African Journal of Food Science and Technology (ISSN: 2141-5455) Vol. 7(5) pp. 100-106, July, 2015
DOI: http:/dx.doi.org/10.14303/ajfst.2016.040
Available online @http://www.interesjournals.org/AJFST

Full Length Research Paper

Importance of damage caused by bugs and caterpillars on flowers and other cotton fructiferous organs in a three-level program of phytosanitary protection in Togo

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ABSTRACT

Bugs (Heteroptera), secondary devastators in comparison to caterpillars before 1980, constitute nowadays an important entomologic factor in the shedding of buds and new bolls. An evaluation of their damage and that of the caterpillars on shed organs was realized in an apparatus corresponding to a three method of protection. Statistical analyses (ANOVA) of results have shown in the first mode (NT) that the average of bugs' damage on buds (49.25 ± 3.94) and new bolls (101.5 ± 6.65) is significantly higher than that of caterpillars (36.75 ± 3.25) and (51.75 ± 7.43) respectively. Treatments realized in the second mode (ST) allowed the reduction of the average of bugs' damage by 31.50 ± 5.12 on buds and by 61.25 ± 2.75 on new bolls and that of caterpillars by 24.25 ± 2.62 and by 29.00 ± 4.43 respectively on buds and on bolls. The treatment of the third mode (PP) also led to a reduction of bugs' damage by 24.25 ± 2.65 on buds and by 56.25 ± 7.20 on new bolls and respectively 16.25 ± 1.93 and 29.75 ± 3.06 the damage of caterpillars.

Keywords: Cotton plant; buds; new bolls; bugs; caterpillars; damage.

INTRODUCTION

In Togo, cotton occupies many years ago the second rank in exports after phosphate. Until 2015, it remains the first cash crop cultivated in a pluvial system. Cotton farming has a three level impact: 1) On the evolution of agricultural exploitation through the augmentation of sown areas and its role of involving some food crops (maize, sorghum, and leguminous plants); 2) On the development of the rural area through the realization of common and individual socio-economic infrastructures (hospitals, schools, credit banks, roads, wells, etc.). 3) On farmers' revenue with a reduction of poverty (OCDE, 2005; Bagayako, 2013). It represents 3 to 10 % OCDE (2006) of the Gross Domestic Product. Since the introduction in Togo of the variety "Allen" (*Gossypium hirsutum* L.) in 1964, the seeded areas and the yield did not stop increasing to reach in 1998, 158 797 hectares and 187 703 tons of cotton, that is an output of 1182 kg.ha^{-1}.

However, this farming has its limits of profitability with a level of production of 900 kg.ha^{-1} or below due to non human, climatic or phytosanitary constraints of which the control of insect pests.

In Togo, the cotton zone is the most widespread in latitude in the whole West Africa, latitude 5° North that is 600 km and thus spreads out on the 5 agroecologic regions of the country. Such geographic layout has as consequence; a large diversity of devastating Arthropoda (Silvie et al., 1993; Poutouli, 1994). Only for phytophageous heteroptera, the works of Poutouli and

Maldès (2000) identified 56 species that can accomplish their cycle of development on the cotton plant leading to important damage. Among this species, the families of Pentatomidae, Pyrrocoridae and Miridae are well represented. Species of the last family have been recognized in various countries as responsible of abscission (shedding) of buds and new bolls when they are bitten (Mauney, 1984; Leigh et al., 1988; Poutouli, 1994 and 2006; Tozoou et al., 2015). They become more important when the variety of cotton bearing *Bacillus thuringiensis* gene (Bt cotton) is cultivated in order to reduce the use of insecticide against caterpillars of cotton plant (Greene and Turnipseed, 1996; Haney, 1996; Green et al., 2001 ; Men et al., 2005; Naranjo, 2008; Soria et al., 2009 and 2010a; Arshad and Suhail, 2010; Bergé and Ricroch, 2010; Lu et al., 2010a and 2010b; Olson et al., 2011; Zhao et al., 2011; Zhu et al., 2011; Hofs et al., 2013). The importance of effect of insect pests led the production of the cotton plant highly dependent on chemical insecticide-based protection especially pyrethroids (Cypermethrin, Lanbdacyhalothrin, indoxacarb), organophosphorus (Profenofos) and Neonicotinoid (Acetamipride). Despite the use of these insecticides, important loss of flowers and fruit-bearing organs through abscission is observed during the cycle of development with stings on ripe bolls during the harvest.

