Impact of insect pollinators on yields of Glycine max L. (Fabaceae) at Yaoundé (Cameroon)

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Abstract

To appreciate the impact of insect pollinators on the pod, seeds, and seed weight yields of Glycine max, the pollinating activities of flowering insects were studied in Yaoundé, during the two mild, rainy seasons in 2016 and 2017 (March-June). Observations were made on 45 to 20400 flowers per treatment. The flowers were subjected to different treatments: Free flowers (Treatment 1), bagged flowers (treatment 2), castrated and free flowers (treatment 3), and castrated and bagged flowers (treatment 4). Some (8695 and 3325) flowers of Glycine max (Fabaceae) were observed in 2016 and 2017, respectively, for the diversity and Frequency of insect visits. For results, 1527 visits of 13 insect species distributed in seven orders were recorded on G. max flowers. The most dominating Hymenoptera observed was Apis mellifera, with 40.20 \% of the total insect visits. The highest number of insect pollinators harvested in the flowers of this Fabaceae was between 8h-9h. The studied insects have a positive impact on the yields of this plant. This positive impact of the pollinator insects on the yields was 26.29 \%, 16.13 \%, 15.02 and 4.45 \% in fructification rate, number of seeds pod, the weight of seeds, and percentage of normal seeds respectively. The avoidance of pesticide treatment of plants during flowering could be a good management strategy to improve on plant yield.

Keywords: Glycine max, flowers, insects, pollination, yield

1. Introduction

Glycine max is a plant that originated from China (Hymowitz, 1970). This plant is annual, herbaceous, and can reach a height of 1.5m (Gallais and Bannerot, 1992); Soybean is grown primarily for its seeds, which have many uses in the food and industrial sectors (USDA, 2002; Tchuenguem and Dounia, 2014). It is a major vegetable source of protein for man and other animals (Tien et al., 2002; MINADER, 2012). The United State of America are the largest Producers of soybean in the world, the production in Cameroon is estimated at 12544 tons. This production is low and the demand for seeds is high in this country (MINADER, 2012). The flowers of G. max produce nectar and pollen which attracts insects (Milfont et al., 2013; Tchuenguem and Dounia, 2014; Dounia et al., 2016). The reproduction system is autogamous/allogamous (Tchuenguem and Dounia, 2014; Dounia, 2015; Kengni, 2017). Therefore, it is important to investigate on the possibilities of increasing the production of this plant in Yaoundé (Cameroon). This can be possible if flowering insects of G. max in this region are known and exploited. The researches conducted in Brazil by Milfont et al. (2013), in Cameroon by Tchuenguem and Dounia (2014) and Dounia et al. (2016) in the Far-Nord Region and Kengni et al. (2015) in the Adamaoua Region revealed that Apoidea visits G. max flowers and collect nectar and pollen. No previous research has been reported on the relations between G. max flowers and the flowering insects in Yaoundé (Centre Region, Cameroon), although, the activities of pollinator insects on the flowers can vary with Region
(Tchuenguem, 2005). The main objective of this research was to gather more data on the relations between G. max and flowering insects. Specific objectives were (a) to determine the diversity of flowering insects of G. max, (b) to evaluate the frequency of these insects on G. max flowers, and (c) to evaluate the impact of flowering insects on pollination and yield of this plant.

2. Materials and methods

2.1. Site and biological materials

The studies were conducted from March to June in 2016 and 2017 (mild rainy season) in the fields located at the campus of Higher Teacher’s Training College of University of Yaoundé I (Latitude 10° 62’ N, Longitude 14° 33’ E and altitude 756 m) in the Center Region of Cameroon. The animal material was represented by the seeds of G. max provided by the Institute of Agricultural Research for Development in Nkolbisson (Yaoundé).

2.2. Methods

2.2.1. Planting and maintenance of culture

On the 12th of March 2016 and the 15th of 2017, the experimental plot was cleaned and divided into 12 subplots, each measuring 1.5m x 1m. Seeds were sown on two lines per subplot; each line had three holes and each hole received five seeds. The spacing was 0.5m between rows and 0.5m on rows. Each hole was 5 cm depth. Two weeks after germination (March 26th, 2016 and March 29th, 2017), the plants were thinned and only two were left per hole. From thinning to the opening of the first flower (May 12th, 2016 and May 21th, 2017), weeding was performed manually as necessary to keep the plot weeds-free.

