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THE INFLUENCE OF INSECT FLOWER VISITORS ON FRUIT SET AND POD DEVELOPMENT OF COWPEA (*VIGNA UNGUICULATA*) IN A LOCALITY OF CENTRAL REGION OF GHANA

HORDZI WHK*

Institute for Educational Development and Extension; University of Education, Winneba, Box 25, Winneba, Ghana

***Corresponding Author: E Mail: wisdomhordzi@gmail.com; wisdomhordzi2@yahoo.com**

ABSTRACT

It is possible to have both self-pollination and cross-pollination in cowpea. Meanwhile, whereas most of the cowpea pollination research findings reported from elsewhere and appear to be very ancient and scanty in depth and coverage it seems African and Ghanaian researchers have completely avoided reporting on cowpea pollination. Taking it that cowpea undergoes self- and cross-pollination it is not known which of the two gives higher fruit set and pod development. Hence, this study found out the influence of cowpea insect flower visitors on fruit set and pod development in a locality near Gomoa Ekwamkrom in the Central Region of Ghana. The likelihood of insect flower visitors as pollinators was estimated by comparing fruit set and pod development of flowers visited by insects with that of control flowers. A total fruit set of 284 (61.7%) and fruit set failure of 176 (38.3%) were recorded in the major rainy season. Flowers visited by *Megachile* sp. recorded higher fruit set (36.7%) than the flowers not exposed to organisms (26.7%). Chi square analysis showed very significant relationship between the expected and observed frequencies ($\chi^2 = 24.0$; $P = 0.001$). Flowers visited by *Megachile* sp. recorded higher pod development (46.1%) than flowers not exposed to organisms (control) (32.9%). The findings proved that pod development in cowpea can be higher for flowers visited and probably pollinated by insects than self-pollinated flowers. Hence, efforts should be made to conserve the two most promising insects (*X calens* and *Megachile* sp.) on cowpea flowers in the research area.

Key words: Cowpea, Pollinator, Flower Visitor, Fruit Set, Fruit Abortion

INTRODUCTION

A number of interactive relationships exist between plants and animals in the ecosystem. One of such relationships is the interaction between flowers and flower visitors. A flower visitor can be any animal that visits the flowers of a plant **[1]**. To attract visitors, plants use various cues such as shape, colour and smell, and they usually provide a food reward **[2]**. Many flower visitors end up causing pollination whilst others just end up obtaining food from the flowers and others are predators that feed on pollinators **[1]**. Pollination is the transfer of pollen grains from an anther to a receptive floral stigma **[3]**. Pollination takes place by means of animals (pollinators), wind and water. Pollinators are organisms that transfer pollen grains from the anther to the stigma of the same flower or different flower of the same plant or another plant of closely related species resulting in fertilization. According to **[2]**, pollinators are animals that provide pollination services. No animal pollinates flowers deliberately. They visit flowers for food, in the form of nectar, pollen and plant oils. Pollination precedes fertilization and fertilization results directly in the plant producing seeds and fruits **[3]**. Generally, pollination is an essential ecosystem service. Cross-pollination by insects is very key to the survival of many flowering plants. In the words of **[4],** insect pollination is an essential link in the ecological global chain. Because insects have become so adept at finding and identifying individual flowering plants, even rare plants may persist so long as pollination occurs **[3]**.

Pollinators are extremely important to agriculture and nature conservation **[2].** Cross-pollination brings about hybrid effects in plant progeny leading to qualitative and quantitative changes in the economic and biological development of the plants **[5]**. Some of such quantitative and qualitative changes stated by **[5]** are stimulation of germination of pollen on stigmas of flowers, increase in viability of seeds, embryos and plants; formation of more nutritive and aromatic fruits and increase in the vegetative mass and faster growth of plants. Others are increase in the number and size of seeds and yield of crops, increased nectar production in the nectarines of plants, increased fruit set and reduction in fruit drop, enhanced resistance to diseases, and increased oil content in oil seed crops **[5].** Also, **[3]** asserted that pollination is a service that is very key to agriculture. Just as pollination is pivotal to agriculture for quantity, quality and diversity of foods, fibres and medicines, it is also essential for maintaining biological diversity **[6]**.

