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Impact of two organic fertilizers (mycorhize and poultry manure) associated with pollinators insects on growth and yields of *Zea mays* L. at Baré (Littorale Region-Cameroon)

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Abstract

Field of maize was conducted during the rainy season in 2021 and 2022 in Baré (Littorale Region - Cameroon) aiming to contribute to the improvement of the yield of maize by combining two organic fertilizers and pollinators insects. The main factor was pollination with two levels (plants left on free pollination and plants isolated from insects). The secondary aspect was fertilization with four points, mycorhize-poultry manure, mycorhize, poultry manure and control. The growth parameters, the diversity and foraging activity of pollinators insects, the influence of organic fertilizers and pollinator insects were evaluated on the yields. The results showed that the plants located on the plots treated with mycorhize-poultry, mycorhize and poultry manure showed significant growth on the number of the leaves (p<0.05) and collar diameter (p<0.05). In both years, a total of four orders of pollinator insects have been identified where Hymenoptera (90.94%) ranks first followed by Diptera (8.71%). Those insects harvested pollen (100%). Mean number of seeds per ears and the normal seeds left on free pollination was greater compared to those isolated from insects (p<0.001). The production (normal seeds and the mean number of seeds per ears) varies to 36.41 to 41.72 % in the plots having mycorhize-poultry manure, to 32.94 to 38.32 % plots having mycorhize and to 30.89 to 31.06 % to poultry manure plots associated with pollinators insect respectively. The use of organic manure especially the mycorhize-poultry manure and the maintenance of pollinators insect nest around the field mays by recommended to improve crop yield.

Key Words: *Zea mays*, poultry manure, mycorhize, insects, pollination, yield.

I. Introduction

In the field, pollinator insects have great ecological and economical importance because they have positive influence on pollination (Pesson and Louveaux, 1984). Those insects can increase fruit yield and best quality of seeds (Morison *et al.*, 2000). The lack of pollinating insects during flowering time can lead to kidney yields fruits and/or seeds for some cultivars plants (Tchuenguem, 2005). Maize (*Zea mays* L.) is originated from North of America (Valdeyron, 1984). Currently, maize is the most widely grown cereal in the world; this poaceae grows well on a wide variety of soils; his biological cycle varies from 90 to 120 days depending on the type of climate (Hoopen and Adbou, 2012). The cob is still elongated; covered with modified leaves called spathes and can contain up to 500 seeds (Tchuenguem *et al.*, 2002). Pollination of female flowers is allogamous, but self-pollination is also observed, pollen is produced by male flowers called panicles (Tchuenguem *et al.*, 2002). All maize in Africa is used for human alimentation; it is also used for animal feed. In the industrial sector, starch extracted from dry corn is used for manufacture of alcohol; the oil produced is used for human diet; manufacture of soaps and production of biofuels (Lamartiniere, 2000). In Cameroon the floral entomofauna of *Zea mays* is not very well studied. The few studies from the literature are that for Tchuenguem *et al.* (2002), Dounia *et al.* (2018). and Pando *et al.* (2019) conducted in the Center and Farth-north regions of Cameroon; which indicate that pollinator insects visit the panicles and collected pollen. According to Gallai *et al*. (2009) floral entomofauna of a plant species can vary from one region to another. The average productivity of maize has remained low with less significant changes over the last decades. The lesser returns obtained has been accredited to many factors such as low soil fertility and insufficiency in vital mineral nutrients, the utilization of local varieties, inappropriate doses of manure (Gardner, 2004) and less knowledge on the pollinating insects. There is therefore a need to meet the increasing demands of the growing population in developing countries especially in Cameroon where obtaining high yields is amongst the main goals of agronomic research. This has led farmers to devising methods through which soil fertility can be improved, mainly through the application of different types of manure (Mathew and Karikari, 1995). Organic manure is naturally available and contains moderate amounts of essential nutrients needed by plants (Shaji and Mathew, 2021). Being a short duration vegetable crop, maize growth, yield and quality are largely influenced by the application of fertilizers. The general objective of this research is to assess the influence of organic fertilizers (mycorhize and poultry manures) associated with pollinator insects on maize development and yields for their optimal management in Baré, specifically (a) to appreciate maize growth, (b) to investigate the activity of pollinating insects on panicles and (3) to assess the effects of organic fertilizers and flowering insects on the yields of this Poaceae.

II. Materials and methods II.1. Study station

The experimental investigations were performed during two seasons from the 1st of March to the 30th of July in 2021 and 2022 at Baré, Moungo division, Littorale Region of Cameroon during the rainy period. The field for investigation was a plot, on 5°00'07.2'' N latitude, 9°57'42.9'' E longitude and 200 m of altitude above sea level. Moungo has an equatorial climate, temperatures varies to 24.89 °C to 32.4 °C, rainfall vary from 14.4 mm to 751.2 mm during the rainy season; in this region of Cameroon the important vegetation present are the mangrove (Dongock, 2004).

II.2. Biological material

The animal material constituted by all pollinator's insects naturally present in the environment of study station ; Vegetal material was represented by seeds of *Z. mays* var. CMS 8704 (figure 1) ; Organics fertilizers were mycorhize and poultry manure.

Figure 1: Seeds of *Zea mays*

II.3. Method

II.3.1. Preparation, sowing and tending of the experimental plot

The experimental field (437 m^2) was cleared and cleaned using a cutlass on March to August 202l and 2022. The soil was tilled forming 4 blocks. Each block has 8 m x 4.5 m x 0.25 m. A weeks before planting (2021 and 2022) in the block, different treatment was made: control ($T0_{2021}$ and $T0_{2022}$), poultry manure ($T1_{2021}$ and $T1_{2022}$), mycorhize ($T2_{2021}$ and $T2_{2022}$) and mycorhize-poultry manure ($T3_{2021}$ and $T3_{2022}$) the organic fertilize was mixed with the soil in each hole, 0.4 kg ± 2.01 poultry manure was use per hole and the corresponding value was 0.10 kg ± 0.10 of mycorhize. Maize seeds were sown at two grains per hole, 10 holes per line and a spacing between the consecutive hole was 0.80 m and the space between line was 0.50 m. Two weeks after germination, the plants were thinned by manual uprooting. From germination to the opening of the first panicle, the experimental farm was weeded and hoed, respectively every two weeks. Pesticides were not used on the farm land.

II.3.2. Determination of the impact of manure on the growth of maize

One week after the plants had emerged, on the 7th of April 2021 and 2022; On 30 plants of *Zea mays* the collar diameter was measured using a vernier calliper and the number of leaves counted manually every week until the first panicle appears.

II.3.3. Diversity and Activity of pollinators insects on the panicles of maize

On each block of the experimental farm two treatment was made; Treatment A: 40 plants witch 10 plants per sub-block (T0.1, T1.1, T2.1 and T3.1) was bellowed for free pollination (figure 2.a) and treatment B witch a same number of plants (T0.2, T1.2, T2.2 and T3.2) destined to prevent pollinators by bagged plants (figure 2.b) in 2021 and in 2022, treatment was repeat witch the same parameter.

a:Plant of *Zea mays* destinated for free pollination

b: Plant of *Zea mays* isolated for pollinator insects

Figure 1: Plants of *Zea mays*

Direct observations on plants destinated for free pollination were made every two days during five daily hours: 7am-8am, 10am-11am, 12am-1pm, 2pm-3pm and 4pm-5pm from the 31^{st} of May to 10^{th} June in 2021 and 2022. During this period the numbers of pollinator insects on panicles were counted and three to five specimens of each species were captured with an insect net and were preserved in a container made of 70 % ethanol for future taxonomic identification except for Lepidoptera which were preserved in wrapper according to the Borror and White (1991) recommendations. Insects have not been marked; the cumulative results were expressed by the number of visits to determine the relative frequency (Fi) of each insect species in the anthophilous entomofauna of *Z. mays* where, $Fi = \{[Vi/VI] * 100\}$ with Vi = number of visits of the insect i on the panicle and VI the number of visits of all the insects on these same panicles (Tchuenguem *et al.,* 2001). Data on the relative frequency of visits to the various listed anthophilous insects will allow determining the place of each insect in the anthophilous fauna of the studied plant (Tchuenguem, 2005).

