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Response of Carpenter Bee Pollination on Quality and Yield of Tomato (*Lycopersicumesculentum*) Grown in an Excluded Area

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ABSTRACT

The effectiveness of the carpenter bee Xylocopa violaceaSmith (Hymenoptera: Apidae) was evaluated and compared to non- carpenter bee pollinated tomato (Lycopersicum esculentum) crop grown under protected conditions. Some qualitative and quantitative characteristics such as day to first fruit harvest, number of fruits, fruit size, in treatments with or without carpenter bee colony were recorded. Results based on measurements of mentioned parameters showed highly significant difference. Laboratory reared carpenter bee colony utilized for pollination of tomato cultivar (Lycopersicum esculentum) grown inside polyhouse resulted in increased number of fruits per cluster (6.76 fruits/cluster), number of fruits (75.80 fruits/plant), fruit length (5.16cm), fruit breadth (5.75cm), fruit weight (93.87g), fruit yield (12.7kg/m2) and healthy fruits (90.33%). Reduction in number of misshapen fruits (9.8%), number of seeds (102.95 seeds/fruit), 1000 seed weight (6.32gm) over control crop was also observed in carpenter bee pollinated crop. Carpenterbee pollination accounted per cent increase in number of fruits per plant, healthy fruits, fruit length, fruit breadth, fruit weight, fruit yield, number of seeds and 1000 seed weight by 38.41, 21.94, 46.45, 50.82, 57.66, 64.79, 78.54 and 78.80 per cent, respectively.

INTRODUCTION

Carpenter bees are species in the genus Xylocopa of the subfamily Xylocopinae. Carpenter bees are the main pollinators of many plants and have been found pollinating many high value crops. Carpenter bees also play a vital role in enhancing the productivity but in many crops like tomato, eggplant and cucumber the carpenter bees are more efficient and reliable pollinators especially under protected conditions. Hobbs et al., (1961) found that the carpenter bees are the suitable pollinator species to pollinate flowers with deep corolla. In many cases more effective, than manual pollination or carpenter bee pollination in terms of the quantity and quality of tomatoes produced. Tomatoes within a greenhouse do not typically achieve adequate pollination without human-introduced agitation. Until the early 1990s, greenhouse tomato growers have relied on manual pollination of their tomato flowers using hand-held electric vibrators (Banda and Paxton, 1991; Kevanet al., 1991), which can be time consuming. The use of carpenter bee within green-houses posed an attractive and eventually cost-effective alternative to manual pollination (Velthuis and van Doorn, 2006).The growers benefited from carpenter bee pollination because of lower production costs, increased yield and improved fruit quality. Carpenter bees are the most efficient pollinators not only for the wild plants, but also for pollination services, used in both outdoor and greenhouse horticulture and orchards (Wolf and Moritz, 2008).

Banda and Paxton (1991) reported that carpenter bees were effective pollinator of green-house tomatoes. Tomatoes were grown in green-house in Britain and experiments were under taken to compare the effectiveness of bees in pollinating them. Carpenter bees were compared with traditional vibration pollination of tomatoes. The effectiveness of the bees was determined by measuring fruit set, size and weight and seed content. Carpenter bees were found to be effective pollinators of green-house tomatoes. In Belgium, carpenter bee queens introduced in tomato green-houses resulted in increased productivity up to 70% (Eijnde et al., 1991).

Abak and Gular (1994) conducted a three year experiment in green-house eggplant with carpenter bees for effective pollination. It was observed that yield increased by 25% and the pollinated fruits increased up to 14% in weight and 7% in length. Buzz pollination of tomato (Lycopersicum esculentum) by four native species of Japanese bee (Bombus hypocrite, B. diversus, B. ignites and B. ardens) was examined. A high (84-100%) fruiting rate and almost no puffy fruits (0-7%) resulted from pollination by these Japanese bees (Asada and Ono, 1996). Sanz and Serrano (2006) recorded the carpenter bee activity on sweet pepper to determine the fruit quality in green-house and found that there is an increase in the seed set per fruit.

They recorded49.8% and 40.7% more seed set than the control (27.5% and 25.71%) in two varieties. In India the studies on effectiveness of carpenter bees pollination under protected as well as open conditions are meager and a very few attempts have been made for evaluating the pollination efficiency of carpenter bee to boost the production of vegetable crops. Keeping all this view, the present studies were, therefore under taken.

