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Cowpea (*Vigna unguiculata* (L.) Walp) field infestation by the bruchids (Coleoptera: Bruchidae) in the northern Senegal: preliminary biological and ecological data

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ABSTRACT

Objective: The objective of this study is to assess, firstly, the effects of distance between the maturing cowpea field and attics storage and secondly the degree of varietal resistance to bruchid infestation *Methodology and Results:* This study was carried out in the northern Senegal. Three cowpea varieties were used: the Mame Fama, the Baye Ngagne and the Ndiaga Aw. For each cowpea variety, two distances between cowpea fields and cowpea store were considered: one cowpea field situated closer and another one farther from cowpea store. Three cowpea samples were collected and then the level of infestation was calculated. The cowpea pods were preserved in the laboratory to identify the emerging species. Results showed that there was a significant effect of field distances to cowpea store on the eggs laid by weevils (P = 0.02). The number of eggs laid also varied with the cowpea variety. Insects preferred laying their eggs more on the Baye Ngagne cowpea variety than the others. But, the highest rate for emerging species is found on the Mame Fama cowpea variety. The main emerging species identified were *Bruchidius atroilineatus* (Pic) and *Callosobruchus maculatus* (F).

Conclusion and application: This preliminary study proved that the level of cowpea infestation in the field varied with the proximity of the field to store and cowpea varieties. The Ndiaga Aw cowpea variety was the most resistant one or the least preferred by weevils. Therefore, it is necessary to widely extend this study to more cowpea fields and more cowpea varieties in order to identify some cowpea varieties which will be more resistant to bruchids than others, and make them accessible for cultivators who face many problems for the conservation of their cowpea crops.

Key words: Cowpea, Senegal, bruchids, Bruchidius atrolineatus, Callosobruchus maculatus.

INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp.) is the most important food legume grown in the tropical Savanna zones of Africa. Although indigenous to southeastern Africa, cowpea has spread worldwide and is extensively cultivated and consumed in regions of Asia, South and Central America, the Caribbean, the United States, the Middle East and southern Europe. Cowpea is a preferred staple food in many regions of Africa. Its desirability reflects the fact that the leaves, immature pods, fresh seeds (southern peas or "green pods"), and dry grain can be eaten or marketed. Also, some varieties have a short cycle and mature early and thus are able to provide food during the "hungry period"—the period at the end of the wet season when food can become extremely scarce in semiarid regions of Sub-Saharan Africa. The dry grain is also commonly milled and consumed in numerous traditional main dishes of Africa as porridge and breads, fed to young children as weaning foods, and eaten as processed snack foods. Cowpea grains, as well as the vegetative parts, make major nutritional contributions to diets. The mature grain contain 23-25% protein, 50-67% starch, B vitamins such as folic acid which is important in preventing birth defects, and essential micronutrients such as iron, calcium, and zinc. Although a significant amount of cowpea is commercialized, it plays a critical subsistence role in the diets of many households in Africa, Latin America and Asia, providing nutrients that are deficient in cereals. An added advantage of cowpea is that the plants can be harvested as fodder for livestock. In certain regions of West and Central Africa the fodder (haulms) is highly valued. During the height of the dry season stored cowpea fodder becomes an important feed for livestock (Cissé & Hall, 1998).

Cowpea (Vigna unguiculata (L) Walp) is the main edible leguminous plant which is cultivated all over the West of Africa (Mondedji et al., 2002). In Senegal, it is the second leguminous plant after groundnut. It is also part of the traditional system of cultivation. As a basic and appreciated food, it is also the cheapest food which provides proteins to most of the rural people (Ndoutoume-Ndong & Rojas-Rousse, 2007). In fact, the cowpea seeds contain most of the amino acids necessary for human feeding, except the sulphured amino acids (Smart, 1964). Thus, its cultivation is considerably interesting, especially in areas located in the North and North-Center of Senegal where it is sometimes considered as the main food supplier for people. Besides its importance for human feeding, cowpea can be the favourite food for cattle because of the virtue of its leaves.