Floral Products harvested by an insect were noted on each panicle; it can be pollen or other product on those panicles. The panicle product being harvested was determined by the position of the insect on the male flower; if insects use its mandibles and legs to scratch the anthers, it is a pollen forager. In this case, balls of pollen are observed in the baskets of the hind legs for Apidae, the collecting hairs of the legs for Halictidae and the ventral brush for Megachilidae (Borror and White, 1991). Pollen harvesting can be active (if pollen is collected) or passive (if the pollen accumulates on the insect's tegument and then collects it in its organs storage (Jousselin and Kjellberg, 2001).

The duration of visit for each insect during the hose activities were recorded. The floral products collected were systematically noted during the recording of the duration of the visits per flower.

II.3.4. Determination of the impact of organic fertilizers and/or pollinator insects on yield of *Zea mays*

II.3.4.1. Evaluation of the impact of organic fertilizers on yield of *Zea mays*

For each year, the evaluation of yields was based on the impact of organic fertilizers on production by the comparison the number of seeds in the fertilizing block (poultry manure and/or mycorhize) and the control block. At maturity, ears grown from each block were individually counted. Comparison was done on the ears set. The percentage of the average number of seeds per ears and the percentage of normal seeds were calculated.

For each block, the percentage of the average number of seeds per ear (Ps) was calculated using the following formula: $Ps = \{[(s1 - s2) / s1] \times 100\}$, where $s1$ and $s2$ represent the average number of seed by pod in each block. The percentage of normal seeds (Pn) was also determined using the formula: $Pn = \{[(ns1 - ns2) / ns1] \times 100\}$, $ns1$ and $ns2$ representing the percentages of normal seeds in each block.

II.3.4.2. Evaluation of the impact of pollinators insects on yield of *Zea mays*

The evaluation of impact of pollinators insects on the production was evaluated. The comparison of the number of seeds in sub-block of plants destinated for free pollination and the plants isolated for the pollinator insects on control block was calculated. The percentage of the average number of seeds per ears and the percentage of normal seeds were calculated using the same formula at evaluation of the impact of organic fertilizers on yield of *Zea mays*.

II.3.4.3. Evaluation of the impact of organic fertilizers and pollinators insects on yield of *Zea mays*

The evaluation of yields based on the organic fertilizers (poultry manure and/or mycorhize) and pollinators insects on production was evaluated. The comparison of the number of seeds in sub-block of plants destinated for free pollination using different fertilizes (poultry manure, mycorhize and poultry manure-mycorhize) and the plants destinated for free pollination in sub-block of control was evaluated. The percentage of the average number of seeds per ears and the percentage of normal seeds were calculated using the same formula at evaluation of the impact of organic fertilizers on yield of *Zea mays*.

II.3.5. Data analysis

Data were analyzed using descriptive statistics, student's t-test for the comparison of means of two samples, correlation coefficient (r) for the study of the association between two variables, chi-square (χ^2) test for the comparison of two percentages using SPSS statistical software (version 19.0, SPSS).

III. Results and Discussion

III.1. Results

III.1.1. Efficacy of amendment with two organic fertilizers (mycorhize and poultry) on the growth of maize (growth parameters)

The collar diameter and the number of leaves increase with time in each of the treatments according to observation days. The plants present in the blocks treated with mycorhize-poultry manure have a rapid growth with regard to the various parameters studied in relation to those of the block treated with mycorhize, poultry manure and those of the control blocks.

- **Collar diameter**

Table 1 and figure 2 presented the results on variation on collar diameter under different treatments.

a)- In 2021, the collars diameters were 0.86 ± 0.4, 1.71 ± 0.20, 2.34 ± 0.27, 2.74 ± 0.27 and 2.83 ± 0.27 in treatment $T0_{2021}$ ($T0_{2021}$, control) ; 0.88 ± 0.15, 1.99 ± 0.32, 2.91 ± 0.35, 3.04 ± 0.30 and 3.23 ± 0.38 in treatment $T1_{2021}$ ($T1_{2021}$, poultry manure) ; 0.91 ± 0.08, 2.13 ± 0.07, 2.98 ± 0.43, 3.19 ± 0.33 and 3.41 ± 0.12 in treatment $T2_{2021}$ ($T2_{2021}$, mycorhize) and 0.97 ± 0.17, 2.42 ± 0.50, 3.18 ± 0.12, 3.48 ± 0.19 and 3.88 ± 0.03 in $T3_{2021}$ ($T3_{2021}$ mycorhize-poultry manure) The correlations are positive and significant between treatments $T0_{2021}$ and $T1_{2021}$ (r = 0,83 ; ddl = 4; P < 0,05); treatments $T0_{2021}$ and $T2_{2021}$ (r = 0,83 ; ddl = 4; P < 0,05); treatments $T0_{2021}$ and $T3_{2021}$ (r = 0,79 ; ddl = 4; P < 0,05); treatments $T1_{2021}$ and $T2_{2021}$ (r = 0,84 ; ddl = 4; P < 0,05); treatments $T1_{2021}$ and $T3_{2021}$ (r = 0,85 ; ddl = 4; P < 0,05) and treatments $T2_{2021}$ and $T3_{2021}$ (r = 0,86 ; ddl = 4; P < 0,05).

In 2022, the same value were 0.86 ± 0.59, 1.85 ± 0.88, 2.87 ± 0.54, 2.87 ± 0.33 and 2.94 ± 0.98 in treatment $T0_{2022}$ ($T0_{2022}$, control) ; 0.88 ± 0.24, 2.02 ± 0.14, 2.99 ± 0.68, 3.11 ± 0.01 and 3.41 ± 0.16 in treatment $T1_{2022}$ ($T1_{2022}$, poultry manure) ; 0.92 ± 0.15, 2.18 ± 0.70, 3.15 ± 0.55, 3.22 ± 0.41 and 3.57 ± 0.26 in treatment $T2_{2022}$ ($T2_{2022}$, mycorhize) and 0.97 ± 0.30, 2.59 ± 0.08, 3.29 ± 0.40, 3.61 ± 0.15 and 3.91 ± 0.49 in $T3_{2022}$ ($T3_{2022}$ mycorhize-poultry manure) The correlations are positive and significant between treatments $T0_{2022}$ and $T1_{2022}$ (r = 0,81 ; ddl = 4; P < 0,05); treatment $T0_{2022}$ and $T2_{2022}$ (r = 0,80 ; ddl = 4; P < 0,05); treatment $T0_{2022}$ and $T3_{2022}$ (r = 0,86 ; ddl = 4; P < 0,05); treatment $T1_{2022}$ and $T2_{2022}$ (r = 0,81 ; ddl = 4; P < 0,05); treatment $T1_{2022}$ and $T3_{2022}$ (r = 0,83 ; ddl = 4; P < 0,05) and treatment $T2_{2022}$ and $T3_{2022}$ (r = 0,84 ; ddl = 4; P < 0,05).