MATERIALS AND METHODS

The present studies were carried out at the Department of Agronomy, University of Uyo, Akwa – Ibom State, Nigeria. A 200m2poly-house was selected for experiment. The total area of the poly-house has been divided into two by using insect proof net in the middle. In one of the portion laboratory reared carpenter bee (Xylocopa violacea) colony (13-15) was placed at the time of flowering (5-10%) of the crop while the second portion was control plot (without carpenter bee).The spacing was 90cm x 30cm from plant to plant and row to row. The data were recorded on ten randomly selected plants for eight replications from both treatment plots (carpenter bee pollinated and control plot) for all the productivity and quality characters of the crop.

RESULTS AND DISCUSSION

Carpenter bee pollination influenced significantly all the quality and productivity parameters of tomato assessed in this study (Table 1). Carpenter bee pollination resulted in higher number of fruits per cluster and plant i.e. 6.76 and 75.80 fruits, respectively as compared to control (3.33, 37.38) treatment without bee pollination. Bee pollinated tomato flowers produced tomatoes that were significantly larger in size (fruit length and breadth 5.16 and 5.75cm, respectively) than control treatment and heavier (93.87g) than produced from flowers without bee pollination. A noteworthy difference in yield was recorded for both the treatments, control and the bee pollinated plants.

The bee pollination treatment recorded significantly higher (12.7 kg/m2) fruit yield than the control (6.86 kg/m2) and resulted in an increase of 64.79% over control (Fig. 1 and Table 2). The number of healthy fruits was also higher in carpenter bee pollinated tomato plants (93.33%) than control (76.54%). Xylocopa violaceapollinated plants accounted 38.41 per cent increase in the number of fruits per plant and 21.9 per cent increase in healthy fruits over control plants. Minimum numbers (9.8) of misshapen were observed in Xylocopa violaceapollinated plants.

Fifty four per cent decreases in number of misshapen fruits were observed in carpenter bee pollinated plants as compared to control plants (Fig.1 and Table 2). The carpenter bee treatment recorded significantly higher (102.95) seed number per fruit than control (59.50). Similarly 1000 seed weight was statistically higher (6.32g) for bee pollinated tomato than without bee (3.53).

Similarly, an increase in the percentage of fruit length, breadth, fruit weight and fruit yield of tomato were recorded in the crop pollinated by carpenter bees and was recorded to be 46.45, 50.82, 64.94 and 57.66%, respectively over the crop without bee pollination (control). Simultaneously percent increase in the seed number and weight (1000 seeds) was recorded to be 78.54 and 78.80 in carpenter bee pollinated plants.

Carpenter bee pollination significantly increased the percentage of fruit set (number of fruits per cluster and per plant), fruit size (length and breadth), fruit weight and yield of tomato crop as compared to crop without bee pollination. Our results indicate that Xylocopa violacea pollination resulted in enhanced quality and quantity of tomato fruit grown under protected conditions.

The data recorded on number of fruits per cluster showed that carpenter bees enhanced the number of fruits per cluster and the fruit weight significantly as compared to control (Table 1).

Table1. *Comparison of Mean ± S.E number of fruits per cluster, number of fruits per plant, fruit length, fruit breadth, fruit weight, fruit yield, healthy fruits, misshapen fruits, number of seed per fruit and 1000 seed weight between bee pollinated and without bee (control).*

Parameter	Treatment	
Carpenter Bee Pollination	**Control (without bee pollination)**	
Number of fruits per cluster	6.76±0.18	3.33±0.17
Number of fruits per plant	75.80±0.78	37.38±0.51
Fruit length (cm)	5.16±0.49	3.52±0.133
Fruit breadth(cm)	5.75±0.32	3.81±0.87
Fruit weight(g)	93.87±1.07	59.75±0.52
Fruit yield (kg/m2)	12.7±0.12	6.86±0.22
Healthy fruits (%)	90.33±4.5	76.54±2.42
Misshapen fruits (%)	9.8±0.46	22.8±0.64
Number of seeds per fruit	102.95±1.52	59.50±2.08
1000 seed weight (gm)	6.32±0.36	3.53±0.03