However, the main problem that farmers face is the conservation of the cowpea crops because 80 to 100 % of grains are destroyed by two bruchid species namely Bruchidius atrolineatus (Pic) and Callosobruchus maculatus (Fab), in a period of 2 to 3 months after storage (Ndoutoume-Ndong & Rojas-Rousse, 2008). Cowpea storage bruchid) eats cowpea grain making distinctive round holes. The infestation of cowpea pods by these insects

begins in the fields when the cowpea plant starts producing pods. The eggs are laid on the cowpea pods and then hatch within 5 to 7 days for both species in the best conditions (Djossou, 2006); Damage is apparent about 2 to 3 months after harvest and virtually all of the grain may have holes by 6 months.

After the hatching, the new larva which has not yet got legs to walk, drills the outer side of the cowpea pod peel or of the seed skin and gets inside (Lenting, 2000). The larval development duration varies with the conditions in which the development occurs. The development passes through four larval phases and one nymphal phase (Nammour, 1985). The average total development period is 28 days in the Sahelian area (Doumma, 1998).

Unlike the cowpea seed where the larva can directly have access to the nutritious provisions with more possibilities to survive, in the case of the cowpea pods the young larva may be lost in the empty space (the space between the cowpea seeds) or during its atrophic transit, and arrives at a small seed (with little nutritional reserve) which will not enable it to reach the final phase of development. In the latter case, the death of the larva is inevitable.

In cowpea, it is difficult to see the symptoms indicating the presence of the insect. In general, they are always undetectable. But after the harvest, it is obviously easier to distinguish the seeds of cowpea which is infested with those intact, particularly when the infestation is relatively old.

In fact, the cowpeas seem to be wholesome at the beginning of the larval evolution. Then, after some times, they have small and perfectly round-shaped spots with colours that vary according to the tint of the cowpea seeds. The appearance of these spots are due to the fact that one part of the cowpea seed is eaten by the larva, and what has left is only an operculum which will be smashed later by the weevil in order to get out. Several months after the infestation starts, some identifications such as perforated cowpea seeds, adult insects and cowpea seeds in which the larvae continue their evolution, are made.

In the aim at reducing the losses caused by the weevils, many control strategies were considered ; Consumers have a strong aversion to grain that has been damaged by weevils, but it still can be although, germination effective as seed. percentage may have been reduced. Among the strategies, there is the use of cowpea varieties which are resistant to weevils' attack. However, a few researches are made to show the relation between the levels of infestation on cowpea in the

MATERIALS AND METHODS

Study area: The present study was conducted in the northern Senegal located between the longitudes 14° 15' and 17° 15' west and the latitudes 13° 60' and 16° 15' north, where cultivation of groundnut dominates. The rainy season generally starts from June up to October with yearly rainfalls averaged 200 to 900 mm. Its largest territory is part of the Sahelo-soudanese area which extends across Senegal from West to East. In this area, the rainy season also called "wintering", starts from June-July up to October according to the latitudes, with yearly rainfalls averaged 200 to 900 mm from North to South. This study was conducted in the Northern part of this area.

Cowpea varieties: In the main cowpea production zone in the northern and center-north areas, the following varieties have been recommended during the 1980's and 1990's: 58-57, Ndiambour, Mougne, Bambey 21, CB5, Mouride and Melakh, Each of these varieties has specific characteristics that make them useful in specific areas of the main production zone and specific environmental conditions.

Cowpea improvement started in the early 1960's, with the identification of adapted and high performing landraces such as the small-seeded 58-57. The variety Baye Ngane was bred using 58-57 and a parent that has larger grain size than Ndiaga Aw. It has a 100-seed weight of 16g compared with 12g for 58-57 (Sene and N'diaye 1974). Baye Ngane also is spreading and matures about 75 days after planting under optimal conditions. Baye Ngane and Ndiaga Aw have some drought resistance and wide adaptation, and they have been recommended for cultivation in the northern and center-north areas. The landrace Mame Fama with a lower potential yield of both hay and grain maintained itself in the northern zone because it reaches maturity 5 days earlier and probably is more reliable than 58-57 when the growing season is very short. The varieties Ndiaga Aw and Baye Ngane are resistant to bacterial field in proportion to the places where the cowpeas are stored and the cultivated cowpea varieties.

The objective of this study is to evaluate the level of cowpea infestation by weevils in the field in proportion to the places where the cowpea is stored and also to the kind of cowpea variety. The rate of emergence of insects is also studied for the varieties.

blight, but are susceptible to cowpea aphid-borne mosaic virus, the parasitic weed striga and several insect pests including: hairy caterpillar, cowpea aphids, flower thrips and bruchids.