However, can the above benefits of cross pollination be said about cowpea also?

Generally, cowpea (*Vigna unguiculata* [L.] Walp) is said to have originated in Africa, where it has become an integral part of traditional cropping systems, particularly in the semi-arid West African Savanna regions **[7]**. Worldwide, cowpea production has increased dramatically in the last 25 years **[8]**. Out of the world's total estimated production area of 10 million ha, Africa alone accounts for over 7.5 million ha of which about 70% lies in West and Central Africa **[9]**. Cowpea is grown mainly for its grain, which contains between 22 and 32% protein on a dry weight basis **[10]**. Therefore, cowpea grain which is valued for its high nutritive quality and short cooking time serves as a major source of protein in the daily diets of the rural and urban poor. Again, **[11]** and **[12]** reported that cowpea is high in protein, to the extent that the grain contains about 25% protein, making it extremely valuable where many people cannot afford protein foods such as meat and fish. Hence, the grain is one of the cheapest sources of protein in the diets of peoples of West and Central Africa **[10]**. The young tender leaves, pods and peas of cowpea are used as vegetables, whilst snacks and main meal dishes are prepared from the dried grain. The plant tolerates drought and fixes nitrogen, thus improving soil fertility. The ability of cowpea plants to tolerate drought and poor soils makes it an important crop in savanna regions where these constraints restrict other crops. After the cowpea pods have been harvested, the rest of the plant can be used as animal feed. Thus, farmers in the dry savanna use cowpea haulms as a nutritious fodder for their livestock. The plant's ability to fix atmospheric nitrogen helps maintain soil fertility, while its tolerance to drought extends its adaptation to drier areas **[13]**.

One major concern about cowpea is the controversy surrounding its mode of pollination. In the first place, remarkably little is known about pollinators in Africa. Virtually, nothing is known about the effectiveness **[3]** and mode of pollination in Africa. A search through the literature provides no or very little information on pollinators and pollination in Africa especially West Africa and particularly Ghana. Literature is so scanty or nonexistent on pollinators of our farm crops to the extent that a crop such as cowpea which is known to exhibit both self and cross-pollination **[14]** is generally considered as self-pollinated by many African research scientists. Since cross-pollination brings about hybrid effects in plant progeny leading to qualitative and quantitative changes in the economic and biological development of the plants then it is obvious that pollinators are extremely important to agriculture and nature conservation. Therefore, there are a lot of implications for the survival and perpetuation of cowpea varieties if the crop is only self-pollinated. However, the fact cannot be denied that cowpea is of tremendous value to mankind for that matter Ghanaians and people of low income bracket. Therefore, it will be in the interest of people of low income country like Ghana and dry regions to show more interest in understanding factors that co-exist with the crop in its natural settings that can enhance its productivity. Hence, the current study is just an attempt to understand how insects contribute to cowpea production in the research area.

Statement of the Problem

Majority of flowering plants require insects or other animals to mediate pollen transfer. However, different floral visitors can vary widely in their ability to transfer pollen **[15]**. The flowers of most plants are visited by diverse types of floral visitors **[16]**. However, there seems to be a controversy over the method of pollination of cowpea. Whilst one school of thought considers it to be self-pollinated **[8, 17, 18]**, another school of thought has it that it undergoes cross-pollination **[19, 20]**, whereas yet another school of thought has it that it undergoes both self- and cross-pollination **[21, 18]**. According to **[21]**, though autogamous, cowpea (*Vigna unguiculata* (L.) Walp) has a cross-pollination rate of 10%. They continued to state that over several years, the mean productivity of cowpea had declined suggesting a decrease in or absence of pollinating insects in the fields **[21]**.

