly populations and damage are high, there was 16 percent parasitism. There have been no observations of larval parasitism in cassava stems.

## Economic damage

It appears that cassava plants can recover rapidly from fruit fly damage, given adequate, well-distributed rainfall. Plants that had been severely *rotted (dead or rotted growing terminals)* when three months old were compared to healthy plants over a six-month period. Plant height measurements showed that within five months, the damaged plants recovered, attaining the same height as nondamaged plants (Fig. 1).

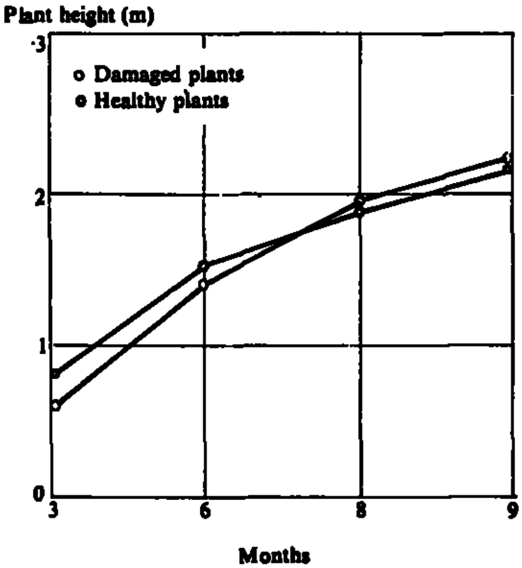


**Figure 1. Recovery of cassava plants severely damaged by the cassava fruit fly (*Anastrepha* sp.) and bacterial stem rot (*Erwinia* sp.).**

Experiments conducted to measure root yield loss due to plant damage resulted in no significant yield differences between treated and nontreated plots. However, because of the difficulty in controlling the very mobile adult, there were no great differences in plant damage between the treated and nontreated plots.

### Damage to planting material

Extensive investigation is being carried out to determine germination and yield losses resulting from the use of *Anastrepha*-damaged planting material. Experiments were conducted on three farms, as well as at CIAT.

Cuttings were separated into five damage grades: 0 = no damage, 1 = a brown discoloration in the pith areas, 2 = discoloration and some rotting of pith at both ends of cuttings, 3 = severe rotting of pith, 4 = severe rotting of pith and tunneling throughout pith area.

Results in farmers' fields showed a decrease in cutting germination ranging from 5% for grade 1 to 16% for grade 4. Damaged cuttings showed an average of 9% reduction in germination compared to nondamaged cuttings (Table 1).

The effect of damaged cuttings on root yield was also measured. Damaged cuttings resulted in a 17.4% yield reduction when compared to undamaged cuttings. Yield losses ranged from 4.2% for grade 1 to 33.1% for grade 3. It is interesting to note that in every trial, damage grade 4 yielded higher than grade 3. Given the yields obtained in these experiments, a 17.4% yield decrease results in a loss of nearly 7 tons of cassava per hectare.

## Control

### Chemical control

Control methods using insecticide applications for the larval and adult stage of the fruit fly were studied. For larval control, carbofuran was applied at three different rates in the soil around each plant; and fenthion in solution was applied to the foliage at three different rates. Larval mortality for each systemic insecticide was recorded at 3, 8 and 16 days after application.

Results showed that fenthion gave 100 percent larval control at all three rates, 8 days after

Table 1. **The effect of damage caused by the fruit fly *Anastrepha manihoti* and the bacterial pathogen *Erwinia carotovora* on germination of cassava cuttings and plant yield.**

| Damage grade | % germination | Yield (kg/ha) Farm no. | | | | % yield reduction | Yield CIAT (kg/ha) | % yield reduction |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | $\bar{X}$ | | | |
| 0 | 90.3 | 38,944 | 41,000 | 40,722 | 40,222 | — | 23,964 | — |
| 1 | 85.7 | 32,922 | 38.083 | 44,528 | 38.511 | 4.2 | 21,868 | 5.0 |
| 2 | 83.7 | 26,333 | 39,194 | 38,333 | 34,638 | 13.9 | 22,108 | 12.9 |
| 3 | 82.7 | 19,966 | 26,528 | 34,194 | 26,896 | 33.1 | 26.237 | 26.1 |
| 4 | 74.0 | 29,288 | 31,639 | 37,694 | 32,873 | 18.3 | — | — |

Table 2. The effect of carbofuran and fenthion on the control of cassava fruit fly larvae (*Anastrepha* sp.) in stems of cassava (var. M Mex 23).

| Treatment | Rate | Application | % mortality of larvae at 3 days | 8 days | 16 days |
|---|---|---|---|---|---|
| Carbofuran | 10 g/plant | Soil | 9.7 | 45.0 | 69.0 |
| Carbofuran | 20 g/plant | Soil | 23.0 | 64.0 | 50.0 |
| Carbofuran | 30 g/plant | Soil | 24.0 | 53.0 | 20.0 |
| Fenthion | 1.5 cc/liter $H_2O$ | Foliage | 76.0 | 100.0 | 95.0 |
| Fenthion | 2.0 cc/liter $H_2O$ | Foliage | 97.0 | 100.0 | 91.0 |
| Fenthion | 2.5 cc/liter $H_2O$ | Foliage | 77.0 | 100.0 | 100.0 |
| Control | | | 22.0 | 24.0 | 40.0 |

application, and was still 90 to 100 percent effective after 16 days (Table 2). Control by carbofuran reached only 69 percent at 16 days. On the other hand, larval mortality in the untreated plants reached 40 percent, supporting the observation that the rotting stem is not a favorable medium for larval development. It should be noted that although larvae were controlled in the stem, the insecticidal sprays did not prevent infestation or rotting of stem tissue.