2.2.2. Diversity and Frequency of flowering insects on the flowers of Glycine max

On May 22th, 2016, 12 subplots carrying 144 plants were labeled. Three subplots carrying 36 plants were left for open pollination (treatment 1), three subplots carrying the same number of plants like treatment 1 were protected with gauze mesh to prevent pollinator insects (treatment 2), 66 flowers were on three subplots contained by 36 plants like treatment 1 where some flowers were destined to be castrated (treatment 3) and 66 flowers were on three subplots with 36 plants where some flowers were destined to be castrated and then protected with gauze mesh like treatment 2 (treatment 4). For castration the stigmata were delicately remove using tongs. On May 31st, 2017, the experiment was repeated. On June 30th, 2016 and 2017 the pods were collected and the seeds were calculated.

The diversity of flowering insects that visited G. max flowers was appreciated; capture was done on flowers of treatment 1 and insects were conserved, described and identified using the method of Borror and White (1991), Eardley et al. (2010) and Pauly (1998). For the Frequency of insect pollinators in the flowers of G. max, observations were done each day, from May 28th to June 6th, 2016 and from May 31st to June 9th, 2017. These observations were done during three slots per day (8 – 9h, 12 – 13 h, and 16 – 17h). The determination of the relative Frequency of all insects that visited the G. max flowers was calculated using the formula: \( F_i = \frac{|V_i|}{|V|} \times 100 \) (1), where \( V_i \) was the number of flowering insect \( i \) on flowers of treatment 1 and \( V \) was the number of visits of all pollinator insects (Tchuenguem, 2005).

2.2.3. Impact of flowering insects on the pollination of Glycine max

The evaluation of the impact of flowering insects on the pollination of G. max was done in the study and the Frequency of insect visits was calculated. It was to record the number of times that the insect’s body comes in contact with the anther of flower. This can indicate the possibility of flowering insect to participation in the self-pollination and cross-pollination (Delaplane et al., 2013). To determine the different categories of
2.2.4. Incidence of flowering insects on *Glycine max* yields

This evaluation was based on the impact of visiting flowers on pollination, the impact of pollination on fruitification of *G. max*, and the comparison of yields [fruiting rate, mean number of seeds per pod, weight of seeds and percentage of normal (well developed) seeds] of treatments 1, 2, 3 and 4.

- The fruting rate due to the activity of insects (*Fr*) was calculated as follows: 
  
  \[ Fr = \left(\frac{F_1}{F_2} / Fr_o\right)\times 100. \]

  Where *Fr* and *Fr* are the fruting rates in each treatment.

- The fruting rate (*Fr*) is: 
  
  \[ Fr = \left(\frac{F_2/F_1} + 100\right). \]

- The percentage of mean number of seeds per pod due to the activity of insects (*Sp*), was calculated using the formula: 
  
  \[ Sp = \left(\frac{(Sp_1 - Sp_2)}{Sp_2} \right)\times 100. \]

- The percentage of number of seeds due to the activity of insects (*Wsi*) was calculated as follows: 
  
  \[ Wsi = \left(\frac{(Wsi - Ws)}{Wsi} \right)\times 100. \]

- The percentage of normal seeds due to the activity of insects (*Nsi*) was calculated as follows: 
  
  \[ Nsi = \left(\frac{(Nsi - Ns)}{Nsi} \right)\times 100. \]

2.2.5. Data analysis

Data were analyzed using descriptive statistics, student’s *t*-test for the comparison of means of the two samples, correlation coefficient (*r*) for the study of the association between two variables, chi-square (*χ*2) for the comparison of two percentages, ANOVA for the comparison of many samples. We also used SPSS statistical software and Microsoft Excel.