In an attempt to throw more light on the controversy, it has been asserted that the cowpea flowers are often visited by honeybees or bumblebees **[22]** and various other insects that forage upon both the nectar and pollen. The pollen is sticky and heavy, indicating that the plant is not wind-pollinated **[14, 23]**. Meanwhile, **[19]** thought that bumblebees are the primary pollinators. Also, **[20]** confirmed this statement by stating that bees pollinate cowpea. The degree of cross-pollination varies considerably in different areas. In California with its dry climate cowpeas are considered almost entirely self-pollinated; in humid areas in the United States and Nigeria considerable cross-pollination occurs **[14]**. Thus, it is possible to have both self-pollination and cross-pollination. Whereas most of the cowpea pollination research findings were reported from elsewhere and appear to be very ancient and scanty in terms of depth and coverage it seems African and Ghanaian researchers have completely avoided reporting on cowpea pollination.

This may be attributed to the fact that African and for that matter Ghanaian researchers have concluded that cowpea is self-pollinated and hence there was no need venturing into further studies on it. Even, taking it that cowpea undergoes self- and cross-pollination which of the two gives higher fruit set and pod development? This has not been explicitly established. Hence, this study was initiated to find out the influence of cowpea insect flower visitors on fruit set and pod development in a locality near Gomoa Ekwamkrom in the Central Region of Ghana.

Objective

The specific objective of the study was to find out whether insect visited flowers would produce higher fruit set and pod development of cowpea (*Vigna unguiculata*) than non-insect visited flowers.

Research Question

- What special role do cowpea insect flower visitors play in fruit formation and pod development?

Hypotheses

- There are no differences between the number of pods formed from flowers visited by various insects and the control.

METHODOLOGY

A cowpea farm was established about one kilometer away from Ekwamkrom in the Gomoa District in the Central Region of Ghana. Ekwamkrom is about one kilometer away from Agona Swedru on the Winneba-Swedru highway. The experimental site was surrounded by a mixture of elephant grass and *Chromolaena odorata* commonly known in Ghana as Acheampong weed. Ekwamkrom is mostly surrounded by transition forest. The farm was 15 by 25 metres in dimension.

Cowpea farmers in the experimental area do major rainy season sowing between April and June while the minor rainy season’s sowing is done between August and October. According to **[24, 25]**, the transition forest zone sowing should be done from April to May in the major rainy season and from August to September in the minor rainy season. Since the experimental site was surrounded more by transition forest than forest itself the major rainy season sowing was done on 3rd April, 2006 and in the minor rainy season sowing took place on 21st September, 2006. It was also observed that farmers preferred a variety commonly called black eye to the nationally recommended varieties. A survey of bean sellers in the area revealed that black eye is commonly consumed by the public. The reasons given for this were that the variety is easy to cook and swells very much. Hence, black eye was the variety used for this experiment. The seeds were purchased from seed sellers. Three seeds were sown about 2.5cm deep per hole. Seeds were sown 30 cm between plants and 90 cm between rows. When seedlings were two weeks old the plants were thinned to two per hole. Plants depended on natural rainfall. Throughout the experiment, there was no pesticide application.

When the plants started flowering, on each day between 100 and 150 flower buds were covered with fine-mesh net such that no organism could get in when the flower opened **(Plate 1)**. In order to prevent ants from entering the fine-mesh net glue was applied to the ends tied with rubber bands. Observation for insect flower visitors was made every other day. An observation by **[14]** states that cowpea flowers open early in the morning, close before noon and fall the same day. Hence, observation was made between 6am and 12 mid-day. On days that observations were made, matured opened flowers that were not covered were removed so that the insect visitors could focus almost entirely on those that were targeted for the experiment. The fine-mesh net was taken off flowers in batches of three in a row (the cowpea was planted in lines). Flowers were selected such that two selected flowers were three meters away from each other.