For the two years (2021, 2022), the same value were 0.86 ± 0.36, 1.78 ± 0.54, 2.60 ± 0.4, 2.80 ± 0.30 and 2.88 ± 0.62 in treatment $T0_{2021/2022}$ ($T0_{2021/2022}$, control) ; 0.88 ± 1.19, 2.00 ± 0.23, 2.95 ± 0.50, 3.07 ± 0.15 and 3.32 ± 0.27 in treatment $T1_{2021/2022}$ ($T1_{2021/2022}$, poultry manure) ; 0.91 ± 0.11, 2.15 ± 0.38, 3.06 ± 0.49, 3.20 ± 0.37 and 3.49 ± 0.19 in treatment $T2_{2021/2022}$ ($T2_{2021/2022}$, mycorhize) and 0.97 ± 0.23, 2.50 ± 0.24, 3.23 ± 0.26, 3.54 ± 0.17 and 3.89 ± 0.26 in $T3_{2021/2022}$ ($T3_{2021/2022}$ mycorhize-poultry manure). The correlations are positive and significant between treatments $T0_{2021/2022}$ and $T1_{2021/2022}$ (r = 0,63 ; ddl = 4; P < 0,05); treatment $T0_{2021/2022}$ and $T2_{2021/2022}$ (r = 0,73 ; ddl = 4; P < 0,05); treatment $T0_{2021/2022}$ and $T3_{2021/2022}$ (r = 0,70 ; ddl = 4; P < 0,05); treatment $T1_{2021/2022}$ and $T2_{2021/2022}$ (r = 0,64 ; ddl = 4; P < 0,05); treatment $T1_{2021/2022}$ and $T3_{2021/2022}$ (r = 0,80 ; ddl = 4; P < 0,05) and treatment $T2_{2021/2022}$ and $T3_{2021/2022}$ (r = 0,89 ; ddl = 4; P < 0,05).

Table 1. Variation of collar diameter of *Zea mays* per treatments

	Diameter of collet									
	S6L		S6L+1W		S6L+2W		S6L+3W		S6L+4W	
	m	*s*	*m*	*s*	*m*	*s*	*m*	*s*	*m*	*s*
Treatment $(F0)_{2021}$	0,86	0,14	1,71	0,20	2,34	0,27	2,74	0,27	2,83	0,27
Treatment $(F0)_{2022}$	0,86	0,59	1,85	0,88	2,87	0,54	2,87	0,33	2,94	0,98
Total $(F0)_{2021/2022}$	**0,86**	**0,36**	**1,78**	**0,54**	**2,60**	**0,40**	**2,80**	**0,30**	**2,88**	**0,62**
Treatment $(F1)_{2021}$	0,88	0,15	1,99	0,32	2,91	0,35	3,04	0,30	3,23	0,38
Treatment $(F1)_{2022}$	0,88	0,24	2,02	0,14	2,99	0,68	3,11	0,01	3,41	0,16
Total $(F1)_{2021/2022}$	**0,88**	**0,19**	**2,00**	**0,23**	**2,95**	**0,50**	**3,07**	**0,15**	**3,32**	**0,27**
Treatment $(F2)_{2021}$	0,91	0,08	2,13	0,07	2,98	0,43	3,19	0,33	3,41	0,12
Treatment $(F2)_{2022}$	0,92	0,15	2,18	0,70	3,15	0,55	3,22	0,41	3,57	0,26
Total $(F2)_{2021/2022}$	**0,91**	**0,11**	**2,15**	**0,38**	**3,06**	**0,49**	**3,20**	**0,37**	**3,49**	**0,19**
Treatment $(F3)_{2021}$	0,97	0,17	2,42	0,50	3,18	0,12	3,48	0,19	3,88	0,03
Treatment $(F3)_{2022}$	0,97	0,30	2,59	0,08	3,29	0,40	3,61	0,15	3,91	0,49
Total $(F3)_{2021/2022}$	**0,97**	**0,23**	**2,50**	**0,24**	**3,23**	**0,26**	**3,54**	**0,17**	**3,89**	**0,26**

(F0) : control ; (F1) : poultry manure (5,6T/ha) ; (F2) : mychoryse (0.5 T/ha) ; (F3) : poultry manure-mychoryse. S6L: stape 6 leaves ; S6F + 1 W: stape 6 leaves + 1 week; S6F + 2 W: stape 6 leaves + 1 weeks; S6F + 3 W: stape 6 leaves + 3 weeks; S6F + 4 W: stape 6 leaves + 4 weeks.

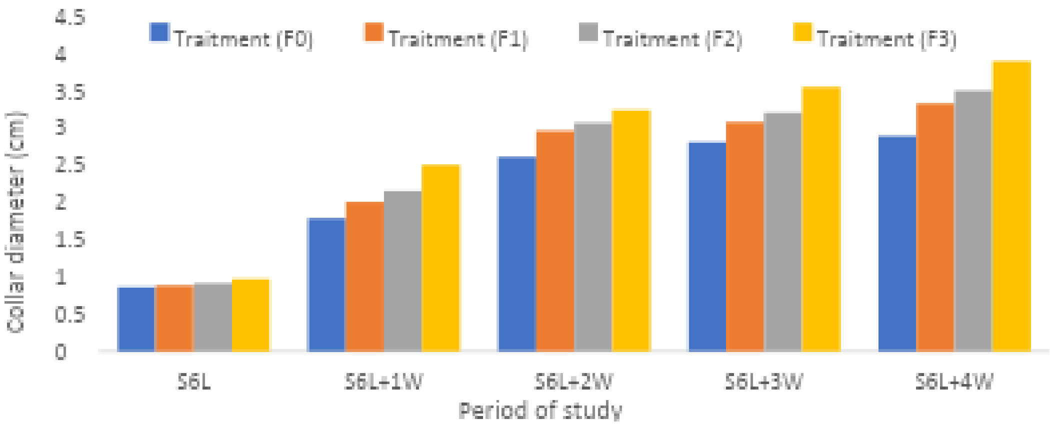

Figure 2. Variation of collar diameter of *Zea mays*

- **Number of leaves**

Table 2 and figure 3 presented the results on variation on number of leaves per different treatments.

a)- In 2021, the number of leaves were 5.73 ± 0.5, 7.57 ± 0.58, 8.97 ± 0.72, 10.2 ± 0.85 and 11.33 ± 0.76 in treatment $T0_{2021}$ ($T0_{2021}$, control) ; 6.09 ± 0.5, 8.45 ± 1.03, 10.53 ± 0.55, 11.04 ± 0.23 and 12.04 ± 0.03 in treatment $T1_{2021}$ ($T1_{2021}$, poultry manure) ; 6.66 ± 0.09, 8.95 ± 0.85, 11.07 ± 0.28, 11.76 ± 1.67 and 12.83 ± 0.49 in treatment $T2_{2021}$ ($T2_{2021}$, mycorhize) and 7.22 ± 0.86, 10.23 ± 1.86, 11.71 ± 1.04, 12.58 ± 1.77 and 13.04 ± 0.57 in $T3_{2021}$ ($T3_{2021}$ mycorhize-poultry manure) The correlations are positive and significant between treatments $T0_{2021}$ and $T1_{2021}$ (r = 0,71 ; *ddl* = 4; P < 0,05); treatment $T0_{2021}$ and $T2_{2021}$ (r = 0,70 ; *ddl* = 4; P < 0,05); treatment $T0_{2021}$ and $T3_{2021}$ (r = 0,77 ; *ddl* = 4; P < 0,05); treatment $T1_{2021}$ and $T2_{2021}$ (r = 0,81 ; *ddl* = 4; P < 0,05); treatment $T1_{2021}$ and $T3_{2021}$ (r = 0,69 ; *ddl* = 4; P < 0,05) and treatment $T2_{2021}$ and $T3_{2021}$ (r = 0,86 ; *ddl* = 4; P < 0,05).