3. RESULTS

3.1. Diversity and Frequency of entomofauna of *Glycine max*

Among the 188 and 1339 visits of 8 and 12 insect species counted on *G. max* flower in 2016 and 2017. For the two cumulated years; seven Orders of anthophilous insects were found on *G. max* flowers including: Diptera, Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera and Nevrpoptera (Table 1). Thirteen (13) flowering insects were represented on *G. max* flowers: constant species that include (*Apis mellifera*, *Dysdercus voelkeri*, *Halictus sp.*, *Lipotriches collaris*, *Musca domestica* and *Synagris cornuta*) and accidental species (*Acrea acerata*, *Calliphiridae*, *Catopsilia flerella*, *Coleoptera*, *Delta sp., Orthoptera and Nevrpoptera*) (Table 2). Flowering insects have been active on the flowers of *G. max* from 8 am to 17 pm, with a peak of visits between 8 and 9 am in 2016 and 2017 (Table 3).

| Table 1. Diversity of flowering insects on *Glycine max* in 2016 and 2017, number and percentage of visits of different insects |
|---------------------------------------------------------------------------------------------------------------|
| **Insects** | **Family** | **Species** | **2016** | **2017** | **Total** |
| Order | | | | | |
| Diptera | Muscidae | *Musca domestica* | 1 | 0.53 | 72 | 5.37 | 73 | 4.78 |

pollinators, the regularity index (*ld*) was calculated using the formula: 

\[ ld = \left(\frac{P}{100} \times \frac{f}{100}\right), \] where *P* and *f* are the percentage of insect visits and the relative Frequency of insect visits.

This study of the association between two variables, chi-

*Ds*
### Table 2: Distribution of flowering insects according to the seasonal Frequency of visits in 2016 and 2017

| Insects                | 2016 | 2017 | Total | Category of insects |
|------------------------|------|------|-------|---------------------|
|                        | \(n_1\) | \(f_1(\%)\) | \(n_2\) | \(f_2(\%)\) | \(n_{1,2}\) | \(f_{1,2}(\%)\) |
| *Apis mellifera*       | 10   | 100  | 10    | 100                | 20       | 100                |
| *Dysdercus voelkeri*   | 1    | 100  | 10    | 100                | 11       | 55                 |
| *Halictus* (sp.)       | 9    | 90   | 10    | 100                | 19       | 95                 |
| *Lipotriches collaris* | 10   | 100  | 0     | 0                  | 10       | 50                 |
| *Musca domestica*      | 1    | 100  | 10    | 100                | 11       | 55                 |
| *Synagris cornuta*     | 7    | 70   | 6     | 60                 | 13       | 65                 |
| *Acrea acerata*        | 1    | 100  | 2     | 20                 | 3        | 15                 |
| Calliphoridae          | 0    | 0    | 4     | 40                 | 4        | 20                 |
| *Catopsilia flerella*  | 0    | 0    | 2     | 20                 | 2        | 10                 |
| Coleoptera             | 0    | 0    | 4     | 40                 | 4        | 20                 |
| Delta sp.              | 0    | 0    | 3     | 30                 | 3        | 15                 |
| Orthoptera             | 1    | 100  | 4     | 50                 | 5        | 25                 |

\(n_1\): number of visits on 8695 flowers in 10 days; \(n_2\): number of visits on 20400 flowers in 10 days; \(n_t\): number of visits on 29095 flowers in 20 days; \(p_1\); \(p_2\); and \(pt\): percentages of visits; \(p_1 = (n_1 / 188) \times 100\); \(p_2 = (n_2 / 1339) \times 100\); \(pt = (nt / 1527) \times 100\); sp.: Undetermined species.
Table 3: Variation of number of visits on flowers of *Glycine max* according to the daily time

| Insects          | Number of visits | 8h-9h | 12h-13h | 16h-17h | Total |
|------------------|------------------|-------|---------|---------|-------|
|                  | n                | p(%)  | n       | p(%)    | n     | p(%)  | Total |
| *Acrea acerata*  | 7                | 0.45  | 5       | 0.32    | 8*    | 0.52  | 20    |
| *Apis mellifera* | 425*             | 27.83 | 17      | 1.11    | 172   | 11.26 | 614   |
| *Calliphoridae*  | 5                | 0.32  | 32*     | 2.09    | 10    | 0.65  | 47    |
| *Catopsilia flerella* | 2       | 0.13  | 9*      | 0.58    | 4     | 0.26  | 15    |
| *Coleoptera*     | 32*              | 2.09  | 14      | 0.91    | 12    | 0.78  | 58    |
| *Delta* sp.      | 22*              | 1.44  | 5       | 0.32    | 5     | 0.32  | 32    |
| *Dysdercus voelkeri* | 66*         | 4.32  | 28      | 1.83    | 32    | 2.09  | 126   |
| *Halictus* (sp.) | 207*             | 13.55 | 49      | 3.20    | 132   | 8.64  | 388   |
| *Lipotriches collaris* | 43*     | 2.81  | 6       | 0.39    | 18    | 1.17  | 67    |
| *Musca domestica*| 19               | 1.24  | 38*     | 2.48    | 16    | 1.04  | 73    |
| *Nevroptera*     | 3*               | 0.19  | 0       | 0       | 2     | 0.13  | 5     |
| *Orthoptera*     | 2                | 0.13  | 6*      | 0.39    | 2     | 0.13  | 10    |
| *Synagris cornuta* | 33*         | 2.16  | 30      | 1.96    | 9     | 0.58  | 72    |
| **Total**        | **866***         | **56.71** | **239** | **15.65** | **422** | **27.63** | **1527** |

