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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 Apoïdea 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 determinate 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 insect pollinators naturally present in the environment. The plant 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 the12th of March 2016 and the 15th of 2017, the experimental plot was cleaned and divided into 12 subplots, each measuring 1.5m × 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: $Fi = \{[(Vi)/VI] \times 100\}$ (1), where *Vi* was the number of flowering insect *i* on flowers of treatment 1 and *VI* 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 pollinators, the regularity index (*Id*) was calculated using the formula: $Id = [(P / 100) \times (f / 100)]$, where *P* and *f* are the percentage of insect visits and the relative Frequency of insect visits.

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 fructification 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 fruiting rate due to the activity of insects (Fr_i) was calculated as follows : $Fr_i = \{[(Fr_x - Fr_y) / Fr_x] * 100\}$. Where Fr_x and Fr_y are the fruiting rates in each treatment.

- The fruiting rate (*Fr*) is: $Fr = [(F_2/F_1) * 100]$. Where F_2 is the number of pods formed and F_1 the number of flowers initially set.

- The percentage of mean number of seeds per pod due to the activity of insects (*Spi*) was calculated using the formula: $Spi = \{[(Sp_x - Sp_y) / Sp_x] * 100\}$. Where Sp_x and Sp_y are the percentages of seeds per pods in different treatments.

- The percentage of weight of seeds due to the activity of insects (*Wsi*) was calculated as follows: $Wsi = \{[(Ws_x - Ws_y) / Ws_x] * 100\}$.

- The percentage of normal seeds due to the activity of insects (*Nsi*) was calculated as follows: $Nsi = \{[(Ns_x - Ns_y) / Ns_x] * 100\}$.

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 ($\chi 2$) 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, Hynemoptera, Lepidoptera, Orthoptera and Nevroptera (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 Nevroptera) (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			**2016**		**2017**		**Total**	
Order	**Family**	**Species**	n_1	P_1 **(%)**	n_2	P_2 **(%)**	n_t	P_t **(%)**
Diptera	Muscidae	*Musca domestica*	1	0.53	72	5.37	**73**	**4.78**

	Calliphoridae	(sp.)	0	0	47	3.51	**47**	**3.07**
Coleoptera		(sp.)	0	0	58	4.33	**58**	**3.79**
Hemiptera	Pyrrhocoridae	*Dysdercus voelkeri*	2	1.06	124	9.26	**126**	**8.25**
Hymenoptera	Apidae	*Apis mellifera*	86	45.74	528	39.43	**614**	**40.20**
	Halictidae	*Halictus* (sp.)	26	13.82	362	27.03	**388**	**25.40**
		Lipotriches collaris	67	35.63	0	0	**67**	**4.38**
	Vespidae	*Synagris cornuta*	3	1.59	69	5.15	**72**	**4.71**
		Delta sp.	0	0	32	2.38	**32**	**2.09**
Lepidoptera	Acraeidae	*Acrea acerata*	2	1.06	18	1.34	**20**	**1.30**
	Pieridae	*Catopsilia flerella*	0	0	15	1.15	**15**	**0.98**
Orthoptera		(sp.)	1	0.53	9	0.68	**10**	**0.65**
Nevroptera		(sp.)	0	0	5	0.37	**5**	**0.32**
Total		**13**	**188**	**100**	**1339**	**100**	**1527**	**100**

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; $p_1 = (n_1 / 188) *100$; $p_2 = (n_2 / 1339) *100$; pt= (nt / 1527)*100; sp.: Undetermined species.

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**	Constant species (f ≥ 50%)
Dysdercus voelkeri	1	10	10	100	**11**	**55**	
Halictus (sp.)	9	90	10	100	**19**	**95**	
Lipotriches collaris	10	100	0	0	**10**	**50**	
Musca domestica	1	10	10	100	**11**	**55**	
Synagris cornuta	7	70	6	60	**13**	**65**	
Acrea acerata	1	10	2	20	**3**	**15**	Accidental species (f < 25%)
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	10	4	50	**5**	**25**	

Nevroptera	0	0	2	20	**2**	**10**	
Total	10		10		**20**		
n_1 : Number of observation days in 2016, n_2 : Number of observation days in 2017, $n_{1,2}$: Number of observation days in 2016 and in 2017, f_1 : relative Frequency of visits in 2016, f_2 : relative Frequency of visits in 2017, $f_{1,2}$: relative Frequency of visits in 2016 and in 2017.							

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**		
	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_T	***SV***	***n***	***p* (%)**
Acrea 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
Halictus 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) × (*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 ($\chi2 = 6.23$, $df = 2$, $P < 0.001$). The difference observed was highly significant between fruiting rate of free opened flowers (treatment 1) and that of bagged flowers (treatment 2) ($\chi2 = 332.78$, $df = 1$, $p < 0.001$), free flowers (treatment 1) and castrated and opened flowers (treatment 3) ($\chi2 = 18.19$, $df = 1$, $p < 0.001$) free flowers (treatment 1) and castrated and bagged flowers (treatment 4) ($\chi2 = 30.85$, $df = 1$, $p < 0.001$) in the first year. In the second year the same results were ($\chi2 = 1439.21$, $df = 1$, $p < 0.001$), ($\chi2 = 51.44$, $df = 1$, $p < 0.001$) and ($\chi2 = 87.84$, $df = 1$, $p < 0.001$). 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 ($\chi 2$ = 108, df = 2, P < 0.001) and in 2017 ($\chi 2$ = 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 ($\chi 2$ = 91.43, df = 1, p < 0.001), the same observation was fund in treatment 1 and treatment 3 ($\chi 2$ = 19.87, df = 1, p < 0.001) in the first year. In the second year the results were $\chi 2$ = 829.81, df = 1, p < 0.001 in treatment 1 and treatment 2 and $\chi 2$ = 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 %.

Table 5. Fruiting rate, number of seed per pod, weight of seeds and percentage of normal seeds according to different treatments of *Glycine max* in 2016 and 2017

Treatments	**Year**	**NF**	**NPd**	**FR**	**Sd/Pd**			**Wg/Sd**			**TSd**	**NSd**	**% NSd**
					n	***m***	***s***	***n***	***m***	***s***			
T_1 (FF)	2016	08695	04606	**52.98**	30	**2.97**	0.86	100	**0.193**	1.273	13673	12063	**88.18**
T_2 (BF)		08503	03325	**39.10**	30	**2.12**	1.01	100	**0.164**	0.771	07049	05886	**83.50**
T_3 (COF)		00045	00009	**20.00**	09	**0.98**	0.08	08	**0.157**	1.735	00008	00003	**37.50**
T_4 (CBF)		00045	00001	**2.00**	01	**1.00**	-	01	**0.098**	-	00001	00000	**00.00**
T_1 (FF)	2017	20400	13509	**66.22**	30	**2.18**	1,13	100	**0.172**	0.428	29568	29431	**99.53**
T_2 (BF)		26830	13077	**48.74**	30	**2.11**	0,02	100	**0.169**	1.147	21439	20569	**95.94**
T_3 (COF)		00045	00007	**15.55**	07	**0.96**	0.04	06	**0.161**	0.336	00006	00002	**33.33**
T_4 (CBF)		00045	00000	**0.00**	00	**0.00**	0.00	00	**0.000**	0.00	00000	00000	**00.00**

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,

Wg/Sd: Weight of Seed, **TSd:** Total of Seeds, NSd: Normal Seeds, **%NSd:** Percentage of Normal Seeds.

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 Ngouandéré 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 (*Id* > 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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