Productivity of Tomato in the Greenhouse Using Bee Pollination

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Abstract: A green house was installed in October 2014. The aim was to increase tomato productivity in the greenhouse using bee pollination. The tomato plant and fruits in the greenhouse were healthier than those in the open field, attaining a maximum weight of 410 gms, for the tomato. The fruit means were: 213 and 162 gms for the inside and outside, respectively. This was highly significant (t=5.39; df=744.2; p<0.001). Similarly, the average weights of the first tomato fruits on each branch were: 117gms and 110 gms in the greenhouse and open field, respectively. The maximum number of fruits per branch in the greenhouse was eleven fruits whereas those on the outside plot were eight. Thus, productivity was higher in the greenhouse plants, with a longer production period, compared to the plants on the outside plot, due to honeybee pollination. Both the greenhouse and outside field plot tomatoes were affected by the tomato leaf miner, *Tuta absoluta*, with time, curtailing further fruit production.

Keywords: Productivity, Greenhouse Technology, Plant Health

1. Introduction

Pollination is vital for improved quantity and quality crop and fruit yields [1-6]. Many pollinating agents are involved in the process, especially insects [7-13]. Insect pollinators play a complementary role in obtaining maximum fruit-set [1-2]. A large number of fruits and vegetables, including: Strawberries (*Fragaria x ananassa* Duch.), Cucumbers (*Cucumis sativa* Linnaeus), Sweet pepper (*Capsicum annum* Linneaus), Egg plant (*Solanum melongena* Linnaeus), Kales (*Brassica spp.* Linnaeus), Tomatoes (*Lycopersicon esculentum* Linnaeus), Pumpkin (*Cucurbita pepo* Linnaeus) and Water melons (*Citrulus lanatus* Thunb. mansf.), are bee pollinated [8, 4-16]. All these contribute to increased food security [17-20].

2. Objectives

a) Enhancing tomato production in a greenhouse using bee pollinators

b) Observation of tomato disease prevalence with time

3. Study Area

The study area was the National Beekeeping Institute, Lenana, Coordinates: UTM 37M 0257490, 9858862, in Nairobi, Kenya.

4. Materials and Methods

A greenhouse (8x24 Metres) was installed in October 2014 as part of collaborative program between the National beekeeping institute and the EU-AU sponsored Bee Health Project at ICIPE with the aim of enhancing tomato productivity in the greenhouse using bee pollination for increased food security. Only part of the greenhouse (8x12 Metres) was used. The test plant was tomato, *Lycopersicon esculentum* Mill, Corazon variety. The honeybee colony was introduced inside the greenhouse at the onset of flowering as the sole tomato pollinator. The outside field plot was enclosed by a concrete perimeter wall, but allowing a select range of pollinators: butterflies, moths, birds and a limited...
number of bees: solitary and stingless. A Split-plot design was applied [25-26].

Table 1. Activities carried out from nursery to transplanting.

| Date               | Activity                          | Remarks                          |
|--------------------|-----------------------------------|----------------------------------|
| 7/10/2014          | Planting seeds on seed bed        | Done                             |
| 8/10/2014 to 14/10/2014 | Watering by spraying            | germination delayed              |
| 15/10/2014         | Watering by spraying              | germination delayed              |
| 16/10/2014         | Watering by spraying              |                                  |
| 17/10/2014 to 19/10/2014 | Apply NPK poly feed starter     | 10gms in 16 litres of water      |
| 20/10/2014         | Plain water                       |                                  |
| 21/10/2014 to 23/10/2014 | Apply NPK poly feed starter     | 10gms in 16 litres of water      |
| 24/10/2014         | Plain water                       |                                  |
| 25/10/2014 to 27/10/2014 | Apply NPK poly feed starter     | 10gms in 16 litres of water      |
| 28/10/2014         | Plain water                       |                                  |
| 30/10/2014         | Transplanting in the greenhouse   | transplanting on the open plot   |
|                    | and thereafter on the outside plot | was done after one week         |

Other activities included: daily irrigation (drip), defoliation and de-suckering, limited application of recommended fertilizer, trellising, checking for diseases/pests, limited spraying, as need arose, with the assistance of a professional and introduction of a honey bee colony for pollination. Transplanted plants were clearly labelled.

5. Results

The green house had consistently higher number of yields than open field plot plants, with the gap widening with plant age. The open field plot tomatoes’ yield decreased with age, whereas the green house plants had a longer production period.

![Figure 1](image1.png)

Figure 1. Productivity: Total number of fruits harvested by plant age.

![Figure 2](image2.png)

Figure 2. Increased tomato productivity per branch. Photo: Asiko, 2015.

Table 2. Tomato productivity as per plant-age.

| Parameter              | estimate | s.e. | t(*) | p pr. | Antilog of estimate |
|------------------------|----------|------|------|-------|---------------------|
| Constant               | -5.67    | 0.776| -7.3 | <.001 | 0.003449            |
| Age_in_days            | 0.02836  | 0.00563| 5.04 | <.001 | 1.029               |
| Location Open          | -0.54    | 1.21 | -0.45| 0.654 | 0.5819              |
| Age_in_days.LOCATION Open | 0.00503 | 0.0088| 0.57 | 0.568 | 1.005               |

Table 3. Average weight of harvested fruits.

| Location | Mean | Standard deviation | Standard error of mean |
|----------|------|--------------------|------------------------|
| Green house | 213.4 | 142                | 6.416                  |
| Open     | 162  | 127.2              | 7.055                  |

The green house had significantly heavier fruits than those in the open field (t=5.39; df=744.2; p<0.001).
Tomatoes in the green house reached their peak fruit weight by day 111, compared to the open field plants, which reached their peak weight at day 122. The fluctuation pattern was however, similar for both green house and open field plants. The total weight of tomatoes decreased with plant age.

