International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 15, No. 3, p. 528-532, 2019

INNSPUB

RESEARCH PAPER OPEN ACCESS

Development and testing of mechanical pollinator for bell pepper in controlled environment agriculture

Zia-Ul-Haq*[1], Muhammad Rehan Jamil[1], Yasir Khalil[1], Muhammad Arslan Anwar[1], Yasir Mehmood[2], Muhammad Adnan Islam[3], Talha Mehmood[1], Sohail Raza Haidree[1], Hamza Muneer Asam[1]

[1]*Faculty of Agricultural Engineering and Technology, PMAS Arid Agriculture University Rawalpindi, Pakistan*

[2]*National Fertilizer Development Center, Ministry of National Food Security and Research Islamabad, Pakistan*

[3]*Agricultural Engineering Institute, Pakistan Agricultural Research Council Islamabad, Pakistan*

Key words: Sweet pepper, Greenhouse, Mechanical Pollinator, Yield

http://dx.doi.org/10.12692/ijb/15.3.528-532 Article published on September 30, 2019

Abstract

Off-season production of sweet pepper (*Capsicum annuum* L.) can achieve recommended consumption with high profit. The process of transfer of pollen grains from the male anther of a flower to the female stigma is known as pollination process. Usually it requires greenhouses construction. Many crops rely on insect pollination. However, insects are commonly not possible in greenhouses due to their control environment, which is a major pollination problem that can decrease fruit size and yield by directly reducing pollen deposition. To avoid this issue, a handy mechanical pollinator was developed with main components; DC motor, rod, battery (4 volts), cam on DC motor, oscillating device, switch, wires, battery connectors and rubber band at Faculty of Agricultural Engineering and Technology. For testing of machine an experiment was conducted at Institute of Hydroponic Agriculture, PMAS-Arid Agriculture University Rawalpindi in cropping season of 2018-19. It was experimentally manipulated artificial/mechanical pollination and its performance was compared with self-pollination. Data were recorded on diameter of fruits (cm), fruit weight per plant (kg), yield (t/ha). For statistical analysis, Statistix. 8.1 software was used by selecting Complete Randomized Design (CRD) with five repeats. All the parameters measured differed significantly. Artificial pollination increased fruit size, suggesting hypothesis that sufficient pollination increases plant fitness.

* **Corresponding Author:** Zia-Ul-Haq ✉ ziaulhaquaf@gmail.com

Introduction

Most of crops depend on insect pollination. Insufficient pollination can reduce fruit size and seed by directly reducing pollen deposition and can also affect the quality of offspring, such as growth rate and herbivore resistance. Fruit size and quality depends upon adequate pollination. Field experiments indicates that as compared to manual and self-pollination, bee pollination increased fruit size, seed set and germination rates, supporting the hypothesis that sufficient pollination increases plant fitness. Herbivorous resistance and plant growth did not differ between one visit to the honeybee and self-pollination, indicating multiple visits to pollinators was necessary to prevent inbreeding.

Bell pepper grown best in warm weather required best temperature range of 25-35°C. It is one of common consumed food of the world, was originated in Mexico and Central America, discovered by 1493 by Christopher Columbus (Kelley and Boyhan 2009).

Sweet pepper is the second largest vegetable after tom ato. It is one of the most valuable vegetables grown in sub-humid and semi-arid tropics in other regions. Over 26 million tons of pepper was produced worldwide in 2007. China ranked first, producing over 50% of the world's pepper, while the United States (U.S.) ranked sixth, producing around 855,000 tons (Aliyu, 2000).

Bell pepper (*Capsicum annum* L.) is commonly known as green pepper or shimla mirch (Sreedhara *et al.*, 2013). Its production increased from 11 to 28 million metric tons from 1990 to 2009. China produces (50%), Mexico (7%), Turkey (7%) and United States (15%) respectively (Tesfaw, 2013).