In 2022, the same value were 5.73 ± 0.51, 7.47 ± 0.74, 9.10 ± 0.71, 11.33 ± 0.71 and 11.73 ± 0.74 in treatment $T0_{2022}$ ($T0_{2022}$, control) ; 6.09 ± 0.14, 9.12 ± 0.88, 10.53 ± 0.55, 11.04 ± 0.23 and 12.04 ± 0.03 in treatment $T1_{2022}$ ($T1_{2022}$, poultry manure) ; 6.66 ± 0.04, 9.35 ± 0.74, 10.86 ± 1.53, 12.03 ± 0.43 and 12.93 ± 0.71 in treatment $T2_{2022}$ ($T2_{2022}$, mycorhize) and 7.22 ± 0.82, 10.54 ± 1.24, 11.29 ± 1.33, 12.47 ± 1.25 and 13.77 ± 0.73 in $T3_{2022}$ ($T3_{2022}$ mycorhize-poultry manure) The correlations are positive and significant between treatments $T0_{2022}$ and $T1_{2022}$ (r = 0,78 ; *ddl* = 4; P < 0,05); treatment $T0_{2022}$ and $T2_{2022}$ (r = 0,82 ; *ddl* = 4; P < 0,05); treatment $T0_{2022}$ and $T3_{2022}$ (r = 0,85 ; *ddl* = 4; P < 0,05); treatment $T1_{2022}$ and $T2_{2022}$ (r = 0,79 ; *ddl* = 4; P < 0,05); treatment $T1_{2022}$ and $T3_{2022}$ (r = 0,84 ; *ddl* = 4; P < 0,05) and treatment $T2_{2022}$ and $T3_{2022}$ (r = 0,84 ; *ddl* = 4; P < 0,05).

For the two years (2021, 2022), the same value were 5.73 ± 0.50, 7.52 ± 0.66, 9.03 ± 0.71, 10.76 ± 0.78 and 11.53 ± 0.75 in treatment $T0_{2021/2022}$ ($T0_{2021/2022}$, control) ; 6.09 ± 0.49, 8.78 ± 0.96, 10.75 ± 0.81, 11.35 ± 0.16 and 12.25 ± 0.04 in treatment $T1_{2021/2022}$ ($T1_{2021/2022}$, poultry manure) ; 6.66 ± 0.06, 9.15 ± 0.79, 10.96 ± 0.90, 11.89 ± 1.05 and 12.88 ± 0.60 in treatment $T2_{2021/2022}$ ($T2_{2021/2022}$, mycorhize) and 7.22 ± 0.88, 10.38 ± 1.55, 11.50 ± 1.18, 12.52 ± 1.51 and 13.40 ± 0.65 in $T3_{2021/2022}$ ($T3_{2021/2022}$ mycorhize-poultry manure). The correlations are positive and significant between treatments $T0_{2021/2022}$ and $T1_{2021/2022}$ (r = 0,59 ; *ddl* = 4; P < 0,05); treatment $T0_{2021/2022}$ and $T2_{2021/2022}$ (r = 0,87 ; *ddl* = 4; P < 0,05); treatment $T0_{2021/2022}$ and $T3_{2021/2022}$ (r = 0,85 ; *ddl* = 4; P < 0,05); treatment $T1_{2021/2022}$ and $T2_{2021/2022}$ (r = 0,81 ; *ddl* = 4; P < 0,05); treatment $T1_{2021/2022}$ and $T3_{2021/2022}$ (r = 0,80 ; *ddl* = 4; P < 0,05) and treatment $T2_{2021/2022}$ and $T3_{2021/2022}$ (r = 0,78 ; *ddl* = 4; P < 0,05).

Table 2. Variation of number of leaves of *Zea mays* per treatments

	number of leaves									
	S6L		S6L+1W		S6L+2W		S6L+3W		S6L+4W	
	m	*s*	*m*	*s*	*m*	*s*	*m*	*s*	*m*	*s*
Treatment $(F0)_{2021}$	5,73	0,50	7,57	0,58	8,97	0,72	10,20	0,85	11,33	0,76
Treatment $(F0)_{2022}$	5,73	0,51	7,47	0,74	9,10	0,71	11,33	0,71	11,73	0,74
Total $(F0)_{2021/2022}$	**5,73**	**0,50**	**7,52**	**0,66**	**9,03**	**0,71**	**10,76**	**0,78**	**11,53**	**0,75**
Treatment $(F1)_{2021}$	6,09	0,85	8,45	1,03	10,53	0,55	11,04	0,23	12,04	0,03
Treatment $(F1)_{2022}$	6,09	0,14	9,12	0,88	10,98	1,07	11,66	0,10	12,46	0,05
Total $(F1)_{2021/2022}$	**6,09**	**0,49**	**8,78**	**0,96**	**10,75**	**0,81**	**11,35**	**0,16**	**12,25**	**0,04**

Treatment $(F2)_{2021}$	6,66	0,09	8,95	0,85	11,07	0,28	11,76	1,67	12,83	0,49
Treatment $(F2)_{2022}$	6,66	0,04	9,35	0,74	10,86	1,53	12,03	0,43	12,93	0,71
Total $(F2)_{2021/2022}$	**6,66**	**0,06**	**9,15**	**0,79**	**10,96**	**0,90**	**11,89**	**1,05**	**12,88**	**0,66**
Treatment $(F3)_{2021}$	7,22	0,86	10,23	1,86	11,71	1,04	12,58	1,77	13,04	0,57
Treatment $(F3)_{2022}$	7,22	0,82	10,54	1,24	11,29	1,33	12,47	1,25	13,77	0,73
Total $(F3)_{2021/2022}$	**7,22**	**0,88**	**10,38**	**1,55**	**11,50**	**1,18**	**12,52**	**1,51**	**13,40**	**0,65**

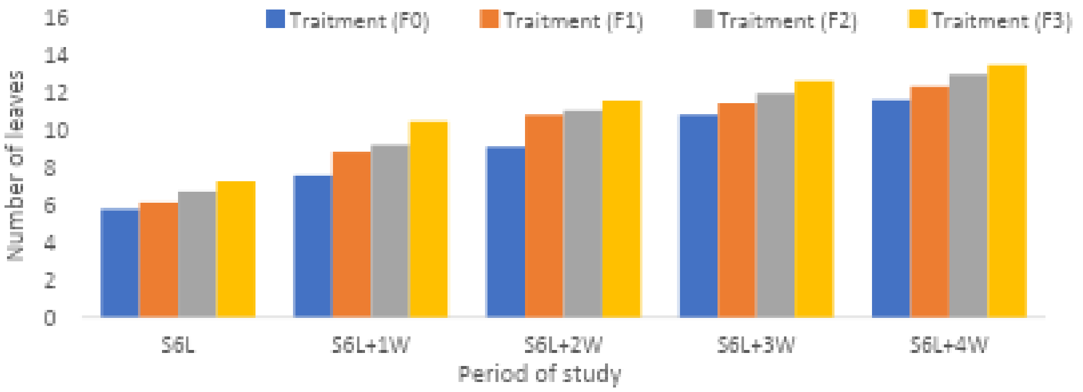

Figure 3. Variation of number of leaves

III.1.2. Diversity and abundance of pollinator insects on panicle of *Zea mays*

Table 3 shows the diversity and abundance of visits on panicles of *Z. mays*. It appears from this table that four groups of pollinators visited panicles belonging to order Diptera, Hymenoptera, Nevroptera and Orthoptera during the flowering period. The number of Hymenoptera was higher (90.94 %), followed by Diptera (8.71 %), Nevroptera (0.30 %) and Orthoptera (0.03%). The results indicate that Hymenoptera are the major pollinators visiting panicles of maize in 2021 and 2022.