Whenever an insect landed at the tip of the stigma of a flower **(Plate 2)** that particular flower was re- covered. When at least two uncovered flowers had been visited by insects and re-covered another two were uncovered to make it three once again. All flowers re-covered after a visit by an insect were observed for fruit formation **(Plate 3)** on the third day. Uncovered flowers that were not visited by insects and those visited by other organisms apart from insects were ignored.

On a day that observation was made for fruit formation a number of flowers that were not exposed at all were also uncovered and observation made for fruit formation. The flowers that were not exposed to any organism served as control. Always the number of control flowers that were observed for fruit formation on any day was equal to the number of flowers observed for fruit formation for a particular insect species with the highest number of visited flowers the previous day. These served as the standard. Flowers visited by insects that formed fruits were assumed to have been pollinated by the visitors concerned. Specimens of the insects were collected and identified **[26]**. At least two flowers were covered on each plant. However, only one of the covered flowers on each plant was opened for observation while the second flower was still covered. It was ensured that in most cases when there was an insect visited flower being observed for fruit set on a plant, on the same plant there was a control flower being observed for fruit formation. This was largely to take care of probable differences in soil conditions.

Observation of flowers for insect visitors as well as observation for fruit formation was done each other day. Therefore, on the day that observation for flower insect visitors was being done observation for fruit formation was not done. In the major rainy season in 2006, observation was made for three weeks and two weeks later when the plants started re-flowering observation was made for one week. However, in the minor rainy season in 2006 the plants died off after sampling for three weeks. Therefore there was no sampling after three weeks.

The fruit sets for flowers visited by different insects and control flowers **(Plate 3)** were counted and tagged until the fruits were completely developed and matured **(Plate 4)**. The fruit sets were monitored to find out which ones successfully formed pods **(Plate 4)** and those that failed to form pods (fruit abortion). The number of fruits that successfully formed pods as well as those that aborted was determined.

The likelihood of the visitors as pollinators was estimated by comparing fruit set and pod development of flowers visited by insects with that of control flowers. Five days after initiation of ripening, pods were matured to be harvested without being vulnerable to insects and other pests. Hence, each ripe pod was harvested five days after initiation of ripening. Therefore, the fifth day for harvesting served as a standard. Harvested pods were sun-dried for seven days and kept in a clean and dry room.

Plate 1: Flowers Covered with Fine-Mesh Net (X 3)

Plate 2: A Cowpea Flower with *Megachile* sp (Arrowed) Sitting on the Tip of the Stigma (X 3)

Plate 3: Cowpea Flowers Developing Into Fruits (X 4)

Plate 4: Developing Cowpea Pods (X 3)

Data Analysis

The percentage fruit set and fruit failure for each insect and control was calculated by dividing the number of flowers re-covered for each insect and the corresponding control flowers by the total number of flowers counted for both control and insect visited flowers multiplied by hundred. Counts were analyzed by using χ^2 to determine the differences between the observed and the expected values by using contingency tables **[27, 28]**.

The percentage number of pods developed was calculated by dividing the total number of pods formed for each insect visited flower as well as the control by the total number of fruits formed multiplied by hundred. Also, the percentage number of fruits failing to form pods (fruit abortion) was calculated by diving the total number of fruits failing to form pods for each insect visited flower as well as the control flowers by the total number of fruits formed multiplied by hundred. Chi-square analysis was done by using contingency table

[27, 28]. Results were presented in tables for comparison.

RESULTS

The results of fruit set for the major rainy season of 2006 have been presented in **Table 1**. A total fruit set of 284 (61.7%) and fruit set failure of 176 (38.3%) were recorded. Out of the total successful fruit set, 20.1%, 19.4% and another 19.4% were recorded for flowers not exposed to organisms (control), flowers visited by *X. calens* and thrips respectively. The differences between the total observed and expected frequencies for the successful fruit set were very highly significant (χ^2 = 155.32; P = 0.001)).

