International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Role of Pollinators and Effectiveness of three Pollination Methods on the Yield of Pumpkin (*Cucurbita Pepo*) at Ashanti - Mampong Campus of College of Agriculture Education in Ashanti Region of Ghana

E. B. Borketey-La

Department of Crop and Soil Sciences Education, Faculty of Agriculture Education, University of Education, Winneba, Mampong-Ashanti, Ghana

Abstract: ***The experiment was conducted at the multipurpose experimental field of the University of Education, Winneba, Mampong – AshantiCampus. The objective was to investigate into the pollination of pumpkin (Cucurbita pepo). The Randomized Complete Block Design (RCBD) was used with three treatments replicated three times. It was observed from the results that most of the foraging activities of bees often occur in the morning (6:00 am – 11:00 am) but from (12:00-6:00pm) their activities reduce drastically. Fruit set, fruit size, weight and number of seed increased as the number of visits by Apis mellifera also increases per female flower, at which the highest fruit set level was reached. The treatments were Hand pollination, Open/Insect pollination and No pollination. It was found out that, with the exception of fruit length and weight the hand pollination was very significant (p < 0.05) onSeed weight, Number of seed per fruit, Pericarp of fruit and Diameter of fruit. The flowers which were Hand pollinated produced the highest mean values for the yield parameters, followed by the Open/Insect pollinated flowers and No pollination which yielded no fruit respectively. Farmers in and around Mampong –Ashanti can adopt hand pollination for better pumpkin yield and increased profit.***

Keywords: Pumpkin, Hand, Open/Insect and No Pollination, Temperature and Pollinators

1. Introduction

Pumpkin, *Cucurbitapepo* (genus; *Cucurbita:* Family; Cucubitaceae (Zhang*et al*, 2015), isexotic to Ghana and Mampong municipality. It is believed to have originated from America with China, India, Ukraine, Mexico, Canada and United States being the largest producing countries in the world (Durante *et al.*,2014,Poushter 2016 and Kousik *et al.*, 2015). United States is now the leading producing country in the world. Pumpkin is one of the most popular crops in the United States; 680,000,000 kilograms or 680,000 tonnes of pumpkins are produced each year. In Ghana, Pumpkin is commonly cultivated in the rural areas on subsistence basis mostly in backyard gardens for its leafy vegetable although the fruit is also consumed in the Northern and Volta regions of the country (Arto *et al.*, 2014 ,Conti, 2017 and Richter,2015).

Pumpkin encompass a wide range of fruit types with regard to size and shapes ranging from globosely to pear-shaped, elongated or flattened; smooth, ribbed or furrowed skin (VIDYA, 2015). Colours vary from green, white and blue grey to yellow, orange or red depending on the species (Wu*et al.*, 2016). All pumpkins have hard skin when matured. *Cucurbita moschata* is the most commonly used in both Asia and the United States (Wellenreuther*et al.*, 2014 and Welbaum, 2015).

Pumpkin provides valuable source of carotenoids, provitamin A and ascorbic acid which have major roles in nutritional aspect as well as an antioxidant.

Current research indicates that a diet rich in foods containing beta carotene may reduce the risk of developing certain types of cancer and offers protection against heart disease. The carotenoid content in Spanish pumpkin was reported to be higher than other pumpkins and even higher than carrots which contained beta- carotene (Pessarakl, 2016). The yellow colour of the pumpkin can be used as natural colour. Pumpkin flour is used because of its highly-desirable flavour, sweetness and deep yellow-orange colour. It is used to supplement cereal flours in bakery products, soups, sauces, instant noodle, spice as well as a natural colouring agent in pasta and flour mixes. Pumpkin is rich in carotene, vitamins, minerals, pectin and dietary fibre (Wellenreuther*et al.*, 2014 and Welbaum, 2015). The active polysaccharides from the pumpkin fruit could increase the levels of serum insulin and thusreduce the blood glucose levels which improve tolerance of glucose, and therefore could be developed as new anti-diabetic agen**t**; these results have drawn the interest among researchers and consumers to investigate into its production (Simpson and Morris*2014*). Pumpkin seed has also been used in traditional medicine with combination from several plants and herbs which contain fatty acids. The seeds are used in the treatment of benign prostatic hyperplasia (García-Parra *et al.*,2018 and Baiano *et al.*, 2016).