Produce new generation is the goal of every creature including plants. Process of transfer of pollen grains from the male anther of a flower to the female stigma is known as pollination process. Pollinators are considering being an important for the production of crops. Bumblebees are large in size as compare to the honeybees. Bumblebees have large hairs on their bodies than honeybees play a great role in the pollination of plants (Klein, 2013). Hydroponics plants are grown with the help of nutrient solution. In hydroponics crop production, the crop produced can be up to ten times higher compared to conventional agriculture and less space is needed. Water use efficiency of more than 80% is achieved in hydroponics crop production compared to growing crop in the soil (Sinsinwar and Teja, 2012).

Large quantity of pollen grains can increase seed production and fruit production and may also effect on qualities and behavior linked to generation quality, including germination rate, size, height, diameter of stem and seedling biomass (Eriksson, 2013).

Pollinator types vary in morphological characteristics and performances that decide their capacity to transferring pollen grains. The most effective pollinator classes are those occurring in high richness, randomly moving from flower to flower, pick the pollens and transfer many pollen grains in the stigmas (Benjamin, 2014).

For that matter, more focus is given to managements of pollinators particularly honeybees and bumblebees populations within agricultural environments. It is expected the efficiencies of natural and artificial pollinators classes through their inspection rate on the flowers of different crops (Abrol, 2013).

In Pakistan consumers demand for year-round vegetables supply while their import increase cost, beyond clients affordability. For off-season vegetable production tunnels and greenhouses are constructed. Presently farmers ignore artificial pollination for the controlled environment bell pepper production system, which result in low and poor quality produce. To avoid this problem a mechanical pollinator was developed at Faculty of Agricultural Engineering and Technology. Keeping in view the importance of artificial pollination, present study was planned to examine the performance of developed pollinator on crop response. It was concluded from the study that production of pollinated plants significantly higher as compared to un-pollinated plant under greenhouse condition.

Materials and methods

Study Area

Experiment for testing the performance evaluation of mechanical pollinator was conducted at Institute of Hydroponic Agriculture, PMAS-Arid Agriculture University Rawalpindi during the year 2018-19.

Development and testing of mechanical pollinator

Different material/elements; Soldering iron (kavia), Aluminum wire, Broza, DC motor, Magic, Rod, Battery (4 volts), Cam on DC motor, Oscillating device, Switch, Wires, Battery Connectors, Inside Casing, Outside Casing, Rubber Band were used in the fabrication of mechanical pollinator (Fig. 1). A soldering iron is a handy tool to supplies heat to melt solder so that it can flow into the joint between two work pieces. Steel rod was connected with device which converts circular motion into vibratory motion. Motion of motor is in circular but in this case vibratory motion is needed to the steel rod. For this purpose oscillating device is using. For vibratory motion, increase the dia. of DC motor shaft by using cam on DC motor and connected cam gear with vibrating rod. DC motor fitted into internal casing and enclosed the internal casing using the rubber bands. A secure connection of positive (+ve) and negative (-ve) wires was made with DC motor. These wires used to provide power supply from battery to DC motor. Connections were made with motor wires through switch which is used to open and close electric in series circuit by using the magic. Internal parts of pollinator were fitted into the casing for protection. After development of artificial pollinator, testing was conducted in one acre European model glasshouse for performance evaluation, and its comparison was made with self-pollinated bell pepper plants.

Plant growth parameters under controlled environment

Testing of mechanical pollinator was conducted on bell pepper under controlled environment. Production of artificial pollinated plants was compared with self-pollination plants. Crop parameter (diameter of fruits in cm, fruit weight per plant in kg and yield t/ha) for six treatment were recorded.

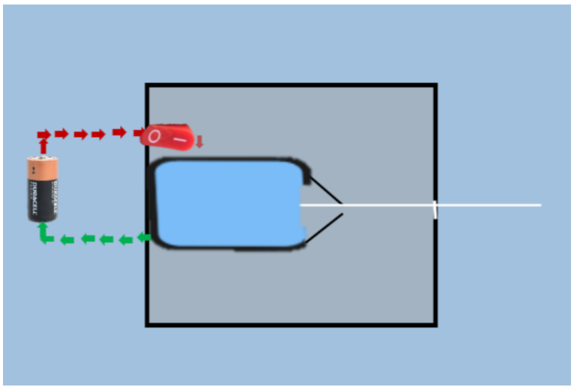

Fig. 1. Auto-cad view of mechanical pollinator.