Results in **Table 2** indicate that flowers visited by *Megachile* sp. recorded higher fruit set (36.7%) than the flowers not exposed to organisms (control) (26.7%). Chi square analysis showed a very significant relationship between the expected and observed frequencies (χ^2 = 24.0; P = 0.001). Out of the 284 successful fruits set, 125 (44.0%) developed into pods whilst 159 (56.0%) aborted **(Table 3)**. In all, 12.3% and 11.3% pod development was recorded for flowers visited by *X. calens* and unexposed flowers (control) respectively. Out of a total of 44.0% successful pod development, 32.7% is cumulatively attributed to insects. The differences between the total observed and expected frequencies for the successful pod development were very highly significant (χ^2 =136.32; P = 0.001). Fruit abortion rate (failure) was highest for flowers visited by thrips (14.1%), followed by control flowers (8.8%), flowers visited by *X. calens* (7.0%), *Apis mellifera* and *X. imitator* (5.3% each) **(Table3)**.

Results in **Table 4** indicate that flowers visited by *Megachile* sp. recorded higher pod development (46.1%) than the flowers not exposed to organisms (control) (32.9%). Chi square analysis showed a very high significant relationship between the expected and observed frequencies (χ^2 = 38.28; P = 0.001).

Table 1: Fruit Set During the Major Rainy Season, 2006

Type	Success		Failure		Total no of flowers
	Freq	% Freq	Freq	% Freq	
Control(Unexposed flowers)	57	20.1	22	12.5	79
Apis mellifera	15	5.3	6	3.4	21
Xylocopa calens	55	19.4	24	13.6	79
Xylocopa imitator	22	7.8	26	14.8	48
Ceratina sp.	21	7.4	6	3.4	27
Megachile sp.	3	1.1	1	0.6	4
Melecta sp	3	1.1	0	0	3
Thrips	55	19.4	15	8.5	70
Flies	18	6.3	5	2.8	23
Lepidopterans	18	6.3	8	4.6	26
Beetle (spotted)	17	6.0	63	35.8	80
Total	284	61.7	176	38.3	460
	χ^2 = 155.32				

Table 2: Fruit Set During the Minor Rainy Season, 2006

Type	Success		Failure	
	Freq	% Freq	Freq	% freq
Unexposed flowers	32	26.7	28	23.3
Flowers Visited by *Megachile* sp.	44	36.7	16	13.3
	χ^2 = 24.0; df = 1			

Table 3: Pod Development During the Major Rainy Season, 2006

Type	Total fruit set	Successful pod development		Failure to develop into pods	
		Freq	% Freq	Freq	% Freq
Control(Unexposed flowers)	57	32	11.3	25	8.8
Apis mellifera	15	0	0	15	5.3
Xylocopa calens	55	35	12.3	20	7.0
Xylocopa imitator	22	7	2.5	15	5.3
Ceratina sp.	21	18	6.3	3	1.1
Megachile sp.	3	0	0	3	1.1
Melecta sp	3	0	0	3	1.1
Thrips	55	15	5.3	40	14.1
Flies	18	5	1.8	13	4.6
Lepidopterans	18	9	3.2	9	3.2
Beetle (spotted)	17	4	1.4	13	4.6
Total	284	125	44.0	159	56.0
		χ^2 = 136.32			

Table 4: Pod Development During the Minor Rainy Season, 2006

Type	Successful pod development		Failure to develop into pods	
	Freq	% freq	Freq	% Freq
Unexposed flowers	25	32.9	7	9.2
Flowers visited by *Megachile* sp.	35	46.1	9	11.8
	χ^2 = 38.28; df = 1			