Pollination of pumpkin is done by insects of which native bees of the genera *Peponapis* and *Xenoglossa* are excellent pumpkin pollinators (López-Uribe *et al.*, 2016 and Jewett,

201). These pollinators transfer pollen from the male blooms to the female blooms and that process set fruit. Commercial growers rely heavily on bees to pollinate their pumpkin crop for the best yield. A female pumpkin flower requires about fifteen (15) visits from pollen-carrying bees for successful pollination and quality fruit development (Milanović *et al*., 2017).

The study was aimed at investigating into the Role of Pollinators and Effectiveness of three Pollination Methods on the Yield of Pumpkin (*Cucurbita Pepo*) at Ashanti- Mampong Campus of the College of Agriculture Education in the Ashanti Region of Ghana.

2. Materials and Methods

The study area
Description of the Study Area

2.1 Geographical Location

The experiment was conducted at the multipurpose experimental field of the University of Education, Winneba, Mampong – Ashanti Campus, which is in the transitional zone between the forest zone and the northern savannah zone of Ghana. The area is geographically located between 07° 04´ 45.8´´ degrees north and longitude 001° 23´ 49.9´´ degrees west on the Equator and have an altitude of 393m.

2.2 Experimental Design

The experimental design used was the Randomized Complete Block Design (RCBD) with three (3) treatment and three replications. Each treatment was randomly allocated to the experimental plots. The planting distance used was 100cm x 100cm. The plants density on the field was twenty four (24) plants per plot totaling four hundred and thirty two (432) with two plants per stand. The area was measured to be 26m x 20m was demarcated after it has been ploughed on the 20th September, 2017. The length of the area, thus 26m contained three plots in a row. The width also measured 20m contained three plots across the row, which constituted a total land area for the experiment covered 1316m² in a perimeter of 180m, which was calculated with the help of a GPS (Global positioning system) machine.

2.3 Data Collection

Sampling and Collection of Pollinators
The survey for pollinators was conducted from 7th – 14th of December, 2017. Sampling was done by the researcher. The method that was used to sample pollinators was similar to (Antonios *et al*., 2015 and Milanović *et al*., 2017). A quadrant measuring 8m x 6m was demarcated (Milanović *et al*., 2017) and six (6) plants 4m apart were sampled and tagged.

Hourly observation begun from 06:00am to 06:00pm for foraging and pollinators counts was done on flowers. Observations were made under conditions favorable for insects' flights, sunny or cool weather and weak wind. Sweep net was used to sample pollinators on the blooms of pumpkin. Sampling was done to collect insects visiting flowers of pumpkin blooming (Milanović *et al*., 2017 , Simpson and Morris, 2014). A visit was defined as occurring when an insect touched the anthers or stigma.

During the hourly observation, insect activities were observed and recorded under the following: insects that visited female flowers, insects that visited male flowers, insects that visited male flowers and moved to female flowers and those insect that visited female flowers and moved to male flowers. Each selected flowers was observed for five (5) minutes throughout the period of observation (6:00am – 6.00pm).

Weekly observations of the foraging insects and pollinator counts were also done on the flowers on the plants. Sampling was done from 06:00hr – 12:00hr. Each flower was observed for five minutes. The sampled insects were killed by drowning in soapy water, cleaned water by shaking and preserved in 70% alcohol.

Samples of preserved insects were sent to taxonomist at the insect museum of the Entomology and wildlife Department for identification. Dried and preserved specimens of insects' pollination were kept in the insect museum of the Department of Entomology and wildlife, University of Cape Coast.

During the weekly observation, insect activities were observed and recorded under the following: insects that visited female flowers only, insects that visited male flowers only, insects that visited male flowers and moved to female flowers and those insect that visited female flowers and moved to male flowers. The selected flowers were observed for five (5) minutes in an hour bases throughout the period of observation (6:00am - 12:00hr).

Estimation of Fruit-Set and Proportion of Bee Contribution to Fruit - Set.
Pumpkin crop fruit-set was calculated as a proportion of total flower buds that set fruit over the total number of flower buds examined per experimental pumpkin pollination. The proportion of bee contribution to fruit-set (open-pollination - pollination exclusive) was calculated (Melathopoulos*et al*., Potter 2015 and Delaplane, *et al*, 2013). It is a measure of the approximate contribution of bees to the fertilization of pumpkin flowers. The number of pollinators encountered per plant was taken as abundance.