This study proposes to sort out the importance of bugs' and caterpillars' damage in the abscission of flowers and bolls in a three level apparatus of protection. This study falls in the scope of finding methods of sustainable management of insect pests in order to increase the production in cotton farming.

MATERIAL AND METHODS

The work was carried out in 2013 in *région des Plateaux*, in *Centre de Recherche Agronomique-Savane Humides* (CRA-SH) of *Anié* (Kolokopé) situated about 250 km northward from Lomé (7°49'N and 1°20'E). This regio n is a plain zone in the center of Togo, covered with dry forests, a savannah, and forest galleries with the presence of bush fires every year. It is characterized by a Guinean type of subtropical climate with roughly two rainy seasons (from March to July and from September to October) and a long dry season (from November to February). The quantity of rain was registered throughout the year. The species of cotton cultivated is *Gossypium hirsutum* L., STAM 129 variety. The adopted apparatus is Fischer block made of three mode of protection:

* Mode 1 **(NT)** = no chemical protection including seeds is used in the three mode of protection.

* Mode 2 **(ST) =** application of insecticide requested by *Nouvelle Société Cotonnière du Togo* (the company in charge of cotton farming in Togo) that is to say a treatment performed each 14 days from the 40th after the planting i.e. 6 treatments during the season. Treatment 1, 2, 3: association (concentrated emulsion) of alphacymethrin/proenos 18/150 g l^{-1} in dosage of 18/300 g ha^{-1}. Treatment 4, 5, and 6: cypermethrin/acetamipride in a dosage of 36/8 g ha^{-1}.

* Mode 3 **(PP)** = weekly application of insecticide from the 31st day after the planting that is a total of 16 treatments during the cotton season.

Treatments 1 to 16: cyperméthrin/acétamiprid + profénofos in a dosage of 36/8+300 g ha^{-1}. The spraying is made with a pressure maintained back sprayer of Berthoud (capacity of 16l of mixture) 16 type equipped with a horizontal handrail of 4 nozzles that allows to spray 2 lines by passage (the walk speed is 1m.s^{-1}). These modes have been applied to four elementary plots (4 repetitions) fragmented as follow.

The 12 so identified plots are disposed on the edge of a block of farming and set in place each year in the center for studies on cotton and its biocenosis. A plot contains 20 lines of 20m each. There are gaps of 0.8m between the lines and 0.3m between the cotton plants on each line.

The sowing was realized on July 4, 2013. Mineral complex NPKSB (12-20-18-5-1) is used as basic fertilizer in a dosage of 150kg/ha on the 20th day (July 24) and urea (46% of nitrogen) as covering fertilizer in a dosage of 50kg/ha on the 40th day after sowing (August 13). A weeding was done on July 22 and banking up on August 16.

Methods of analysis of damage on fallen organs

Space between two central lines of each plot is swept twice a week. Buds and new bolls fallen in this space are collected on the following day of the sweeping. This type of collect was carried out during 8 weeks, from September 13 to October 30, 2013.

Analyses of organs thus collected consist of their dissection under binocular magnifying glass following the methods as described by Mauney and Henneberry (1979), Mauney (1984), Poutouli (1994), except if damage are externally visible. The following variables were defined.

Ftot (total number of collected buds),
Fpi (total number of buds pierced by various caterpillars),
Fst (total number of stung buds),
Fgo (total number of good buds: no damage observed),
Btot (total number of collected bolls),
Bpi (total number of bolls pierced by various caterpillars),
Bst (total number of stung bolls),
Bgo (total number of good bolls: no damage observed)

Statistical analysis

The data of my observation allowed calculating the average of bugs' damage and that of caterpillars in each