Table 3 : pollinators insects counted on the panicles of *Zea mays*, number et percentage of visits

Insects			**2021**		**2022**		**2021/2022**	
Orders	**Family**	**Genre, Species**	***n***	***p %***	***N***	***p %***	***n***	***p %***
Diptera	Calliphoridae	(1 sp.)	6	0.38	10	0.70	16	0.54
	Muscidae	*Musca domestica*	156	10.12	86	6.05	242	8.17
	Total	**2 species**	**162**	**10.51**	**96**	**6.76**	**258**	**8.71**
Hymenoptera	Apidae	*Apis mellifera*	1025	66.51	947	66.96	1972	66.59
		Xylocopa olivacea	103	6.68	156	10.98	259	8.74
		Amegilla sp.	53	3.43	33	2.32	86	2.90
	Eumenidae	*Delta* sp.	15	0.97	7	0.49	22	0.74
	Halictidae	*Halictus* sp.	166	10.77	177	12.46	343	11.58
	Vespidae	*Synagris cornuta*	9	0.58	2	0.14	11	0.37
	Total	**6 species**	**1371**	**88.96**	**1322**	**93.09**	**2693**	**90.94**
Nevroptera		(1 sp)	7	0.45	2	0.14	9	0.30
	Total	**1 espèce**	**7**	**0.45**	**2**	**0.14**	**9**	**0.30**
Orthoptera		(1 sp)	1	0.06	0	0	1	0.03

	Total	**1 species**	**1**	**0.06**	**0**	**0**	**1**	**0.03**
Total	**10 species**		**1541**		**1420**		**2961**	

n **:** number of visits; ***p*** **:** percentage of visits ; p = (n/total of visits) × 100.

III.1.3. Activity of pollinators insects

III.1.3.1. Floral products harvested

The foraging behavior of these insect species is only to pollen harvest.

III.1.3.2. Duration of insect visits to okra flower

In 2021, the mean duration of a visit on *Z. mays* panicle was 39.98 sec ($n = 100$; $s = 13.89$). In 2022, the corresponding figure was 42.38 sec ($n = 100$; $s = 8.62$). The difference between the mean duration of the visit in 2021 and 2022 was highly significant ($t = -9.99$; $ddl = 198$; $p < 0.001$). For the cumulate period 2021 and 2022, the mean duration of visit on panicle was 41.68 sec ($n = 200$; $s = 2.95$) (table 4).

Table 4: Visits duration of pollinators insects of panicles of *Zea mays* in 2021 and 2022

Years	Orders	*n*	Visits duration of panicles (sec.)			
			m	***s***	***Mini***	***Maxi***
2021	Diptera (2 species)	50	75.08	25.05	40	124
	Hynemoptera (6 species)	50	4.88	2.74	2	9
		100	39.98	13.89	2	124
2022	Diptera (2 species)	50	81.33	16.21	35	134
	Hynemoptera (7 species)	50	5.44	3.04	2	11
		100	42.38	9.62	2	134
Total	Diptera (2 species)	100	78,20	20,63	35	134
	Hynemoptera (7 species)	100	5,16	2,89	2	11
		200	**41,68**	**2,95**	**2**	**134**

III.1.4. Yield evaluation

III.1.4.1. Impact of manure on yields

The manure increases the yields of *Z. mays* by improves seed quality. Table 4 presents the results on number of seeds per pod and percentage of normal seeds in different treatments.

⇒ Poultry manure

In 2021 (a)- the mean number of seeds per ears was 580.64±42.10 in treatment $T1.2_{2021}$ and 412.96 ±35.02 in treatment $T0.2_{2021}$; The comparison of these means shows that the difference is very highly significant between treatments $T1.2_{2021}$ and $T0.2_{2021}$ ($t = 63.86$; $ddl = 58$; $P < 0.001$) ; (b)- the percentage of normal seed was 82.00 % in treatment $T1.2_{2021}$ and 62.00 % in treatment $T0.2_{2021}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T1.2_{2021}$ and $T0.2_{2021}$ ($X^2 = 1574.65$; $ddl = 1$; $P < 0.001$). In 2021 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure were 28.87 % and 24.39 % respectively. In 2022: (a)- the mean number of seeds per ears was 609.58±8.23 in treatment $T1.2_{2022}$ and 498.05 ±45.66 in treatment $T0.2_{2022}$; The comparison of these means shows that the difference is very highly significant between treatments $T1.2_{2022}$ and $T0.2_{2022}$ ($t = 50.13$; $ddl = 58$; $P < 0.001$); (b)- the percentage of normal seed was 84.77 % in treatment $T1.2_{2022}$ and 60.17 in treatment $T0.2_{2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T1.2_{2022}$ and $T0.2_{2022}$ ($X^2 = 2585.31$; $ddl = 1$; $P < 0.001$). In 2022 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure were 18.29 % and 29.01 % respectively.

For the two years, the mean number of seeds per ears was 595.11±25.16 in treatment $T1.2_{2021/2022}$ and 455.50 ± 40.34 in treatment $T0.2_{2021/2022}$; The comparison of these means shows that the difference is very highly significant between treatments $T1.2_{2021/2022}$ and $T0.2_{2021/2022}$ ($t = 132.54$; $ddl = 118$; $P < 0.001$). the percentage of normal seed was 83.41 % in treatment $T1.2_{2021/2022}$ and 61.03 in treatment $T0.2_{2021/2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T1.2_{2021/2022}$ and $T0.2_{2021/2022}$ ($X^2 = 4093.14$; $ddl = 1$; $P < 0.001$). In 2021/2022 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure were

23.45 % and 26.83 respectively.