2.4 Comparison of Types of Pollination

Hand Pollination
Before the beginning of the Hand pollination, Flower buds were observed and covered with nylon net (muslin) in the evening to prevent landing of pollen on the stigma a day before the flower buds opens and dehisces for hand pollination. Five (5) female flower buds were selected for each level of pollination. After the opening and dehiscing of the buds, the selected buds were pollinated seven (7) times, five

(5) times, three (3) times and once (1) as the levels of pollination for fruit-set. During the hand pollination, the anthers from the male flowers were carefully rubbed on the dehisced surface of the stigma of the flower for the pollen to be glued on the stigma to set fertilization.

Open (Natural/Cross) Pollination

Fruit– set refers to the overall process of pollination and early growth of pumpkin fruit. Open pollination is a type of pollination where insects (bees, especially the honey bee) play important role. Before open pollination took place, flower buds were observed and covered with a nylon net (muslin) in the evening to prevent landing of pollen on the stigma a day before the flower buds opens and dehisces. Pollination took place in the morning because the weather then encourages insect flight and foraging activities. Five (5) female flower buds were selected for each level of open pollination for fruit set. During the pollination, nylon net (muslin) was removed after the bud had opened and the flower dehisced. The dehisced flowers weare observed for touching of bee for pollination after that the flowers were covered again to prevent further pollination. The observation was done for the various level of pollination, thus seven (7) times, five (5) times, three (3) times and once.

No Pollination

Flower buds were also covered to prevent pollination in other to observe whether fruits would be formed in pumpkin if the flowers are not pollinated. The number of fruit formed when covered were noted and recorded.Weights of the three selected fruits of the various level of pollination for different method of pollination were taken on a top-pan weighing scale and their means were calculated.Thickness of the pericarp per fruit of the selected fruits were measured, by the use of venire calliper and their means computed according to the levels of pollination for both Hand and Open pollination treatments.

Number of seeds per fruit of the various treatments was counted after they have been extracted from the fruit of both Hand and Open pollination methods. Their weights were also measured, by the use of electronic kitchen scale.Diameter of fruit for the various treatments were measured by the use of measuring tape after it has been rolled over the bulb of the fruit and stretched over the meter rule for the reading.

2.5 Analysis of Data

Data collection began 50 days after pollination. Three fruits were selected from each Treatment and therefore 12 fruits were selected from each of the three experimental plots for the determination of yield and yield components. Analysis of variance method (ANOVA) was used to determine the level of significance among the three pollination methods with respect to the data collected. Data was also presented graphically to indicate the comparisons.

The proportion of bee contribution to fruit-set (open-pollination - pollination exclusion) was calculated as recommended by (Melathopoulos *et al*., Potter 2015 and Delaplane, *et al.*, 2013).Means were calculated on the number of seeds per three selected fruits from the various levels of pollination after the fruit were harvested, the weight of the three selected fruits were also calculated based on the different level of pollination and different pollination methods, the thickness of the pericap of the fruit, the weight of seeds of the fruit, mean of the diameter of the fruits of the different level of pollination and the different methods of pollination were also calculated and compared.

Diurnal foraging pattern of pollinators

From the study, it was observed that Honey bees (*Apis mellifera*) were the most abundant and frequent insect that visited the flowers of pumpkin (*Cucurbita pepo*) vines. The mean time of foraging of bee per flower was 42.0 seconds.
From the result (fig. 1), there were a higher number of bees foraging in the morning (6:00am to 11:00am) but from noon onwards (12:00pm to 6:00pm) the number of bees foraging declined with lower number of foraging.The number of bees that visited the male flowers was higher than those that visited the female flowers. A relative lower population moved from the male to the female flowers. The bees that moved from the female to the male were fewer than those that moved from male to female flowers.