Three cowpea varieties were selected: the Mame Fama cowpea variety, the Ndiaga Aw cowpea variety and the Baye Ngagne cowpea variety. Both the Mame Fama cowpea pods and the Baye Ngagne cowpea pods have almost the same length whereas those of the Ndiaga Aw are shorter (See table 1).

Cowpea fields: Six cowpea fields, cultivated by farmers from different villages, were regularly examined from sowing to harvest. For each cowpea variety, two fields are selected according to their proximities or not from the places where the cowpeas are stored. Two signs are used to distinguish the different distances. The minus sign (-) indicates that the cowpea field of the variety is closer (less than 500 m) to a place where the cowpeas are stored and the plus sign (+) indicates that the cowpea field of the same variety is farther (more than 500 m) from any places where the cowpeas are stored (See tab.2).

Samples and data analysis: The cowpea seeds were sown by the farmers between the late of June and the early of July 2009 under the same standard cultural practices. At the end of August when the first cowpea pods appeared three cowpea samples were collected with 15 days intervals. The first cowpea sample was collected on 1st September, the second on 15th September and the third on 30th September, 2009. For each cowpea sample, 50 cowpea pods were collected at random from each cowpea field. The initial level of cowpea pods infestation was determined by counting the number of eggs laid on the cowpea pods and also through the number of holes from where adult insects emerge. Afterwards, the cowpea pods were conserved at the laboratory in ventilated scientific jars under the ambient temperature and examined every day for weevil emergence. Adult weevils were identified using Delobel & Tran (1993).

For each cowpea sample, the initial level of infestation on cowpea pods in the field proportionally to the position of the places where the cowpeas are stored and to the kinds of cowpea variety were determinate. Additionally, the rates for emerging adult insects and the number of each identified species were also calculated for each cowpea sample. The initial level of infestation for each sample corresponds to the number of eggs laid by the weevils.

If X is the number of eggs laid and Y the number of emerging adult insects, the algebraic expression for the rate of emergence

(Re) is: Re = (Y / X)*100

If Z is a kind of identified species, the algebraic expression for the whole number of species in Z is: (number of species for Z/Y)*100.

Statistical analyses: All the collected data were analysed through R (version 2.12.0). Those which are not correctly distributed were transformed by using the following function: X^0.5. After variance analysis, Fisher's experiment was chosen to separate the averages from the level of 5%.

| Table 1: The average length of cowbea bods for the different cowbea varietie | Table 1: The | average length of | cowpea pods for t | he different cow | pea varieties |
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| Cowpea Varieties | Average length of the cowpea pods (cm) |
|------------------|--|
| Mame Fama | 17,77 |
| Ndiaga Aw | 14,2 |
| Baye Ngagne | 18,2 |

| Cowpea varieties | Cowpea | fields | Closer villages | Distances (m) | | |
|------------------|--------|--------|-----------------|---------------|--|--|
| Mame Fama(vb) | P1 | vb (-) | Mérina | 200 | | |
| | P2 | vb (+) | Kandala Mbengue | 1100 | | |
| Ndiaga Aw (vr) | P3 | vr (-) | Mérina | 130 | | |
| | P4 | vr (+) | Gade Kébé | 1200 | | |
| Baye Ngagne(vt) | P5 | vt (-) | Gadafé | 150 | | |
| | P6 | vt (+) | Gade Kébé | 1200 | | |

Table 2: The different cowpea fields and their distances to the closest villages

RESULTS

Eggs laid by weevils in the cowpea field as affected by field-store distance: The sharing out of eggs laid by bruchids, has significantly varied in proportion to the groups of cowpea fields (P = 0.02). The number of eggs laid by weevils on the group of cowpea fields termed as 'closer cowpea fields' is the double of the number of eggs laid on the group of cowpea fields termed as 'farther cowpea fields' (fig.1).

Effect of different cowpea varieties on the egg laid and on the adult emergence rates: Among the cowpea fields, insects prefer laying more eggs on the Baye Ngane cowpea variety and after on the Mame Fama cowpea variety. But, with the Ndiaga Aw cowpea variety, the insects lay few eggs on it in the cowpea field (fig. 2). Statistically, the differences in terms of the number of eggs laid between the Mame Fama cowpea and the Ndiaga Aw cowpea and on the other side between the Mame Fama cowpea and the Baye Ngagne cowpea are not significant (P > 0.05). But, between the Ndiaga Aw cowpea variety and the Baye Ngagne cowpea variety, the number of eggs laid on them by weevils is significantly different (P = 0.017).