⇒ Mycorhize

In 2021 (a)- the mean number of seeds per ears was 697.09±37.41 in treatment $T2.2_{2021}$ and 412.96 ±35.02 in treatment $T0.2_{2021}$; The comparison of these means shows that the difference is very highly significant between treatments T2.2 $_{2021}$ and T0.2 $_{2021}$ (t = 115.64; *ddl* = 58; $P < 0.001$) ; (b)- the percentage of normal seed was 92.11 % in treatment $T2.2_{2021}$ and 62.00 % in treatment $T0.2_{2021}$; The comparison of these percentages shows that the difference is very highly significant between treatments T2.2 $_{2021}$ and T0.2 $_{2021}$ (X^2 = 4816.31; *ddl* = 1; $P < 0.001$). In 2021 the mean number of seeds per ears and the percentage of normal seeds improves by mycorhize were 40.75 % and 32.68 % respectively. In 2022: (a)- the mean number of seeds per ears was 702.63±14.33 in treatment $T2.2_{2022}$ and 498.05 ±45.66 in treatment $T0.2_{2022}$; The comparison of these means shows that the difference is very highly significant between treatments T2.2 $_{2022}$ and T0.2 $_{2022}$ (t = 89.21; *ddl* = 58; $P < 0.001$); (b)- the percentage of normal seed was 87.00 % in treatment $T2.2_{2022}$ and 60.17 in treatment $T0.2_{2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments T2.2 $_{2022}$ and T0.2 $_{2022}$ (X^2 = 3500.49; *ddl* = 1; $P < 0.001$). In 2022 the mean number of seeds per ears and the percentage of normal seeds improves by mycorhize were 21.11 % and 30.83 % respectively.

For the two years, the mean number of seeds per ears was 699.86±25.82 in treatment $T2.2_{2021/2022}$ and 455.50 ± 40.34 in treatment $T0.2_{2021/2022}$; The comparison of these means shows that the difference is very highly significant between treatments T2.2 $_{2021/2022}$ and T0.2 $_{2021/2022}$ (t = 214.64; *ddl* = 118; $P < 0.001$). the percentage of normal seed was 89.57 % in treatment T2.2 $_{2021/2022}$ and 61.03 in treatment $T0.2_{2021/2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments T2.2 $_{2021/2022}$ and T0.2 $_{2021/2022}$ (X^2 = 8229.57 ; *ddl* = 1; $P < 0.001$). In 2021/2022 the mean number of seeds per ears and the percentage of normal seeds improves by mycorhize were 34.91 % and 31.86 respectively.

⇒ Poultry manure-Mycorhize

In 2021 (a)- the mean number of seeds per ears was 756.47±59.05 in treatment $T3.2_{2021}$ and 412.96 ±35.02 in treatment $T0.2_{2021}$; The comparison of these means shows that the difference is very highly significant between treatments T3.2 $_{2021}$ and T0.2 $_{2021}$ (t = 104.35; *ddl* = 58; $P < 0.001$) ; (b)- the percentage of normal seed was 95.07 % in treatment $T3.2_{2021}$ and 62.00 % in treatment $T0.2_{2021}$; The comparison of these percentages shows that the difference is very highly significant between treatments T3.2 $_{2021}$ and T0.2 $_{2021}$ (X^2 = 6775.19; *ddl* = 1; $P < 0.001$). In 2021 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure - mycorhize were 45.80 % and 34.78 % respectively. In 2022: (a)- the mean number of seeds per ears was 736.81±44.99 in treatment $T3.2_{2022}$ and 498.05 ±45.66 in treatment $T0.2_{2022}$; The comparison of these means shows that the difference is very highly significant between treatments T3.2 $_{2022}$ and T0.2 $_{2022}$ (t = 77.68; *ddl* = 58; $P < 0.001$); (b)- the percentage of normal seed was 96.95 % in treatment $T3.2_{2022}$ and 60.17 in treatment $T0.2_{2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments T3.2 $_{2022}$ and T0.2 $_{2022}$ (X^2 = 8295.41; *ddl* = 1; $P < 0.001$). In 2022 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure - mycorhize were 32.40 % and 37.93 % respectively.

For the two years, the mean number of seeds per ears was 746.64±52.20 in treatment $T3.2_{2021/2022}$ and 455.50 ± 40.34 in treatment $T0.2_{2021/2022}$; The comparison of these means shows that the difference is very highly significant between treatments T3.2 $_{2021/2022}$ and T0.2 $_{2021/2022}$ (t = 186.06; *ddl* = 118; $P < 0.001$). the percentage of normal seed was 95.98 % in treatment T3.2 $_{2021/2022}$ and 61.03 in treatment $T0.2_{2021/2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments T3.2 $_{2021/2022}$ and T0.2 $_{2021/2022}$ (X^2 = 15170.52 ; *ddl* = 1; $P < 0.001$). In 2021/2022 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure - mycorhize were 38.99 % and 36.41 respectively.

III.1.4.2. Impact of pollinators insects on yields

During pollen harvest, pollinators insects of *Z. mays* are regular shaken panicle, then pollen was released and transported by the wind until female flower. These insects therefore increase the possibilities of pollination. Table 4 presents the results on number of seeds per pod and percentage of normal seeds in different treatments. It is clear from

this table that:

In 2021 (a)- the mean number of seeds per ears was 514.86±27.09 in treatment $T0.1_{2021}$ and 412.96 ±35.02 in treatment $T0.2_{2021}$; The comparison of these means shows that the difference is very highly significant between treatments T0.1 $_{2021}$ and T0.2 $_{2021}$ (t = 48.00; *ddl* = 58; $P < 0.001$) ; (b)- the percentage of normal seed was 83.02 % in treatment $T0.1_{2021}$ and 62.00 % in treatment $T0.2_{2021}$; The comparison of these percentages shows that the difference is very highly significant between treatments T0.1 $_{2021}$ and T0.2 $_{2021}$ (X^2 = 1643.69; *ddl* = 1; $P < 0.001$). In 2021 the mean number of seeds per ears and the percentage of normal seeds done by pollinators insects were 19.79 % and 25.31 % respectively. In 2022: (a)- the mean number of seeds per ears was 559.45±14.36 in treatment $T0.1_{2022}$ and 498.05 ±45.66 in treatment $T0.2_{2022}$; The comparison of these means shows that the difference is very highly significant between treatments T0.1 $_{2022}$ and T0.2 $_{2022}$ (t = 26.75; *ddl* = 58; $P < 0.001$); (b)- the percentage of normal seed was 81.03 % in treatment $T0.1_{2022}$ and 60.17 % in treatment $T0.2_{2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T0.1_{2022}$ and $T0.2_{2022}$ (X^2 = 1699.33; *ddl* = 1; $P < 0.001$). In 2022 the mean number of seeds per ears and the percentage of normal seeds done by pollinators insects were 10.97 % and 25.75 % respectively.

For the two years, the mean number of seeds per ears was 537.15±20.72 in treatment $T0.1_{2021/2022}$ and 455.50 ± 40.34 in treatment $T0.2_{2021/2022}$; The comparison of these means shows that the difference is very highly significant between treatments $T0.1_{2021/2022}$ and $T0.2_{2021/2022}$ (t = 75.14; *ddl* = 118; $P < 0.001$). the percentage of normal seed was 82.02 % in treatment $T0.1_{2021/2022}$ and 61.03 % in treatment $T0.2_{2021/2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T0.1_{2021/2022}$ and $T0.2_{2021/2022}$ (X^2 = 3349.08 ; *ddl* = 1; $P < 0.001$). In 2021/2022 the mean number of seeds per ears and the percentage of normal seeds done by pollinators insects were 15.20 % and 25.59 % respectively.