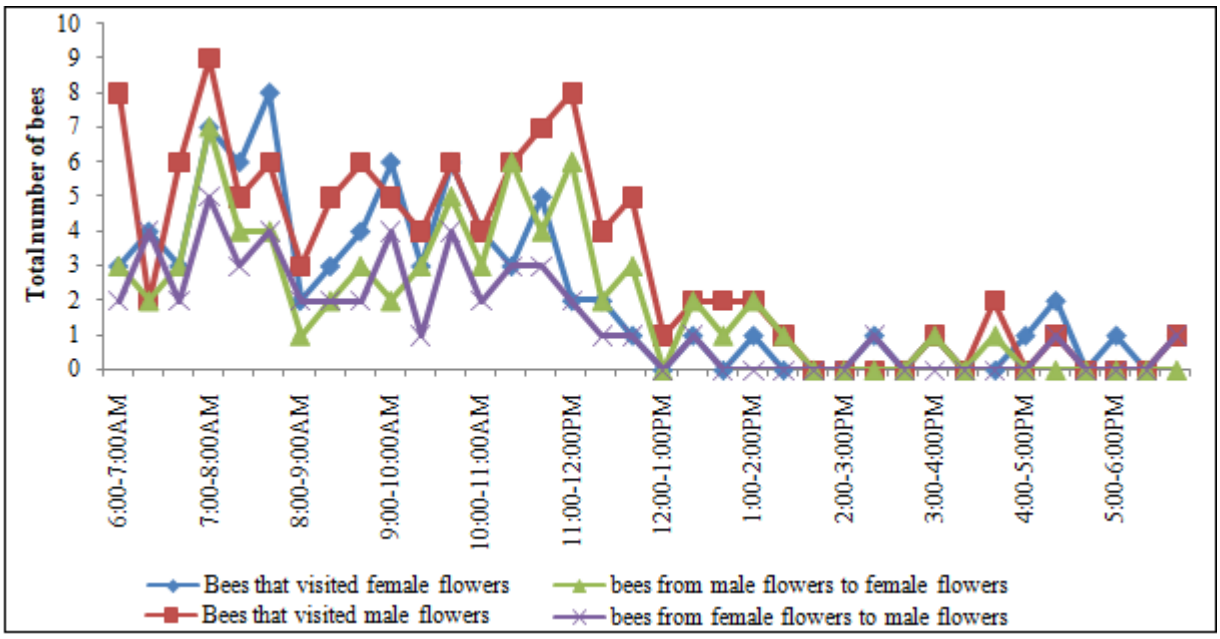

Figure 1: Diurnal foraging pattern of pollinators

Major pollinators of pumpkin fruit set

Results from the field indicated that four (4) species of insects belonging to the orders Hymenoptera, Diptera and Lepidoptera visited pumpkin flowers. They consisted of Honeybee, Housefly, Butterfly and Dragonfly (Table 1).Honey bee constitute 82% of the flower visitors, and they were therefore the dominant insects. They were followed by Housefly 10%, Butterfly 5% and Dragonfly 3% (Table 1). Honey bees foraged either for nectar or pollen. Some bees were seen carrying pollen grains in their corbicula (pollen basket) others left the flower without any visible sign of carrying pollen; they may be carrying nectar (leaving the flower with nectar).

Table 1: Types of insects that visited the flowers

Type of insect	No. of insect on flowers	%
Honey bee (Hymenoptera)	49	82
House fly (Diptera)	6	10
Butter fly (Lepidoptera)	3	5
Dragon fly (Hymenoptera)	2	3

Comparison of three different pollination methods (Hand, Open and Self – pollination)

From the results for the comparison of three pollination methods for yield and yield parameters indicated that, Hand pollination was better than Open-pollination. Self-pollination however did not yield fruit throughout the experiment. This means that pumpkin is cross-pollinated and Honey bees are the main pollinators. Statistical analysis using ANOVA indicated that Self-pollination was significantly ($P<0.05$) lower than Hand and Open-pollination which were not significantly ($P<0.05$) different from each other for fruit length (cm) and fruit weight (kg). For fruit diameter (cm), fruit pericarp thickness (cm), number of seed and seeds weight (g) of Self-pollination was significantly lower ($P < 0.05$) than Open pollination which was also significantly($P < 0.05$) lower than Hand pollination.