*n* : number of visits ; *p(%)* : percentage of visits ; (*) : peak of visits

3.2. Impact of flowering insects on pollination of *Glycine max*

Three categories of pollinators were observed on flowers of *G. max* in 2016 and 2017 (Table 4):

- Major pollinators (*Id > 0.05 and/or p > 50 %*) *Apis mellifera* and *Halictus* sp.
- Minor pollinators (*0.05 ≤ Id < 0.001 and/or 50 ≤ p < 25*) *Calliphoridae, Delta* sp., *Dysdercus voelkeri, Lipotriches collaris, Synagris cornuta, Musca domestica*.
- Occasional pollinators (*Id<0.001 and/or p<25*) *Acrea acerata, Catopsilia flerella, Coleoptera, Nevroptera, Orthoptera.*
### Table 4: Regulator index, number and percentage of visits with stigmata contact of flower of *Glycine max*

| Insects               | 2016     | 2017     | Total  | NPV     |
|-----------------------|----------|----------|--------|---------|
|                       | $Id_1$  | $Id_2$  | $Id_1$ | $SV$    | $n$     | $p$ (%) |
| *Acera acerata*       | 0.00106  | 0.00264  | 0.001950 | 20   | 0      | 0      |
| *Apis mellifera*      | 0.45740  | 0.39430  | 0.402500 | 614  | 614    | 100    |
| Calliphoridae         | -        | 0.01404  | 0.006140 | 47   | 14     | 29.78  |
| *Catopsilia flerella* | -        | 0.00230  | 0.000980 | 15   | 0      | 0      |
| Coleoptera            | -        | 0.01732  | 0.007580 | 58   | 0      | 0      |
| Delta sp.             | 0.00684  | 0.003135 |         | 32   | 3      | 9.37   |
| Dysdercus voelkeri    | 0.00106  | 0.09260  | 0.043750 | 126  | 83     | 65.87  |
| Holictus sp.          | 0.12438  | 0.27030  | 0.241300 | 388  | 388    | 100    |
| Lipotriches collaris | 0.35630  | -        | 0.021900 | 67   | 67     | 100    |
| *Musca domestica*     | 0.00053  | 0.05370  | 0.026290 | 73   | 70     | 95.89  |
| Nevroptera            | -        | 0.00074  | 0.000320 | 5    | 0      | 0      |
| Orthoptera            | 0.00053  | 0.00340  | 0.001625 | 10   | 0      | 0      |
| Synagris cornuta      | 0.01113  | 0.03090  | 0.030615 | 72   | 55     | 76.38  |

$Id = (P/100) \times (f/100)$; $P$: percentage of visits; $f$: relative Frequency of visits; $SV$: study visits; $NPV$: number and percentage of visits with stigmata contact; $n$: number of visits with contact; $p$ (%) : percentage of visits with contact.

#### 3.3. Impact of anthophilous flowering insects on yield of *Glycine max*

During foraging behaviour on flower of *G. max*, flowering insects always shook flowers and are regularly in contact with the anthers and stigma ($p = 76.38\%$), increasing cross pollination possibility of *G. max* fruiting rate, number of seeds per pod, weight of seeds and percentage of normal seeds in different treatments (Table 4).