## Attractants

Adult fruit flies are highly mobile and difficult to control. However, trapping of adult fruit flies with the appropriate bait or attractant could result in an effective means of control. This method could also be used to measure adult fruit fly populations in order to determine when control measures should be employed. Field experiments were designed to determine which baits or attractants would trap fruit flies or increase the effectiveness of insecticide application. The insecticide EPN was used because of its quick knockdown effect, which was necessary to get an accurate mortality count. Three bait combinations were studied: yeast, molasses and yeast plus molasses. Yeast alone was the most effective bait, causing more than double the adult mortality of the insecticide used alone (Table 3). The addition of molasses had no effect on

Table 3. Evaluation of yeast and molasses as baits mixed with the insecticide EPN for control of cassava fruit fly (*Anastrepha* sp.) adults in field trials.

| Treatment (rate) | Adult mortality/replication 1 | 2 | 3 | 4 | Av adult mortality |
|---|---|---|---|---|---|
| EPN (12 cc/12 liters $H_2O$) | 25 | 42 | 43 | 3 | 28.3a* |
| EPN (12 cc/12 liters $H_2O$) + yeast (0.5 kg) | 71 | 103 | 41 | 17 | 58.0b |
| EPN (12 cc/12 liters $H_2O$) + molasses (0.5 liters) | 49 | 49 | 18 | 14 | 32.5a |
| EPN (12 cc/12 liters $H_2O$) + yeast (0.5 kg) + molasses (0.5 liters) | 34 | 79 | 24 | 3 | 35.0a |

*Averages followed by different letters are significantly different at 0.05.

**Table 4. Comparison of five attractants in capture efficiency of the adult cassava fruit fly *(Anastrepha manihoti)* using McPhail traps.**

| Attractant | Rate | Av no. of *Anastrepha* captured/wk |
|---|---|---|
| Brewers yeast | 40 g brewers yeast, 6 g sugar, 1 g borax 400 cc H O | 23.1 |
| Hydrolyzed protein | 55 cc/1000 c $H_2O$ | 17.1 |
| Hydrolyzed maize | 20 cc/1000 cc $H_2O$ | 60.7 |
| Hydrolyzed yeast | 20 g/1000 cc $H_2O$ | 21.9 |
| Hydrolyzed soybean | 20 g/1000 $H_2O$ | 18.4 |

mortality; and when combined with yeast, mortality was greatly reduced.

Five attractants—brewers yeast and hydrolyzed protein, maize and soybeans—were compared for effectiveness in fruit fly capture using the McPhail trap. Hydrolyzed maize gave nearly three times greater capture than any of the other attractants. (Table 4). Hydrolyzed maize was then compared with 100 synthetic fruit fly attractants obtained from the USDA. Results showed that hydrolyzed maize was nearly twice as effective as the most successful synthetic attractants. (Table 5).

## Conclusions

Plant damage caused by the cassava fruit fly/bacterium association is most severe in areas of high humidity and well-dispersed rainfall. Nevertheless, these same conditions enable the cassava plant to recover from insect damage. If a leafy cassava variety is being grown in the area, there will probably be no economic loss caused by fruit fly damage.

**Table 5. Comparison of efficiency of 100 synthetic attractants, water and hydrolyzed maize in capturing adult cassava fruit flies *(Anastrepha manihoti)* using McPhail traps.**

| Attractant | Av no. captured |
|---|---|
| Hydrolyzed maize | 47.9 |
| Water | 1.42 |
| *p*-Methyldithiocarbonilic acid Ammonium salt | 32.00 |
| Ethyl chrysanthemumate | 28.00 |
| Ammonium sulfate | 24.66 |
| Phenethyl anthranilate | 15.5 |
| Melonal (stench) | 14.33 |

Chemical control to prevent plant damage is costly and impractical. The adults are highly mobile; and although baits increase insecticidal effectiveness, they are difficult to control. Larval control is also effective, but this does not necessarily prevent the bacterial pathogen from entering the stem and causing it to rot. The data presented on insect control in this paper are presented as scientific information, but their mention does not imply endorsement of these practices.

The greatest economic losses in cassava due to *Anastrepha* damage are in planting material. Both germination and yield losses can be considerable when infected planting material is used. The selection of healthy planting material is therefore highly recommended and should be included in any farm management program. We have observed in some areas of heavy fruit fly infestation that it is difficult to obtain sufficient completely healthy planting material. In this case it is recommended that slightly damaged (grades 1 and 2) cuttings be selected, and heavily damaged ones (grades 3 and 4) be discarded. All cuttings should then be treated with a fungicide before planting.

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