Table 1. of fragmented plots of the experimental device

objects	I	II	III	IV
A	103	106	108	110
B	102	104	107	112
C	101	105	109	111

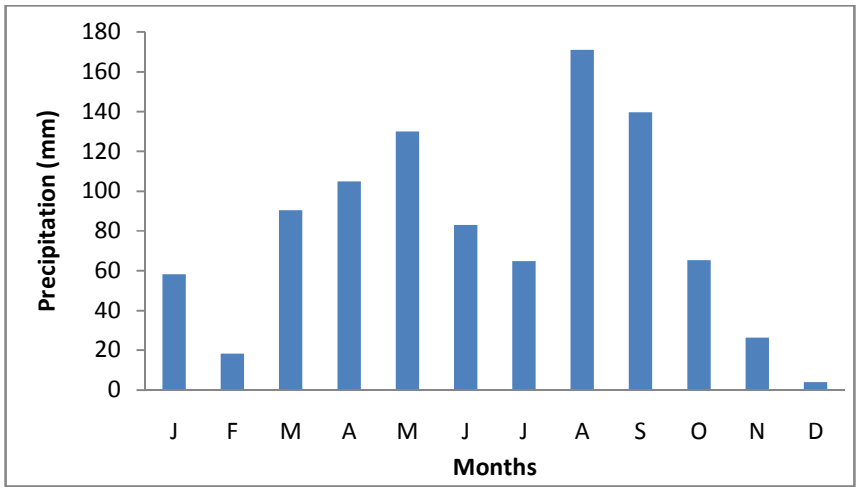

Figure 1. Monthly precipitation in 2013 at Kolokopé

mode after accumulating the numbers collected each week. These averages concern buds (1st variable) and bolls (2nd variable). Results of damage were expressed as an average ± ESM and analyzed with the software, Graph pad Prism Software 4,00 version. The analysis of the variance (ANOVA) was made with Test of Student unpaired. Significance threshold is set at $p < 0.05$.

RESULTS AND DISCUSSION

Precipitation

Rains are shared out throughout the year and results have shown that monthly quantities vary according to months (figure 1). This regularity of rains plays an important role in the maintenance of infestation through host plants, stores of insect pests. In fact, vegetal species like *Crotalaria retusa*, *Indigofera hirsuta*, *Pseudarthria hookeri*, and *Celosia trigyna* attract bugs after cotton and other crops are harvest, assure their maintenance when cotton is not in season and thus constitute reservoirs.

Yearly accumulation of precipitation from 2004 to 2013 (figure 2) is variable. The highest was in 2007 (1527.8 mm) and the lowest in 2011 (944.5 mm). Cotton being a plant of sub-humid and semi-arid zones, benefits from an annual precipitation that is in between 600 and 700 mm, and 1200 and 1300 mm respectively. This shows that the annual accumulations in Togo are enough for cotton farming.

Damage on different organs observed

Buds

Stung buds presented zones of necrosis on petals and stamens (Mauney and Henneberry, 1979; Mauney, 1984; Poutouli, 1994; Tozoou et al., 2015).

* Obtained results showed difference in averages of damage on buds fallen off in each mode of protection (figure 3). In mode 1 in A (NT), a high average of fallen buds was registered: 49.25 ± 3.94 stung buds and 36.75 ± 3.25 pierced buds.

* In mode 2, the average was reduced to 31.50 ± 5.12 stung buds and 17.50 ± 2.25 pierced buds in B (ST).

* In mode 3, results were 24.25 ± 2.62 of stung buds and 16.25 ± 1.93 of pieced buds in C (PP).

The average of good buds but fallen was 24.00 ± 3.89, 35.00 ± 2.44, and 40.75 ± 5.10 in the three modes respectively. The increase of damage average together with intensity of protection, shows the actual level of cotton plant's organs lost apart from entomologic actions.

Analysis of variance of damage nature through the Test of Student unpaired indicated significant differences with a threshold of 5 % in the three modes of protection.

Damage of stings were significantly superior to that of caterpillars in A ($p = 0.05$), B ($p = 0.0465$), and C ($p = 0.0495$). These results show that bugs cause more damage on buds than caterpillars. Results are similar to that of Poutouli (2006) who found a higher rate of buds

