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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	
15/10/2014	Watering by spraying	germination delayed
16/10/2014	Watering by spraying	germination delayed
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 green house and thereafter on the outside plot	transplanting on the open 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

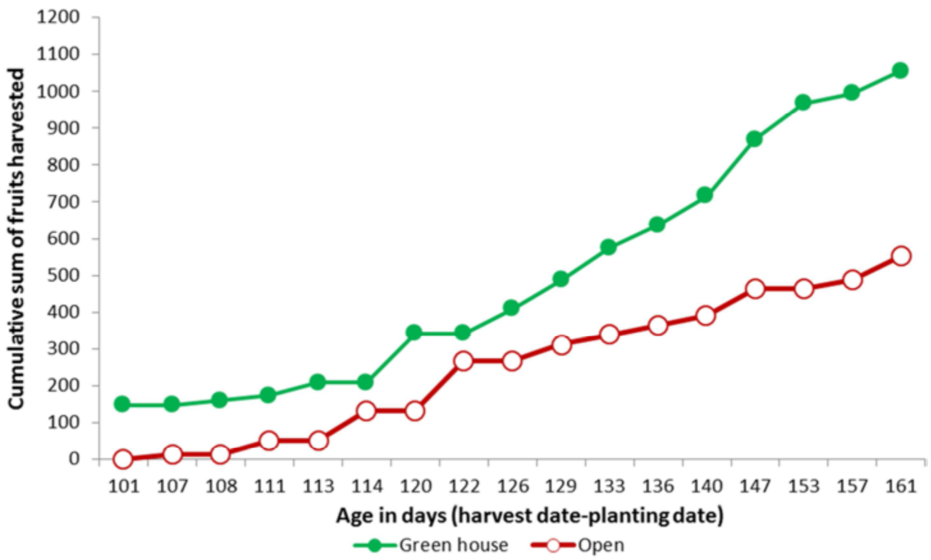

Figure 1. *Productivity: Total number of fruits harvested by plant age.*

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

Table 2. *Tomato productivity as per plant-age.*

Parameter	estimate	s.e.	t(*)	t 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 ($t=5.39$; $df=744.2$; $p<0.001$).