DISCUSSION

In this study, during the major rainy season a total fruit set of 284 (61.7%) was recorded. Out of the total successful fruit set, 20.1%, 19.4% and 19.4% were recorded for flowers not visited by any organism and flowers visited by *X. calens* and thrips respectively. The results thus showed a very close percentage fruit set for unexposed (control) flowers and the two most promising insects namely, *X. calens* and thrips which visited flowers in the major rainy season. These findings suggest that both self-pollination and cross-pollination might have taken place. Cowpea is cleistogamous, producing viable pollen and receptive stigma before anthesis. This phenomenon imposes entirely self-pollination on the crop **[18]**. However, outcrossing mediated by insects occur in nature **[18]**. According to **[29]**, over several years, the mean productivity of cowpea in the Amazon has declined. This might be linked to a decrease in or an absence of pollinating insects in the fields. This submission also suggests that pollinators can boost higher yields in cowpea.

In the minor rainy season, flowers visited by *Megachile* sp. recorded a higher fruit set (36.7%) than unexposed flowers (26.7% fruit set). Here also it appears that *Megachile* sp promised to be a pollination agent of cowpea flowers because the flowers visited by *Megachile* sp. formed more fruits than the unexposed or control flowers.

In this study, out of the 44.0% successful pod development in the major rainy season, flowers visited by *X. calens* recorded 28.0%, unexposed or control flowers 25.6% and flowers visited by thrips 12.0%. Fruit abortion rate was highest for thrips (14.1%) followed by unexposed flowers (8.8%), *X. calens* (7.1%), *Apis mellifera adansoni* (5.3%) and *X. imitator* (5.3%). Therefore the results of this research suggest that flowers visited by *X. calens* showed slightly higher pod formation than unexposed flowers and flowers visited by thrips during the major rainy season. It further shows that though unexposed flowers (self-pollinated flowers) recorded the highest fruit set, it also recorded very high rate of fruit abortion (did not develop into pods). The same story can be told about flowers visited by thrips. The results confirm the idea of cowpea undergoing both self- and cross-pollination. This is further buttressed by the statement of **[29]** that although cowpea is autogamous, it has a cross-pollination rate of 10%. Similar observation was made by **[30]** that crops vary in the extent to which they benefit from insect cross-pollination. Some crops such as field beans and mangoes are self-pollinating but can give better yields if pollinated by insects. The findings also agreed with the assertion among others that cowpea gives a substantially increased yield when pollinated by insects **[30]**.

In cowpea, premature flower drops and bud abortion are greatest when the plant nears maturation, when the two gametes are incompatible, and when temperatures are high and humidity is low **[31]**. Since both unexposed flowers and flowers visited by *X. calens* under this study were all exposed to the same environmental conditions, the differences in fruit abortion may not be attributed to temperature or humidity. The only factor that can be considered here is compatibility of the gametes. Even here, since the plants were of the same variety and sown on the same day and both flowers visited by *X. calens* and unexposed flowers were all randomly mixed up on the field the contributing factor towards differences in fruit abortion may be self- and cross-pollination. Here, since the unexposed flowers and flowers visited by other insects had more of their fruits formed aborting than fruits formed from flowers visited by *X, calens* it can be said that *X. calens* might have caused pollination of the flowers that it visited leading to improvement of fruit retention and thereby preventing high fruit abortion.

Though the flower thrips *Megalurothrips sjostedti* (Trybom) is considered as one of the most destructive pests attacking the reproductive structures of cowpea during plant development **[32]**, it appears from this study in the major rainy season that in some cases fruit set and pod formation can still take place even when the thrips affect the flowers. Writers such as **[19]** and **[33]** credited thrips for cross-pollination in *Phaseolus lunatus* L. (Lima beans). The finding of this study is in line with the views of **[19]** and **[33]** suggesting that thrips could cause cross-pollination. It further goes to support the point made by **[19]** that thrips were responsible for 0.7% outcrossing observed in common beans.