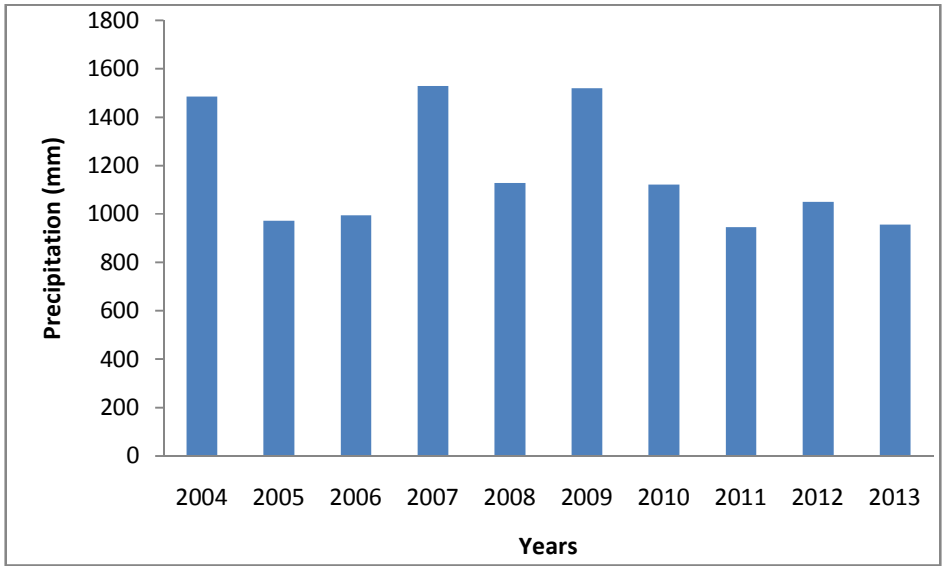

Figure 2. Variation of the accumulation of annual precipitation.

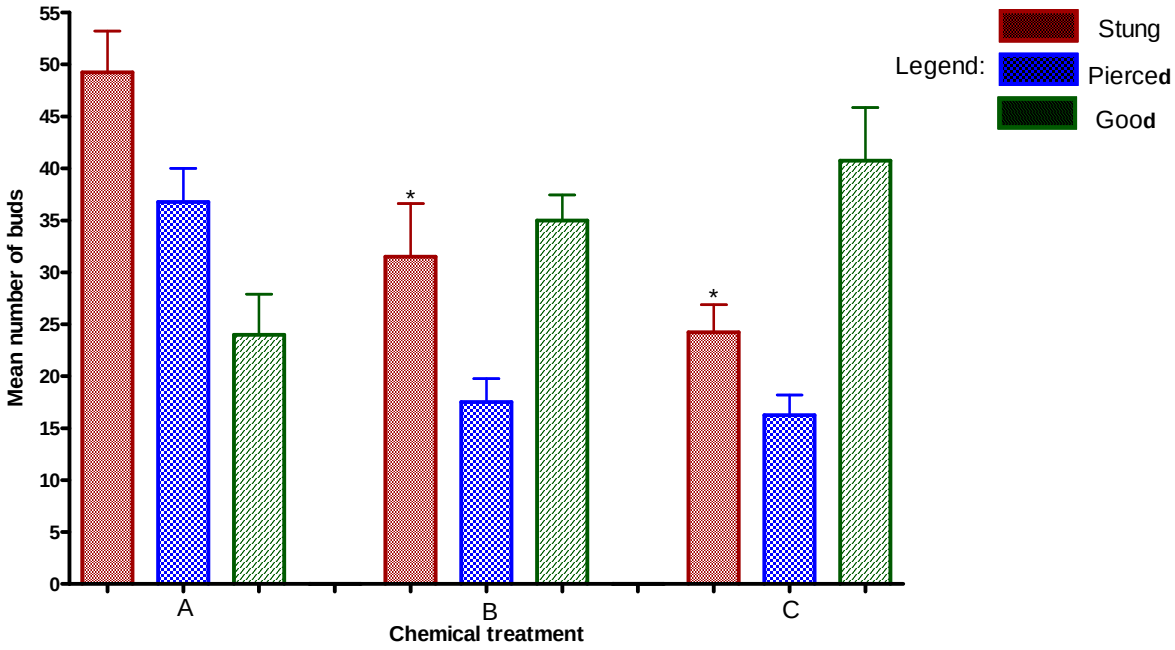

Figure 3. Evolution of buds sanitary state in the objects A = NT, B = ST, C = PP. Results are expressed as ± ESM values. Significant difference (Stung vs Pierced), * = P < 0.05.

stung by bugs than that of bolls pierced by caterpillars. On the other hand, they are contrary to those of Badiane (1995) in Sénégal who showed that buds are more attacked than bolls by carpophage caterpillars and the rate of pierced buds was in average 60 % against 32 % for bolls. The same results also showed that the action of other endogenous and exogenous factors were more important on the "shedding" than that of carpophage caterpillars (parasitic action of bugs were forgotten).