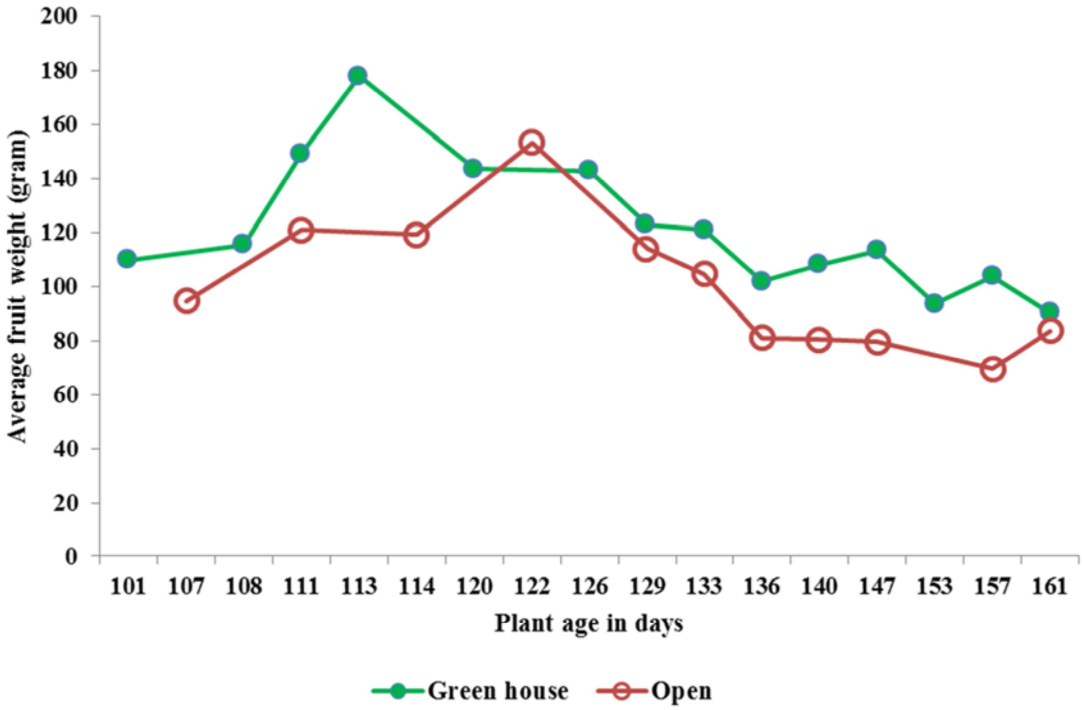

Figure 3. *Average fruit weight by location and stem age.*

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	68.66666667		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	96.5
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

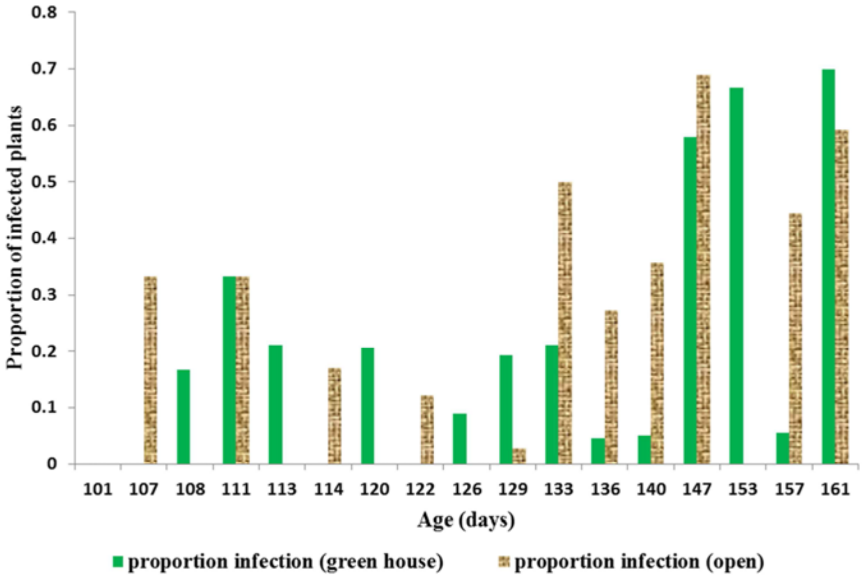

Figure 4. *Disease incidence by locality over time.*

Although the number of plants infected by *Tuta absoluta*, significantly increased over time, there was no difference in disease infestation between the green house and open field plants. The interaction time was also, not significant.

Table 5. A*verage TOTAL WT (gms).*

Average TOTAL WT (gms)			
Date	**Green house**	**Open**	**Grand Total**
16/1/2015	261.4		261.4
22/01/2015		120.5	120.5
23/1/2015	121.6666667		121.6666667
26/1/2015	171.8888889	169.9166667	170.4545455
28/1/2015	255.2631579		255.2631579
29/1/2015		199.7659574	199.7659574
4/2/2015	234.4657534		234.4657534
6/2/2015		218.2560976	218.2560976
10/2/2015	202.8888889		202.8888889
13/2/2015	295.2941176	173.5	229.4594595
17/2/2015	186.1964286	135.8	172.9342105
20/2/2015	149.9642857	91.55	125.625
24/2/2015	221.275	80.39285714	163.2647059
3/3/2015	291.4736842	119.9259259	220.2153846
9/3/2015	166.0588235		166.0588235
13/3/2015	141.8888889	85.66666667	113.7777778
17/3/2015	164	177.4814815	170.3859649
Grand Total	213.4142857	162	192.9116564

a

b

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

a

b

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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