a. The comparison of the fruiting rate showed that the difference was very highly significant between treatments in 2016 ($F = 9.02, df = 3, P < 0.001$) and in 2017 ($\chi^2 = 6.23, df = 2, P < 0.001$). The difference observed was highly significant between fruiting rate of free opened flowers (treatment 1) and that of bagged flowers (treatment 2) ($\chi^2 = 332.78, df = 1, p < 0.001$), free flowers (treatment 1) and castrated and opened flowers (treatment 3) ($\chi^2 = 18.19, df = 1, p < 0.001$) free flowers (treatment 1) and castrated and bagged flowers (treatment 4) ($\chi^2 = 30.85, df = 1, p < 0.001$) in the first year. In the second year the same results were ($\chi^2 = 1439.21, df = 1, p < 0.001$), ($\chi^2 = 51.44, df = 1, p < 0.001$) and ($\chi^2 = 87.84, df = 1, p < 0.001$). The fruiting rate of treatment 1 was higher than treatments 2, 3 and 4 in 2016 and in 2017. The fruiting rate due to the action of insects was 26.19 and 26.39 % in 2016 and 2017 respectively. For the two cumulated years, the fructification rate due to the influence of insects was 26.29 %.

b. The comparison of the mean number of seeds per pod showed that the difference was highly significant between treatments in 2016 ($F = 6.44, df = 3, P < 0.001$) and in 2017 ($F = 5.83, df = 2, P < 0.001$). The difference observed was highly significant between mean number of seeds per pod in
treatment 1 and treatment 2 (t = 13.38, df = 58, p < 0.001), the same observation was fund in treatment 1 and treatment 3 (t = 6.75, df = 37, p < 0.001) and the difference observed was significant between mean number of seeds per pod in treatment 1 and treatment 4 (t = 2.21, df = 29, p < 0.02) in the first year. In the second year the difference was significant between mean number of seeds per pod in treatment 1 and treatment 3 (t = 2.41, df = 35, p < 0.02). The mean number of seeds per pod in treatment 1 was higher than treatments 2, 3 and 4 in 2016 as well as in 2017. The mean number of seeds per pod due to the action of insects was 28.61 in 2016 and 3.65 % in 2017. For the two cumulated years, the mean number of seeds per pod due to the influence of insects was 16.13 %.

c. The comparison of the mean weight of seeds showed that the difference was significant between treatments in 2016 (F = 4.98, df = 3, P < 0.001) and not significant in 2017 (F = 1.09, df = 2, P > 0.05). The difference was significant between weights of seeds in treatment 1 and in treatment 2 (t = 1.37, df = 198, p < 0.02) in 2016. The weight of seeds due to the action of insects was 15.02 % in 2016.

d. The comparison of percentage of normal seeds showed that the difference was highly significant between treatments in 2016 (χ² = 108, df = 2, P < 0.001) and in 2017 (χ² = 955.94, df = 2, P < 0.001). The difference observed was highly significant between the percentage of normal seeds of in treatment 1 and treatment 2 (χ² = 91.43, df = 1, p < 0.001), the same observation was fund in treatment 1 and treatment 3 (χ² = 19.87, df = 1, p < 0.001) in the first year. In the second year the results were χ² = 829.81, df = 1, p < 0.001 in treatment 1 and treatment 2 and χ² = 554.10, df = 1, p < 0.001 in treatment 1 and treatment 3. The percentage of normal seeds of treatment 1 was higher than treatments 2 and 3 in 2016 as well as in 2017. The mean percentage of seeds due to the action of insects was 5.31 % in 2016 and 3.60 % in 2017. For the two cumulated years, the mean number of seeds per pod due to the influence of insects was 4.45 %.