Table 4: Mean number of seeds per ears and percentage of normal seeds according to different treatments of *Zea mays* in 2021 and 2022

Treatments	Number of seed per ears			Normal seed	Total of seed	% of normal seed
	n	*m*	*s*			
$T0.1_{2021}$	30	514.86	27.09	13325	16050	83.02
$T0.2_{2021}$	30	412.96	35.02	8185	13200	62.00
$T0.1_{2022}$	30	559.45	14.36	13858	17100	81.04
$T0.2._{2022}$	30	498.05	45.66	9030	15005	60.17
$T0.1_{2021/2022}$	**60**	**537.15**	**20.72**	**27183**	**33150**	**82.02**
$T0.2_{2021/2022}$	**60**	**455.50**	**40.34**	**17215**	**28205**	**61.03**
$T1.1_{2021}$	30	623.52	19.65	16520	18910	87.36
$T1.2_{2021}$	30	580.64	42.10	14640	17853	82.00
$T1.1_{2022}$	30	698.05	9.99	18775	21057	89.16
$T1.2._{2022}$	30	609.58	8.23	15641	18450	84.77
$T1.1_{2021/2022}$	**60**	**660.78**	**14.82**	**35295**	**39967**	**88.31**
$T1.2_{2021/2022}$	**60**	**595.11**	**25.16**	**30281**	**36303**	**83.41**
$T2.1_{2021}$	30	744.77	12.99	20935	22505	93.02
$T2.2_{2021}$	30	697.09	37.41	20215	21946	92.11
$T2.1_{2022}$	30	732.23	29.08	20375	22880	89.05
$T2.2._{2022}$	30	702.63	14.23	18845	21659	87.00
$T2.1_{2021/2022}$	**60**	**738.50**	**21.03**	**41310**	**45385**	**91.02**
$T2.2_{2021/2022}$	**60**	**699.86**	**25.82**	**39060**	**43605**	**89.57**
$T3.1_{2021}$	30	785.59	88.31	24480	25244	96.97
$T3.2_{2021}$	30	756.47	59.05	23129	24326	95.07
$T3.1_{2022}$	30	777.65	64.28	24528	25009	98.07
$T3.2._{2022}$	30	736.81	44.99	21965	22654	96.95
$T3.1_{2021/2022}$	**60**	**781.62**	**76.29**	**49008**	**50253**	**97.52**
$T3.2_{2021/2022}$	**60**	**746.64**	**52.02**	**45094**	**46980**	**95.98**

III.1.4.3. Impact of organic fertilizers combined with pollinators insects on yields of *Zea mays*

The organic fertilizers combined with pollinators insects increases the yields of *Z. mays* by improves seed quality. Table 4 presents the results on number of seeds per pod and percentage of normal seeds in different treatments.

⇒ Poultry manure with pollinators insects

In 2021 (a)- the mean number of seeds per ears was 623.52±19.65 in treatment $T1.1_{2021}$ and 412.96±35.02 in treatment $T0.2_{2021}$; The comparison of these means shows that the difference is very highly significant between treatments $T1.1_{2021}$

and $T0.2_{2021}$ (t = 109.36; ddl = 58; P < 0.001) ; (b)- the percentage of normal seed was 87.36 % in treatment $T1.1_{2021}$ and 62.00 % in treatment $T0.2_{2021}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T1.1_{2021}$ and $T0.2_{2021}$ (X^2 = 2816.28; ddl = 1; P < 0.001). In 2021 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure combined with pollinators insects were 33.76 % and 29.01 % respectively. In 2022: (a)- the mean number of seeds per ears was 698.05± 9.99 in treatment $T1.1_{2022}$ and 498.05 ± 45.66 in treatment $T0.2_{2022}$; The comparison of these means shows that the difference is very highly significant between treatments $T1.1_{2022}$ and $T0.2_{2022}$ (t = 89.24; ddl = 58; P < 0.001); (b)- the percentage of normal seed was 89.16 % in treatment $T1.1_{2022}$ and 60.17 in treatment $T0.2_{2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T1.1_{2022}$ and $T0.2_{2022}$ (X^2 = 4168.87; ddl = 1; P < 0.001). In 2022 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure combined with pollinators insects were 28.65 % and 32.40 % respectively.

For the two years, the mean number of seeds per ears was 660.78±14.82 in treatment $T1.1_{2021/2022}$ and 455.50 ± 40.34 in treatment $T0.2_{2021/2022}$; The comparison of these means shows that the difference is very highly significant between treatments $T1.1_{2021/2022}$ and $T0.2_{2021/2022}$ (t = 99.62; ddl = 118; P < 0.001). the percentage of normal seed was 88.31 % in treatment $T1.1_{2021/2022}$ and 61.03 in treatment $T0.2_{2021/2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T1.1_{2021/2022}$ and $T0.2_{2021/2022}$ (X^2 = 6951.47 ; ddl = 1; P < 0.001). In 2021/2022 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure combined with pollinators insects were 31.06 % and 30.89 % respectively.

⇒ Mycorhize combined with pollinators insects

In 2021 (a)- the mean number of seeds per ears was 744.77±12.99 in treatment $T2.1_{2021}$ and 412.96 ±35.02 in treatment $T0.2_{2021}$; The comparison of these means shows that the difference is very highly significant between treatments $T2.1_{2021}$ and $T0.2_{2021}$ (t = 185.27; ddl = 58; P < 0.001) ; (b)- the percentage of normal seed was 93.02 % in treatment $T2.1_{2021}$ and 62.00 % in treatment $T0.2_{2021}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T2.1_{2021}$ and $T0.2_{2021}$ (X^2 = 5321.23; ddl = 1; P < 0.001). In 2021 the mean number of seeds per ears and the percentage of normal seeds improves by mycorhize combined with pollinators insects were 44.55 % and 33.34 % respectively. In 2022: (a)- the mean number of seeds per ears was 732.23±29.08 in treatment $T2.1_{2022}$ and 498.05 ±45.66 in treatment $T0.2_{2022}$; The comparison of these means shows that the difference is very highly significant between treatments $T2.1_{2022}$ and $T0.2_{2022}$ (t = 90.22; ddl = 58; P < 0.001); (b)- the percentage of normal seed was 89.05 % in treatment $T2.1_{2022}$ and 60.17 % in treatment $T0.2_{2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T2.1_{2022}$ and $T0.2_{2022}$ (X^2 = 4347.95; ddl = 1; P < 0.001). In 2022 the mean number of seeds per ears and the percentage of normal seeds improves by mycorhize combined with pollinators insects were 31.98 % and 32.43 % respectively.

For the two years, the mean number of seeds per ears was 738.50±21.03 in treatment $T2.1_{2021/2022}$ and 455.50 ± 40.34 in treatment $T0.2_{2021/2022}$; The comparison of these means shows that the difference is very highly significant between treatments $T2.1_{2021/2022}$ and $T0.2_{2021/2022}$ (t = 129.74; ddl = 118; P < 0.001). the percentage of normal seed was 91.02 % in treatment $T2.1_{2021/2022}$ and 61.03 in treatment $T0.2_{2021/2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T2.1_{2021/2022}$ and $T0.2_{2021/2022}$ (X^2 = 19968.30 ; ddl = 1; P < 0.001). In 2021/2022 the mean number of seeds per ears and the percentage of normal seeds improves by mycorhize combined with pollinators insects were 38.32 % and 32.94 % respectively.