Despite chemical treatments, stung organs are still numerous. The reasons are not clarified. However, many hypotheses can be put forwarded. Larvae of *Lepidoptera* are more known devastating than bugs. Most of the protection measures directed against these larvae and

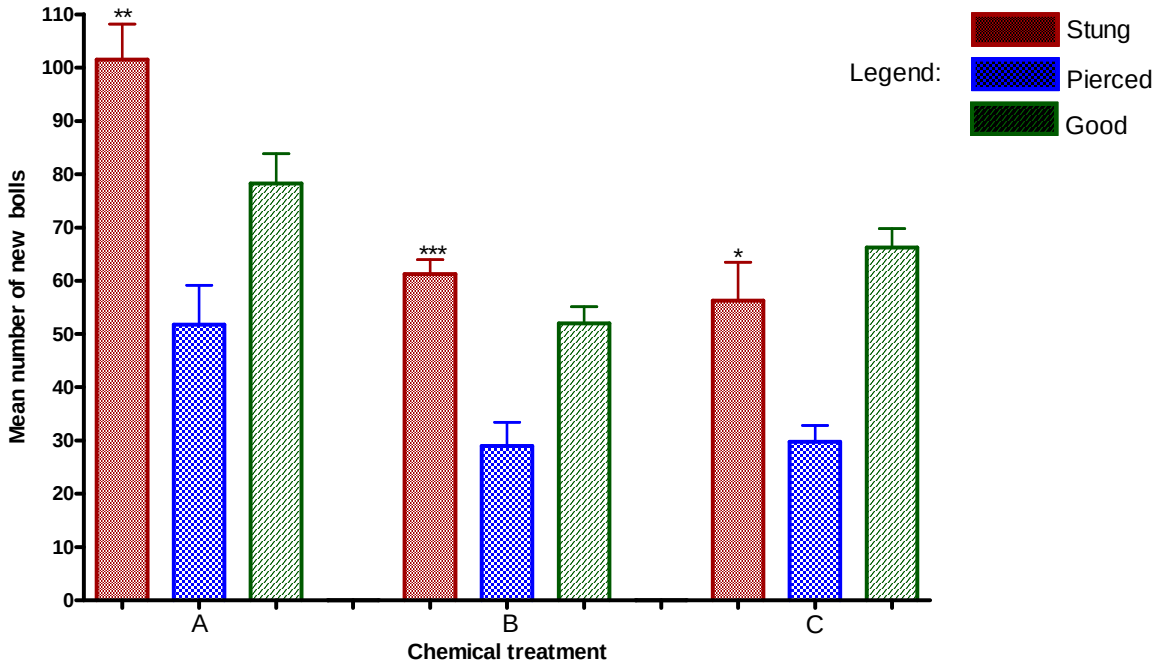

Figure 4. Evolution of new bolls sanitary state in the objects A = NT, B = ST, C = PP. Results are expressed as ± ESM values. Significant difference (Stung vs Pierced), * = P < 0.05

bugs would avoid active matters used. Moreover, popularization of new phytosanitary protection programs aiming at the management of *H. armigera* and pyréthrinoïd resistance with the use of very specific alternative product is another hypothesis. Development of insecticide resistance already observed in some populations of bugs especially in the family of Pentatomidae, Coreidae, and Pyrrhocoridae could reduce the efficacy of insecticide application Sosa-Gomez et al., 2001; ARS, 2010).