Table 4. Average weight of first fruit.

| Date       | Average WT of 1st fruit in gms | Green house | Open          | Grand Total |
|------------|--------------------------------|-------------|---------------|-------------|
| 16/1/2015  | 109.75                         | 109.75      |               |             |
| 22/01/2015 | 94.5                           | 94.5        |               |             |
| 23/1/2015  | 68.666666667                    | 68.66666667 |               |             |
| 26/1/2015  | 115.7777778                     | 116.7916667 | 116.5151515   |             |
| 28/1/2015  | 177.875                         | 177.875     |               |             |
| 29/1/2015  | 119.1276596                     | 119.1276596 |               |             |
| 4/2/2015   | 143.5205479                     | 143.5205479 |               |             |
| 6/2/2015   | 153.308642                      | 153.308642  |               |             |
| 10/2/2015  | 142.9333333                     | 142.9333333 |               |             |
| 13/2/2015  | 122.8461538                     | 114.0277778 | 119.2386364   |             |
| 17/2/2015  | 121.1754386                     | 104.4       | 116.8181818   |             |
| 20/2/2015  | 101.6590909                     | 80.86363636 | 94.72727273   |             |
| 24/2/2015  | 107.775                         | 80.39285714 | 86.5          |             |
| 3/3/2015   | 113.2368421                     | 79.48275862 | 98.62686567   |             |
| 9/3/2015   | 93.64705882                     | 93.64705882 |               |             |
| 13/3/2015  | 103.7777778                     | 69.55555556 | 86.66666667   |             |
| 17/3/2015  | 90.2                            | 83.77777778 | 87.15789474   |             |
| Grand Total| 116.9548023                     | 110.4534884 | 114.3988571   |             |
Although the number of plants infected by *Tuta absoluta*, significantly increased over time, there was no difference in disease infestation between the greenhouse and open field plants. The interaction time was also, not significant.

**Table 5. Average TOTAL WT (gms).**

| Date    | Green house | Open    | Grand Total |
|---------|-------------|---------|-------------|
| 16/1/2015 | 261.4       | 120.5   | 261.4       |
| 22/01/2015 | 121.6666667 | 121.6666667 | 243.3333333 |
| 23/1/2015 | 171.8888889 | 169.9166667 | 341.8055556 |
| 26/1/2015 | 255.2631579 | 199.7659574 | 455.0301153 |
| 28/1/2015 | 199.7659574 | 199.7659574 | 399.5319148 |
| 29/1/2015 | 234.4657534 | 234.4657534 | 468.9315068 |
| 3/2/2015  | 202.8888889 | 202.8888889 | 405.7777778 |
| 10/2/2015 | 295.2941176 | 229.4594595 | 524.7536071 |
| 13/2/2015 | 186.1964286 | 173.5     | 359.7419172 |
| 17/2/2015 | 149.9642857 | 125.625   | 275.5900435 |
| 20/2/2015 | 221.275     | 220.2153846 | 441.4909401 |
| 24/2/2015 | 159.9259259 | 220.2153846 | 380.1413104 |
| 3/3/2015  | 85.6666667  | 66.6666667 | 152.3333334 |
| 9/3/2015  | 141.8888889 | 141.8888889 | 283.7777778 |
| 13/3/2015 | 164         | 170.3859649 | 334.3919748 |
| 17/3/2015 | 164         | 170.3859649 | 334.3919748 |
| Grand Total | 213.4142857 | 192.9116564 |

**Figure 5.** Damaged tomato fruit by *Tuta absoluta*. Photo: Asiko, January, 2015.

**Figure 6.** Caterpillar a, with damage on tomato leaf. b. Photo: Asiko, 2015.
6. Conclusions

The tomato fruits inside the greenhouse were significantly heavier, with a maximum weight of 410 gms, than those in the open field plot (t=5.39; df=744.2; p<0.001). The inside tomatoes too, were healthier than those in the open field, with the means, 213 and 162 gms, for the inside and outside, respectively. Fruit productivity was higher in the greenhouse, expressed in the number of tomatoes per branch, Figure 2. A maximum of 11 tomatoes was recorded in the greenhouse compared to 8, on the outside plot. This concurs with Slaa’s experiments on bees in applied pollination [7] and several other scientists [1-13]. There was fluctuation in the average weights of the first fruit, 117 gms in the greenhouse and 110 gms, in the open field plot. Field plot tomato production decreased significantly with plant-age. The greenhouse tomatoes had a longer production period, before being curtailed by the tomato leaf miner, *Tuta absoluta*, which equally affected the field tomatoes.

The greenhouse technology, combined with honeybee pollination impacted positively on tomato production. This impact was significant, evidenced in quantity and quality. The perimeter wall surrounding the outside field plot deterred a number of efficient and effective pollinators to the tomato plant.

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