⇒ Poultry manure-Mycorhize combined with pollinators insects

In 2021 (a)- the mean number of seeds per ears was 785.59±88.31 in treatment $T3.1_{2021}$ and 412.96 ±35.02 in treatment $T0.2_{2021}$; The comparison of these means shows that the difference is very highly significant between treatments $T3.1_{2021}$ and $T0.2_{2021}$ (t = 81.80; ddl = 58; P < 0.001) ; (b)- the percentage of normal seed was 96.97 % in treatment $T3.1_{2021}$ and 62.00 % in treatment $T0.2_{2021}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T3.1_{2021}$ and $T0.2_{2021}$ (X^2 = 8296.91; ddl = 1; P < 0.001). In 2021 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure - mycorhize combined with pollinators insects were 47.34 % and 36.06 % respectively. In 2022: (a)- the mean number of seeds per ears was 777.65±64.28 in treatment $T3.1_{2022}$ and 498.05 ±45.66 in treatment $T0.2_{2022}$; The comparison of these means shows that the difference is very highly significant between treatments $T3.1_{2022}$ and $T0.2_{2022}$ (t = 73.96; ddl = 58; P < 0.001); (b)- the percentage of normal seed was 98.07 % in treatment $T3.1_{2022}$ and 61.17 in treatment $T0.2_{2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T3.1_{2022}$ and $T0.2_{2022}$ (X^2 = 9953.79; ddl = 1; P < 0.001). In 2022 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure - mycorhize combined with pollinators insects were 35.95 % and 37.62 % respectively.

For the two years, the mean number of seeds per ears was 781.61±76.29 in treatment $T3.1_{2021/2022}$ and 455.50 ± 40.34 in treatment $T0.2_{2021/2022}$; The comparison of these means shows that the difference is very highly significant between treatments $T3.1_{2021/2022}$ and $T0.2_{2021/2022}$ (t = 78.81; ddl = 118; P < 0.001). the percentage of normal seed was 97.52 % in treatment $T3.1_{2021/2022}$ and 61.03 in treatment $T0.2_{2021/2022}$; The comparison of these percentages shows that the difference is very highly significant between treatments $T3.1_{2021/2022}$ and $T0.2_{2021/2022}$ (X^2 = 27021.28 ; ddl = 1; P < 0.001). In

2021/2022 the mean number of seeds per ears and the percentage of normal seeds improves by poultry manure - mycorhize combined with pollinators insects were 41.72 % and 36.41 % respectively.

III.1.4.4. Quantitative evaluation for two years

The percentage of number of seeds per ears and the percentage of normal seeds due to the action of poultry manure were 23.45 % and 26.83 % respectively; The same numbers due to the action of mycorhize were 34.91 % and 31.86 % ; the result of the percentage of number of seeds per ears and percentage of normal seeds due to the action of poultry manure - mycorhize were 38.99 % and 36.41 % respectively. The percentage of number of seeds per ears and the percentage of normal seeds due to the action of pollinators insects were 15.20 % and 25.59 %. The percentage of number of seeds per ears and the percentage of normal seeds due to the action of poultry manure-pollinators insects were 31.06 % and 30.89 % respectively; The same numbers due to the action of mycorhize-pollinators insects were 38.32 % and 32.94 % and the result of the percentage of number of seeds per ears and percentage of normal seeds due to the action of poultry manure-mycorhize-pollinators insects were 41.72 % and 36.41 % respectively.

III.2. Discussion

The maize (*Z. mays*) responds positively to the application of organic manure. The different treatments are capable of improving the yield of the crop. There were changes in number of leaves and collar diameter in both years. This result corresponds to that of Sharma (2004) in India; Nweke *et al.* (2013) in Nigeria, who showed that plant height, yield and weight yield of maize increases with the application of organic manure. Shahriazzaman *et al.* (2014) in Dhaka (Bangladesh) also showed that application of organic manure (precisely poultry manure) not only improved the yield of okra but also sustained its production. Organic content of the soil also increases with the application of organic manure Gardner (2004) ; Leng (2006) stated in his findings that increase in yield when organic manure is applied is due to increase cation exchange capacity of cations such as phosphor, calcium, magnesium, ammonium and potassium, thereby supplying all necessary nutrients required for growth.

The treatment with mycorhize-poultry manure had the highest number of leaves collar diameter and highest number of seeds compared to poultry manure and mycorhize. These results show that mycorhize-poultry manure had more impact on the vegetative growth of the plant compared to mycorhize and poultry manure. Nweke *et al.* (2013) in Nigeria where in their study of the influence of different types of animal manure on the growth and yield of maize, ranked poultry manure first, followed by goat manure before pig manure. Gardner (2004), Nweke *et al.* (2013) and Fagwalawa and Yahaya (2016) also obtained a same result in their individual studies of Okra with poultry manure. Increase number of leaves in treatments containing poultry manure means that the nutrients were readily available for easy absorption by the plants, thereby boosting the structural growth of the plant. This is also due to higher branching which leads to more leaves, and the more the leaves mean more photosynthesis resulting in higher yield.

The panicles of *Z. mays* are brightly colored and its products are attractive to a variety of insects, which visit the plants to collect pollen during their foraging activities. This corresponds with what was stated by Dounia *et al.* (2018) and Pando *et al.* (2019), in Cameroon, these insects visit maize panicles for their floral product. In this study, Hymenoptera, mainly the bees have been reported on *Z. mays*. Free (1993) in the UK showed that the Apidae had a vital role to play in the pollination of *Z. mays*. This corresponds to that of Crane (1991) in India who identified the genus Apis as the prime maize pollinator. The floral products (pollen) of maize flowers are available in great quantities and is also a rich source of proteins ; This shows that insect activity had great influence on the yield of maize. The number of seeds obtained in the free plants was higher than that of the plants covered to prevent pollinator. These differences were highly significant indicating that pollination had a significant effect on yield. Fruiting is dependent on pollination intensity most of the times (Mc Gregor, 1976) and significant difference in fruiting rate of the plant which let to increase yield is a consequence of the foraging activity of insects. The number of seeds in free pollinated plants was more than that obtained from plants that were covered to prevent pollinators. This is because in open panicles, there was sufficient pollination and more ovules were fertilized which developed into matured seeds, while most seeds were aborted in covered plants due to inadequate pollination.

The fructification rate in manured plots (mycorhize-poultry, mycorhize and poultry) was higher compared to that obtained from the control. The fructification rate in treatment with mycorhize-poultry manure was higher compared to that of treatment with mycorhize and poultry manure. Nweke & Nsoanya (2013) also showed that the administration of poultry manure doubled the quantity of pods compared to the control. Mycorhize-Poultry manure provides greater organic content compared to other manures. The increase in seeds number was as a result of the physical and chemical properties of the soil that were improved under the application of manure, so plant responded well under these conditions especially poultry manure with more yields (Nweke & Nsoanya, 2013). The organic content of the soil was increased with application of organic manure, but mycorhize associated to poultry manure was a better source of organic content compared to poultry manure only because it has a rich amount of phosphorus, nitrogen and potassium.

Conclusion

The application of mycorhize-poultry, mycorhize and poultry manure had an impact on the vegetative parameters of the maize as the number of leaves and collar diameter were higher in treatments containing manure compared to the control. Ten insect's species belonging to three Orders which visited the maize during the two studied periods; Order of

Hymenoptera has the highest number of species. Those insects are attracted by the pollen of *Z. mays*. The number of seeds obtained in the free pollinated plants was higher than that of the plants covered to prevent pollinators. The fructification rate in manured plots (mycorhize-poultry, mycorhize and poultry) was higher compared to that obtained from the control. Therefore, the use of organic fertilizers, mainly mycorhize-poultry manure is recommended for a better growth and production of our plant. Moreover, building and conservation of insect nests around maize should be suggested so as to benefit from the natural assistance of pollinating insects thus increase the yield of *Z. mays*.

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