Another writer, **[5]** stated that the most efficient pollinators must carry plenty of pollen on their bodies, brush against stigmas of flowers, transferring the pollen, visit several flowers of the same species in succession and move frequently from flower to flower and plant to plant. These descriptions fit the behaviour of *X. calens* and *Megachile* sp. on the cowpea flowers. It was realized that both *X. calens* and *Megachile* sp. carried a lot of pollen grains on their bodies. Both insects were also found to move very fast from flower to flower. Within one minute, *X. calens* or *Megachile* sp. visited between 6 to 8 flowers. When on the flower, they inserted their tongues down the ovary and their bodies brushed against the tip of the stigma of the flowers. These characteristics of *Xylocopa calens* and *Megachil*e sp. put them in favourable positions to cause pollination in cowpea. However, there is the need to undertake another study using a technique that will help in finding out whether pollen grains deposited on the stigmas of flowers visited by the insects are actually deposited there by the insects and if such pollen grains are from flowers of other cowpea plants.

The findings seem to be confirming the assertion by **[5]** that cross-pollination improves the quantity of fruits. This is because in the major rainy season flowers visited by *X. calens* formed more fruits than unexposed flowers and flowers visited by thrips respectively. Similarly, during the minor rainy season the total number of pods developed from flowers visited by *Megachile* sp. was more (46.1%) than that from unexposed flowers (32.9%). Here the percentage failure for pod development was higher for flowers visited by M*egachile* sp than unexposed flowers. This was as a result of higher fruit set rate for flowers visited by *Megachile* sp. than unexposed flowers. This result confirms the findings of **[34]** that frequent visitation by pollinating insects to blossoms of cowpeas are beneficial in increasing the number of pod set.

Also, **[35]** reported the development of a male-sterile mutant cowpea. They went on to say that it has not been utilized in hybrid seed production, but if such a mutant were used, since cowpeas are not wind pollinated, insects large enough to operate the floral mechanism would be required to carry pollen from fertile to male-sterile plants. In this study, results are suggesting that large bees such as *X calens* and *Megachile* sp. are the promising cowpea pollinators from the research area.

According to **[36]**, viruses, web blight, *Cercospora*, brown blotch, Septoria and Scab in the moist savanna and bacterial blight, false smut and ashy stem blight in the dry savanna are some of the major diseases that affect cowpea plant growth and biomass production and affect the quality of both grains and fodder **[36]**. In this study, during the major rainy season, majority of the pods developed became mouldy, withered and later fell off as a result of withering of the plants. This might probably be due to soil borne disease.

CONCLUSION

Findings from this study confirm the fact that both self-pollination and cross-pollination are possible for cowpea, and cross pollination by insects can boost higher yields. In cowpea, fruit abortion for self-pollinated flowers can be higher than that of insect pollinated flowers. Pod development in cowpea can be higher for flowers visited and probably pollinated by insects than self-pollinated flowers. Though, known to be notorious cowpea pests, findings from this study point to the fact that thrips could cause cross-pollination. Evidence from this study points to the fact that bees such as *X calens* and *Megachile* sp. are the promising cowpea pollinators from the research area. Hence, it can be said that some of the insects found on the cowpea flowers in the research area are probable cowpea pollinators.

RECOMMENDATIONS

Since cowpea flowers visited by insects showed lower level of fruit abortion leading to higher pod development in cowpea, efforts should be made to conserve the two most promising insects (*X calens* and *Megachile* sp.) on cowpea flowers that prove to be probable pollinators of the crop. Once the cowpea flowers open early in the morning and close before 12.00 noon, the two insects can probably pollinate the flowers early in the morning. Hence, it is recommended that cowpea farmers should avoid spraying farms before 11.00 an in order to prevent the destruction of these useful insects. It is also recommended that further research should be carried out where *X calens* and *Megachile* sp. are artificially reared and released into the cowpea farm and monitored for probable cross-pollination of the crop. A further research of the season in which the two insects can exert the best influence on pollination in cowpea should also be carried out. Further, it is recommended that research should find out which of the two insects is the better pollinator of cowpea.

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