Table 2: Effectiveness of three different pollination methods (Open, Hand and No pollination)

Treatment	Mean fruit Length (cm)	Mean fruit diameter (cm)	Mean Fruit Pericap (cm)	Mean Number of seed	Mean seed Weight (g)	Mean fruit Weight (kg)
Hand Pollination	2.96b	2.29b	2.48b	365.25b	254.42b	10.05b
Open Pollination	2.84b	2.01c	1.75c	255.08c	190.17c	7.43b
Self-Pollination	0a	0a	0a	0a	0a	0a
Mean	1.46	1.32	1.31	11.81	10.16	2.24
LSD ($P<0.05$)	0.057	0.03	0.06	0.75	0.23	0.67

Means followed by the same letter in superscript are not significantly different based on least significant (LSD) test at 95% significance level.

Influence of level of Pollination on Yield of Pumpkin

From the results amount of pollination for hand and open pollination seem to increase the yield of pumpkin. Mean fruit weight increased from 1.567kg for single pollination to 3.033kg for pollination seven times in hand pollination (Table 3) whilst for open pollination it increase from 1.200kg for singe pollination to 1.867kg for pollination seven times (Table 3). Fig. 2 and 3 below shows the comparison between single and seven times pollination in Hand and Open pollination.

Table 3: Influence of amount of pollination on the yield of Pumpkin

Treatment	Hand pollination Mean Weight of fruit(kg)	Open pollination Mean Weight of fruit(kg)	Self-pollination Mean Weight of fruit(kg)
Single pollination	1.567	1.200	0.00
Three times pollination	2.033	1.467	0.00
Five times pollination	2.100	1.500	0.00
Seven times pollination	3.033	1.867	0.00
Mean	2.183	1.508	0.00
LSD ($P<0.05$)	0.59**	0.14***	N/A

Hand pollinated **Open / Insect pollinated**

Figure 2: Comparing single pollinated fruits

Hand pollinated **Open / Insect pollinated**

Figure 3: Comparing seven times pollinated fruits

Diurnal foraging pattern of pollinators of pumpkin

During the period of the experiment it was observed that *Apis mellifera* (Honey bee) were the most frequent insects on the flowers of pumpkin plants. Honey bee (*Apis mellifera*) has been reported as a major pollinator (Godfray*et al.*, 2014, Goulson *et al.*, 2015). From the results in figure 1, it can be deduced that most of the foraging activities of bees often occur in the morning (6:00am-11:00am) but from (12:00pm-6:00pm) their activities gradually decline drastically. Intense foraging of Honey bees occurs in the early morning from 9:00am when temperature is not so high between 20^0C to 29^0C. By 12:00pm when temperature is very high bees recede to the cooler areas of the environment (Kastbergei, *et al.*, 2016).

ajor pollinators of pumpkin and their role in fruit set

The study has revealed Honey bee (*Apis mellifera*) as the most predominant pollinator of pumpkin (*Cucurbita pepo*). In earlier studies bees have been reported as important pollinators of pumpkin (Godfray *et al.*, 2014, Goulson *et al.*, 2015). *Apis mellifera* has also been reported as a major pollinator of Agriculture crops (Giannini, *et al*., 2015) and the World's dominant pollinator (Powell, *et al*., 2014).

Influence of hand pollination, open/insect pollination and self-pollination on the yield of pumpkin

It was observed that the methods of pollination showed tremendous differences in fruits size, fruits weight, seed weights, thickness of pericap, diameter of fruits and fruit lengths (Kaur, 2016 and Nantoume*et al.*, 2012).The analysis of the results on the mean of seed weight, number of seed per fruit, thickness of pericap and the diameter of fruit, showed a significant but there was no significant difference between the fruit length and fruit weight. The variations in the mean in the seed weight, number of seed per fruit, thickness of pericap and the diameter of fruit recorded between the hand pollination and open/insect pollination and self-pollination treatments might be due to the number of pollen that were glued on the stigma.

Influence of level of Pollination on Yield of Pumpkin

It was observed that the levels of pollination within the Hand and Open pollination increased in size of fruit, fruits weight, seed weights, thickness of pericap, diameter of fruits and fruit lengths as the amount or eve of pollination increase. This is consistent with (Kaur, 2016 and Nantoume*et al.*, 2012) who reported that higher amount of pollination increases fruit set, fruit size, fruit weight and the number of seeds.

3. Conclusion

It was observed that a higher number of bees foraged in the morning (6:00am to 11:00am) but from noon onwards (12:00pm to 6:00pm) the number of bees foraging declined drastically. The mean time of foraging of bee per flower was 42.0 seconds. The number of bees that visited the male flowers was higher than those that visited the female flowers.