New bolls

Results have shown in each mode of protection high averages of good but fallen boll organs. Their averages were respectively estimated at 78.25 ± 5.28, 52.00 ± 3.13, and 66.25 ± 3.52 (figure 4). Fruit plants in general and cotton plant in particular by nature lose their fruit organs (Cognée, 1968). With the works of some authors (Pack and Tugwell, 1976; Tugwell et al., 1976), one knows now that fruits that fall in such way are not good. Some were previously stung at bud stage and yet continued their evolution till fruit stage. Actually, if buds lost 30 %, 60 % or 90 % of their anther out of stings, they could continue their development till new boll stage where we find 13 %, 35 %, or 73 % of abscission respectively. Obtained results (in the three modes of protection as far as observed damage are concerned) showed a high average of damage on boll organs fallen in A (NT): 101.5 ± 6.65 of stung bolls, 51.75 ± 7.43 of pierced bolls. This average was reduced to 61.25 ± 2.75 of stung bolls, to 29.00 ± 4.43 of pierced bolls in B (ST) and to 56.25 ± 7.20 of stung bolls and to 29.75 ± 3.06 of pierced bolls in C (PP) (figure 4).

Variance analysis on the nature of damage through the Test of Student unpaired showed that the damage from stings were significantly superior to that of caterpillars in A ($P < 0.01$), B ($P < 0.001$), and C ($P < 0.05$). These analyses allowed saying that bugs caused more damage to new bolls than caterpillars. According to Poutouli (2006), the average of bugs' and caterpillars' damage on new bolls is statically the same in the absence of any chemical treatment. Our results showed that in general bugs played an important role in buds and new bolls abscission more than caterpillars in cotton farming in Togo. This could be explained by the capacity of bugs to move easily from one young plant to another thus causing damage to many organs.

In cotton farming in the sub region, and to the best of our knowledge and to date, no study is carried out on this and available in literature. Indeed, observations are made on shedding but emphasis is rather laid on carpophage caterpillars (Couilloud, 1964; Cauquil and Vincens, 1982; Badiane, 1995). The spreading of rain all over the year could have an important role in bugs' infestation upholding through host plants which play the role of reservoir for devastating insects. These host plants have an early maturity. They grow on farms and on their edges and quickly wither. This allows migration of aged larvae

and some adults toward cotton plants. Among bugs that strongly want to sting buds and new bolls, many works stress the family of miridae (Tugwell et al., 1976; Tingey et al., 1977; Mauney and Henneberry, 1979). Genera and species identified on cotton plant cause serious damage on the various developmental stages. In Côte d'Ivoire, Congo, Soudan or Syria, *C. pallidus* is well known for its role in buds and new bolls abscission and was named "the shedder bug" Stam (1987). In Egypt, the expression "Cotton square shedder" was attributed to it in order to better characterize its actions Soyer (1942).

The damage observed on fruit organs in our study is identical to that described by Pack and Tugwell (1976) in the USA in the case of *Lygus* and *Pseudatomosceli* genera, Cadou (1994) in Africa and Madagascar, Poutouli (1994) and Tozoou et al. (2015) in Togo in the case of *Creontiades pallidus*, *Taylorilygus arboreus* and *Megacoelum apicale*. Physical destruction of stamens constitutes the main cause of their abscission (Tugwell et al., 1976; Mauney and Henneberry, 1979; Leigh et al., 1988; Poutouli, 2006; Tozoou et al., 2015). But miridae stings have a physiological action on hormonal balance (auxin and ethylene) (Tingey et al., 1977; Burden et al., 1989) since inhibitive capacity of ethylene on auxin transport is well known and the same as that of auxin to delay or prevent abscission (Beyer and Morgan, 1971). Moreover, the presence of 1-amino-Cyclopropane-1-Carboxylic acid (ACC) precursor of ethylene in miridae saliva is mentioned by Burden et al. (1989). This vegetal hormone in miridae saliva is from alimentary origin Taylor (1945).

CONCLUSION

The importance of bugs and caterpillars in bud and boll organs is shown in this study. It brought out that bugs caused more damage to buds and new bolls than caterpillars, for the average of pierced organs is statistically lower than that of stung organs. Formerly considered as minor insect pests, bugs are becoming a significant entomologic factor that needs a particular attention in matter of protection. Despite treatment, the average of stung organs is still relatively high. No work to the best of my knowledge in matter of economic threshold is presently available to know whether these treatments permit reducing averages of bugs and caterpillars damage or not. In Togo, chemical treatments are performed following a timetable; it is therefore necessary to take into account these bugs in the management of cotton insect pests through appropriate phytosanitary methods in order to get good yield in cotton farming.

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