Statistical analysis

The data measured was statistically analyzed by using, Statistix. 8.1 software by selecting Complete Randomized Design (CRD) with five repeats. All the parameters measured differed significantly. Artificial pollination increased fruit size, suggesting hypothesis that sufficient pollination increases plant fitness.

Results and discussion

Research was conducted for the development and performance evaluation of mechanical pollinator. Data recorded during experiment was statistically analyzed by using Completely Randomized Design (CRD) with the help of suitable software ''Statistix 8.1" at 5% level of probability. Measuring variables including; diameter of fruit and yield.

Plant diameter (cm)

Results of measuring variables with respect to fruit diameter and yield are given in Table 1. Mean fruit diameter in the different treatments (T_1, T_2, T_3, T_4, T_5 and T_6) was measured 10.7, 9.1, 10.2, 8.9, 9.6 and 7.9cm respectively. Maximum diameter (10.7cm) was measured in treatment T_1 (mechanical pollination on front side) while second highest diameter (10.2cm) was measured in treatment T_3 (mechanical pollination in center). Minimum diameter (7.9cm) was measured in treatment T_6 (Self Pollination in the end) of the greenhouse. Results of fruit diameter indicates that T_1 is non-significant with T_3 while results of T_1 are significantly different with T_2, T_4, T_5 and T_6.

Fruit weight per plant (kg)

Yield per plant in treatments (T_1, T_2, T_3, T_4, T_5 and T_6) was observed 8.6, 5.7, 7.9, 5.8, 7.7 and 5.4kg respectively. Maximum yield (8.6kg) was observed in T_1 (mechanical pollination on front side) while second highest yield (7.9kg) was observed in treatment T_3 (mechanical pollination in center). Minimum yield was observed in treatment T_6 (Self Pollination in the end) of the greenhouse. Maximum plant yield (215t/ha) was recorded in T_1 (mechanical pollination on front side) while minimum yield was observed in treatment T_6 (Self Pollination in the end) of the greenhouse. Statistical analysis indicates that yield in T_1 (mechanical pollination on front side), T_3 (mechanical pollination in center) and T_5 (mechanical pollination in end of greenhouse) were non-significantly different with each other while they were significantly different with T_2 (Self-pollination on front side), T_4 (Self-pollination in center), and T_6 (self-pollination in end of greenhouse). Results of present research is similar to the findings of scientists (Hanna, 2004; Cuellar *et al.*, 2001) who reported that pollination of flowers is very imperative and is required for the optimal fruit diameter and yield of quality vegetables. In protected environment it can be achieved manually, mechanically (electric vibrators and air blowers) or through use of bumblebees, depending upon crop. Mechanical pollination is more helpful as compared to self-pollination and also generate better yield.

Table 1. Effect of different treatments on fruit diameter and yield.

Treatments	Fruit dia (cm)	Yield (kg/plant)	Yield (t/ha)
T_1 (Mechanical pollination on front side)	10.7 a	8.6 a	215.0 a
T_2 (Self-pollination on front side)	9.1 bc	5.7 b	142.5 b
T_3 (Mechanical pollination in center)	10.2 a	7.9 a	197.5 a
T_4 (Self-pollination in center)	8.9 c	5.8 b	145.0 b
T_5 (Mechanical pollination in the end)	9.6 b	7.7 a	192.5 a
T_6 (Self-pollination in the end)	7.9 d	5.4 b	135.0 b
LSD	0.64	1.8	45

Mean with similar letters are statistically non-significant at 5% level of probability.

Results of measuring variables with respect to average fruit diameter and average yield are displayed in Table 2. Mean average fruit diameter of treatments T_1 and T_2 were measured 10.3 and 8.7cm respectively. Maximum average diameter (10.3cm) was measured in treatment T_1 (artificial pollination) while minimum average diameter (8.7cm) was measured in treatment T_2 (self-pollination). Results showed that treatment T_1 (artificial pollination) was non-significant with treatment T_2 (self-pollination) at 5% level of probability.