The study has revealed Honey bee (*Apis mellifera*) as the most predominant pollinator of pumpkin (*Cucurbita pepo).* Although Housefly, Dragonfly and Butterfly were seen hovering around.

The results of the analysis revealed that, Seed weights, number of seeds per fruit, the thickness of pericap and the

diameter of fruits were very significant ($p < 0.05$) base on hand pollination with fruits Length and fruits weight which were not significant ($p > 0.05$) according to the analysis of the Data collected. The Hand pollination treatment yielded fruits of higher numbers of seeds, higher weights of fruits, higher thickness of pericap, and higher weight of seeds, higher diameter of fruits than Open/Insect pollinated treatment.

From the results, amount of pollination for hand and open pollination increased the yield of pumpkin. Mean fruit weight increased from 1.567kg for single pollination to 3.033kg for pollination seven times in hand pollination (Table 3) whilst for open pollination it increase from 1.200kg for singe pollination to 1.867kg for pollination seven times (Table 3).

4. Recommendation

1) Farmers of pumpkin should not spray insecticides in the morning as that is the active period for foraging bees.
2) Honey bees are the major pollinators of pumpkin; they should not be sprayed when found in a pumpkin farm. Commercial pumpkin farmers should add apiculture to their activities to enhance pollination and fruit formation.
3) Farmers who are into pumpkin production can use hand pollination to significantly achieve good seed weight, high number of seed, thick Pericap as well as large diameter of fruit.
4) Farmers who are into pumpkin production can increase the amount of pollination from seven (7) to twelve (12) for bigger fruits of pumpkin.

References

[1] Antonios, G., Borgers, H., Richard, B. C., Brauß, A., Meißner, J., Weggen, S. ...& Matthews, D. (2015). Alzheimer therapy with an antibody against N-terminal Abeta 4-X and pyroglutamate Abeta 3-X. *Scientific reports*, *5*, 17338.

[2] Arto, I., Rueda-Cantuche, J. M., Andreoni, V., Mongelli, I., & Genty, A. (2014). Thegame of trading jobs for emissions. *Energy policy*, *66*, 517-525.

[3] Baiano, A., & Del Nobile, M. A. (2016). Antioxidant compounds from vegetable matrices: Biosynthesis, occurrence, and extraction systems. *Critical reviews in food science and nutrition*, *56*(12), 2053-2068.

[4] Conti, V. (2017). *Gendered Crops from an Intersectional Perspective: Which Factors Influence Women's Dry-Season Farming Choices?* (Master's thesis).

[5] Delaplane, K. S., Dag, A., Danka, R. G., Freitas, B. M., Garibaldi, L. A., Goodwin, R. M., & Hormaza, J. I. (2013). Standard methods for pollination research with Apis mellifera. *Journal of Apicultural Research*, *52*(4), 1-28.

[6] Durante, M., Lenucci, M. S., & Mita, G. (2014). Supercritical carbon dioxide extraction of carotenoids from pumpkin (Cucurbita spp.): a review. *International journal of molecular sciences*, *15*(4), 6725-6740.

[7] García-Parra, J., González-Cebrino, F., Delgado-Adámez, J., Cava, R., Martín-Belloso, O., Elez-Martínez, P., & Ramírez, R. (2018). Application of innovative technologies, moderate-intensity pulsed electric fields and high-pressure thermal treatment, to preserve and/or improve the bioactive compounds content of pumpkin. *Innovative Food Science & Emerging Technologies*, *45*, 53-61.

[8] Giannini, T. C., Boff, S., Cordeiro, G. D., Cartolano, E. A., Veiga, A. K., Imperatriz-Fonseca, V. L., & Saraiva, A. M. (2015). Crop pollinators in Brazil: a review of reported interactions. *Apidologie*, *46*(2), 209-223.

[9] Godfray, H. C. J., Blacquiere, T., Field, L. M., Hails, R. S., Petrokofsky, G., Potts, S. G., ... & McLean, A. R. (2014). A restatement of the natural science evidence base concerning neonicotinoid insecticides and insect pollinators. *Proc. R. Soc. B*, *281*(1786), 20140558.

[10] Goulson, D., Nicholls, E., Botías, C., & Rotheray, E. L. (2015). Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. *Science*, *347*(6229), 1255957.