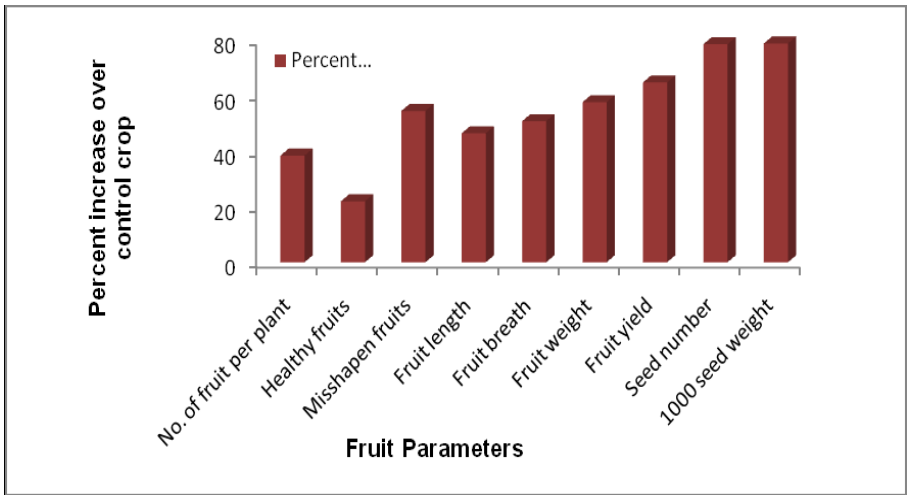

Figure1. *Influence of carpenter bee pollination on fruit parameters of tomato over Control (Crop without pollinator)*

Table2. *Percent increase in the quality and productivity parameters of tomato grown under poly house conditions with Xylocopa violacea pollination.*

Quality parameters	Percent increase
No. of fruit per plant	38.41
Healthy fruits	21.94
Misshapen fruits*	54.49 *
Fruit length	46.45
Fruit breadth	50.82
Fruit weight	57.66
Fruit yield	64.79
Seed number	78.54
1000 seed weight	78.80

These findings are in agreement with those of Al-Attal *et al.*, (2003) who studied the influence of different pollination techniques on green house tomato production and reported that the average cluster yield and fruit weight were significantly higher in the carpenter bee treatment. Dasgan *et al.*, (2004) reported 52.3 and 67.0% increase in number of fruits by carpenter bee pollination over vibration and growth regulator applicators, respectively. In the present studies, the fruit weight and size has been found to be increased in bee pollinated plants compared with control treatment which resulted in small fruits with less weight. Similar results have been reported by Neto *et al.*, (2013) and Hatami *et al.*, (2013) for carpenter bee pollination.

Flowers pollinated by carpenter bees gave fruits that looked better in shape and were plump without puffiness, harder and of uniform colour. Similar result was shown by Chauhan (2011) who reported less number of crooked fruits in carpenter bee pollinated cucumber plants compared to control. Asada and Ono (1996) also reported a high (84-100%) fruiting rate and almost no puffy fruit (0-7%) in carpenter bee pollinated tomato crop. The yield increases of carpenter bee pollination compared to non-bee pollination have been reported in earlier studies on various vegetables grown under poly-house viz cucumber (Chauhan, 2011), eggplant (Abak

and Gular, 1994). In the present study, the data recorded on number of seeds per fruit clearly indicate that carpenter bee pollination enhanced the number of seeds significantly as compared to control. These findings are in line with those of Vergara and Buendia (2012) and Neto *et al.*, (2013) who reported more number of seeds in tomato pollinated by *B. Ephippiatus* (201.00) and (183.94) as compared to control (139.03 and 59.63, respectively) grown inside polyhouse. Similar results were reported by Ahmad *et al.*, (2015) in carpenter bee pollination (126 seeds / fruit) as compared to manual pollination (102 seeds/fruit).

Seed count may be the most accurate method for determining levels of pollination because fruit weight is influenced by environmental conditions such as plant resources but not seed count (Picken, 1984).

Bee pollination significantly increased seed count over the non-bee pollination treatment indicating that carpenterbees are good pollinators. The present investigations clearly indicated that *Xylocopa violacea*provides high yield of tomato (*Lycopersicum esculentum*) over self-pollination (crop without pollinator) under poly-house conditions with respect to quantitative (number of fruits per cluster, number of fruits per plant, fruit weight, yield, seed number, 1000 seed weight) as well as qualitative (fruit size, and healthy rounder fruit) parameters of tomato seed and fruit.

It may be concluded that the carpenter bee pollination (*Xylocopa violacea*) in protected condition is better mode of pollination for pollinating tomato crop and should be exploited to enhance the yield and quality of tomato grown under protected condition.

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