Yield (t/ha)

Mean average yield of treatment T_1 and T_2 was recorded 8.1 and 5.6kg/plant respectively. Maximum average yield (8.1kg/plant) was recorded in treatment T_1 (artificial pollination) while minimum average yield (5.6kg/plant) was recorded in treatment T_2 (self-pollination). Results showed that treatment T_1 (artificial pollination) was non-significant with treatment T_2 (self-pollination) at 5% level of probability. Mean average yield of treatment T_1 and T_2 was calculated 202.5 and 141.6 (tons/hectare) respectively. Yield difference of 60.9 tons/hectare was observed between mechanical and self-pollination in greenhouse environment. Performance of mechanical pollinator was satisfactory in all the locations of greenhouse while the yield difference at different location of greenhouse was observed due to variation in climatic factor i.e. temperature, humidity and sunlight etc. Present results of research was in line with the findings of researchers (Sabir and Singh, 2013) who reported that fruit setting depends on optimum light, temperature and increased CO_2 concentration.

Table 2. Effect of different treatments on average diameter and yield.

Treatments	Average diameter (cm)	Average yield (kg)	Average yield (Ton/ hectare)
T_1 (Artificial pollination)	10.3 a	8.1 a	202.5 a
T_2 (Self-pollination)	8.7 b	5.6 b	141.6 b
LSD	1.2	0.8	20.2

Mean with similar letters are statistically non-significant at 5% level of probability.

Conclusion and recommendation

It was concluded that mechanical pollinated sweet pepper yield was significantly higher as compare to the self-pollinated. It is recommended that mechanical mode of pollination should be adopted to improve fruit quality and yield under greenhouse environment.

Acknowledgments

I am highly thankful to Dean, Faculty of Agricultural Engineering and Director, Institute of Hydroponic Agriculture for providing me opportunities and facilities required during this research.

References

Abrol DP. 2013. Pollination biology: biodiversity conservation and agricultural production. New York.

Aliyu L. 2000. The effects of organic and mineral fertilizer on growth, yield and composition of pepper. Biological Agriculture and Horticulture **18,** 29-36

Benjamin FE, Winfree R. 2014. Lack of pollinators limits fruit production in commercial blueberry (*Vaccinium corymbosum*). Environ. Entomol **43,** 1574-1583.

Cuellar J, Cooman A, Arjona H. 2001. Increase of the productivity of a greenhouse tomato crop improving the pollination. Agronomia Colombiana **18(3),** 39-45.

Eriksson O. 2013. A comparative study of seed number, seed size, seedling size and recruitment in grassland plants. Oikos **88,** 494-502.

Hanna HY. 2004. Air blowers are less effective pollinators of greenhouse tomatoes than electric vibrators but cost less to operate. Hort. Technology **14(1),** 104-7.

Kelley WT, Boyhan G. 2009. Commercial Pepper Production Handbook. The University of Georgia, Cooperative Extension.

Klein AM. 2009. Nearly rainforest promotes coffee pollination by increasing spatio-temporal stability in bee species richness. Forest Ecology and Management **258,** 1838-1845.

Sabir N, Singh B. 2013. Protected cultivation of vegetables in global arena: A review. Indian Journal of Agricultural Sciences **83(2),** 123-35.

Sinsinwar S, Teja K. 2012. Development of a cost effective, energy sustainable hydroponic fodder production device. Agri. Engineering Interns. III, Kharagpur p 335.

Sreedhara DS, Kerutagi MG, Basavaraja H, Kunnal LB, Dodamani MT. 2013. Economics of capsicum production under protected conditions in Northern Karnataka. Karnataka Journal of Agricultural Sciences **26,** 217-219.

Tesfaw A. 2013. Benefit-cost analysis of growing pepper: A trial at west Gojjam, near the source of blue Nile. International Journal of Agriculture and Crop Sciences **6,** 1203-1214.