[11] Jewett, C. T. (2017). *An assessment of pollinator abundances and environmental relationships at cultivar, field, and landscape scales in cultivated pumpkins on the Texas High Plains* (Doctoral dissertation).

[12] Kastberger, G., Waddoup, D., Weihmann, F., & Hoetzl, T. (2016). Evidence for Ventilation through Collective Respiratory Movements in Giant Honeybee (Apis dorsata) Nests. *PloS one*, *11*(8), e0157882.

[13] Kaur, N. (2016). *Genetic analysis of important economic traits and validation of molecular markers linked to hull-less seed trait in pumpkin (Cucurbita pepo subsp. pepo var. styriaca)*(Doctoral dissertation, Punjab Agricultural University, Ludhiana).

[14] Kousik, C. S., Levi, A., Wehner, T. C., & Maynard, D. N. (2015). Cucurbitaceae (Vine Crops). *eLS*.

[15] López-Uribe, M. M., Cane, J. H., Minckley, R. L., & Danforth, B. N. (2016). Crop domestication facilitated rapid geographical expansion of a specialist pollinator, the squash bee Peponapis pruinosa. *Proc. R. Soc. B*, *283*(1833), 20160443.

[16] Melathopoulos, A. P., Cutler, G. C., & Tyedmers, P. (2015). Where is the value in valuing pollination ecosystem services to agriculture?. *Ecological Economics*, *109*, 59-70.

[17] Milanović, V., Kasturi, A., Yang, J., & Hu, F. (2017, May). Closed-loop control of gimbal-less MEMS mirrors for increased bandwidth in LiDAR applications. In *Laser Radar Technology and*

[18] *Applications XXII* (Vol. 10191, p. 101910N). International Society for Optics and Photonics.Nantoume, A. D., Christiansen, J. L., Andersen, S. B., & Jensen, B. D. (2012). On-farm yield potential of local seed watermelon landraces under heat- and drought-prone conditions in Mali. *The Journal of Agricultural Science*, *150*(6), 665-674.

[19] Pessarakli, M. (Ed.). (2016). *Handbook of Cucurbits: Growth, Cultural Practices, and Physiology*. CRC Press.

[20] Potter, A., & LeBuhn, G. (2015). Pollination service to urban agriculture in San Francisco, CA. *Urban ecosystems*, *18*(3), 885-893.
[21] Poushter, J. (2016). Smartphone ownership and internet usage continues to climb in emerging economies. *Pew Research Center*, *22*.
[22] Powell, J. E., Martinson, V. G., Urban-Mead, K., & Moran, N. A. (2014). Routes of acquisition of the gut microbiota of the honey bee Apis mellifera. *Applied and environmental microbiology*, *80*(23), 7378-7387.
[23] Richter, K. (2015). Gone with the Wind…: Why Alcatrazes, the Second European Tropical Settlement, Vanished. *Mande Studies*, *16*(1), 119-167.
[24] Simpson, R., & Morris, G. A. (2014). The anti-diabetic potential of polysaccharides extracted from members of the cucurbit family: A review. *Bioactive Carbohydrates and Dietary Fibre*, *3*(2), 106-114.
[25] VIDYA, D. (2015). *DEVELOPMENT OF INSTANT FOOD MIXES FROM DEHYDRATED PUMPKIN (Cucurbita moschata Duch ex Poir)* (Doctoral dissertation).
[26] Welbaum, G. E. (2015). *Vegetable production and practices*. CABI .
[27] Wellenreuther, M., Svensson, E. I., & Hansson, B. (2014). Sexual selection and genetic colour polymorphisms in animals. *Molecular ecology*, *23*(22), 5398-5414.
[28] Wu, J., Zhang, H., & Du, S. (2016). Tunable luminescence and white light emission of mixed lanthanide–organic frameworks based on polycarboxylate ligands. *Journal of Materials Chemistry C*, *4*(16), 3364-3374.
[29] Zhang, G., Ren, Y., Sun, H., Guo, S., Zhang, F., Zhang, J., & Li, H. (2015). A high-density genetic map for anchoring genome sequences and identifying QTLs associated with dwarf vine in pumpkin (Cucurbita maxima Duch.). *BMC genomics*, *16*(1), 1101.