| Treatments | Year | NF  | NPD | FR  | Sd/Pd | Wg/Sd |
|------------|------|-----|-----|-----|-------|-------|
|            |      | n   | m   | n   | m    | s     |       |
|            |      |     |     |     |       |       |       |
| T1 (FF)    | 2016 | 0869| 0460| 52.9| 8     | 2.9   | 0.19  |
|            |      | 6   | 7   | 0.8 | 6     | 3     | 1.273 |
| T2 (BF)    | 2016 | 0850| 0332| 39.1| 0     | 2.1   | 0.16  |
|            |      | 3   | 2   | 1.0 | 1     | 4     | 0.771 |
| T3 (COF)   | 2016 | 0004| 0000| 20.0| 0     | 0.9   | 0.15  |
|            |      | 9   | 8   | 0.0 | 8     | 7     | 1.735 |
| T4 (CBF)   | 2016 | 0004| 0000| 2.00| 0     | 1.0   | 0.09  |
|            |      | 1   | 0   | -   | 0     | 8     | 0.0   |
| T1 (FF)    | 2017 | 2040| 1350| 66.2| 2     | 2.1   | 0.17  |
|            |      | 9   | 3   | 1.1 | 1     | 2     | 0.428 |
| T2 (BF)    | 2017 | 2683| 1307| 48.7| 4     | 2.1   | 0.16  |
|            |      | 7   | 1   | 0.0 | 2     | 9     | 1.147 |
| T3 (COF)   | 2017 | 0004| 0000| 15.5| 5     | 0.9   | 0.16  |
|            |      | 7   | 6   | 0.0 | 4     | 1     | 0.336 |
| T4 (CBF)   | 2017 | 0004| 0000| 0.00| 0     | 0.0   | 0.00  |
|            |      | 0   | 0   | 0.0 | 0     | 0     | 0.00  |

FF: Free Flowers, BF: Bagged Flowers, COF: Castrated and opened Flowers, CBF: Castrated and Bagged Flowers, NF: Number of Flowers, NPD: Number of Pod, FR: Fruiting Rate, Sd/Pd: Seeds per pod,
3.4. Discussion

Flowering insects visited the G. max flowers during our observation period and the Hymenoptera is the most important order. This order is being reported as the main of this Fabaceae in Maroua (Thuenguem & Dounia, 2014) and in Ngaoundéré (Kengni et al., 2015). In Yaoundé we found 13 insect’s species visiting this Fabaceae; Kengni et al. (2015) and Thuenguen & Dounia (2014) found 7 and 28 insect’s species respectively in Nguoundéré and in Maroua. The significant difference between the number of flowering insects visiting G. max flowers for the two studied years could be attributed to the experimental site. The peak of the activity of flowering insects on G. max flowers was located between 08am and 09am, which correlated with the highest availability period of nectar on G. max flowers. For this research, it has been indicated that Apis adansonii and Halictus sp can provide benefits to pollination management of G. max. During the collection of nectar and or pollen on each flower, the bee foragers regularly come into contact with the stigma (100 %) and they have the most important regulator index (ld > 0.05). They were also able to carry pollen with their hair, legs and mouth accessories from a flower of one plant to stigma of another flower of the same plant (geitonogamy), to the same flower (autogamy) or to that of another plant (xenogamy). The significant contribution of insect pollinators in pods and seed yield of G. max is in agreement with the similar findings in Brazil (Milfont et al., 2013), in three Regions of Cameroon such as in Maroua (Thuenguem & Dounia, 2014; Dounia et al., 2016), in Ngaoundéré (Kengni et al., 2015), in Douala (Taimanga & Thuenguem, 2018). The impact of insect pollinators of to G. max production was significantly higher than that of protected flowers. The weight of some insect pollinators such as A. adansonii, Dysdercus voelkeri, Halictus sp., Lipotriches collaris, Musca domestica and Synagris cornuta played a positive role during nectar and or pollen collection. The pollinator insects shook flowers and could facilitate the liberation of pollen by anthers for the optimal occupation of the stigma. This observation was also reported by Thuenguem & Dounia (2014), Dounia et al., (2016) and Taimanga & Thuenguem, 2018 on Glycine max. The higher productivity of pods, seeds and weight of seeds in the treatment with unlimited visits when compared to treatment with protected flowers showed that pollinator insect visits were effective in increasing cross-pollination. Our results confirmed those of Rortais et al. (2005), Milfont et al. (2013), Kengni et al. (2015) and Taimanga & Thuenguem (2018) who revealed that G. max flowers set little pods in the absence of insect pollinators. Similar observations done in Cameroon (Dounia, 2015; Kengni, 2016) have shown that pollination by insects was not always needed. Woodworth (1922) showed that self-pollination of G. max flowers produced as many pods and seeds as exposed plants. Thus, pollination requirements may differ between plant varieties and /or Region.

CONCLUSION

This study revealed that the flowers of the variety of G. max studied attracted insect pollinators and the plant obtained benefits from the pollination by those insects. By comparison of pods, seeds and seed weights, between unprotected flowers and protected flowers, it was observed that insect pollinators contribute positively in increasing pods, seed and seed weight yields as well as seed quality.

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