The whole numbers of adult weevils emerging from cowpea pods were small for all of the three cowpea varieties but with significant differences on the rates for emerging adults. Though the number of eggs laid on the cowpea fields is larger with the Baye Ngagne cowpea variety, the rates for emerging adults is more important with the Mame Fama cowpea variety. Yet, the difference is not significant (P > 0.05). With the Ndiaga Aw cowpea variety, this rate is very few and its difference with those obtained from the other cowpea varieties is very significant (between the Mame Fama cowpea variety, P = 0.003 and on the other side between Ndiaga Aw and Baye Ngagne, P = 0.005).



Figure 1: The number of eggs laid in the fields in proportion to the position of the places where the cowpeas are stored



Figure 2: The number of eggs laid and the rate of emergence in proportion to the cowpea varieties

The identified species of weevils: The emerging weevils from cowpea pods that were conserved at the laboratory are divided into two species: Bruchidius atrolineatus (Pic) and the *Callosobruchus maculatus* (F). The most important numbers of emerging B. atrolineatus species are obtained from the cowpea samples collected from the cowpea fields which are closer to the places where the cowpeas are stored. This difference in terms of the emerging adults between the two groups of cowpea fields is significant (P=0.01). With the *C. maculatus* species, though in terms of absolute magnitude the rate for emerging species is slightly superior with the cowpea samples collected

from cowpea fields which are closer to the places where the cowpeas are stored, this difference is statistically not significant between the two groups (P>0.05) (fig.3). It is found that the whole numbers for each species vary in proportion to the periods when the cowpea samples are collected. The most important number of emerging *B. atrolineatus* species is obtained from the cowpea samples collected on 1st September, 2009. But, with *C. maculatus*, the most important number of emerging species is obtained from the cowpea samples collected on 30th September, 2009 (figure 2).



Figure 3: The sharing out of the *B. atrolineatus* adults and the *C. maculatus* adults in the two groups of the cowpea fields

DISCUSSION

From the field up to the places where it is stored, the cowpea is threatened by various insects. If some of them are in the cowpea fields, the damages they cause are only limited in the fields and the first signs are visible there. These signs are warnings for cultivators to take some measures in order to control them. The recurring problem, of which the cultivators have to fight every time, is the weevils' attack on the crops that are already stored, especially on the stored cowpea crops. Even if this infestation is only visible after the cowpea harvest it starts in the cowpea fields when the cowpea plants start its fruition (Doumma et al., 2006). The question that needs to be asked is: Does relation exist between eggs laid on the cowpea pods and the position of the cowpea fields from the places where the cowpeas are stored? During this study, it was noticed that the cowpea fields located far from villages were more numerous, and in those cowpea fields the availability of resources usable by weevils was more substantial. Normally, in those cowpea fields, the infestation on cowpea pods should have been more important. The results that are found proves the contrary, since from the two groups of cowpea fields that are termed as ('farther cowpea fields' and 'closer cowpea fields'), it is noticed that there is a significant

weevils either on the farther cowpea fields or on the closer cowpea fields. The cowpea fields which are located near the places where the cowpeas are stored. have the most infested cowpea pods. This may be due to the fact that most of the weevils which are responsible for the infestation of cowpea in the closer field come from the places where the cowpeas are stored. This effect of the distance on the infestations of cowpea pods by weevils may be due to the fact that the female egg-layers have a weak flight ability and cannot also live for a long time, only a few of them can fly to reach the farther cowpea fields. In the same way, Nansen et al. (2005) have found that field borders have an effect on the infestations on wheat fields by Cephus cinctus. In this case, the infestations are more important on the wheat located closer to the borders and less important on those situated centre-wards. Likewise, while Seck (1991) was studying the initial infestation for millet fields by Sitotroga cerealella (Oliv), he found that the millet fields which were closer to huts were more infested than those which were far away from the huts. These discoveries are different from the one done by Ganasalingham & Krishnarajah (1979) on rice fields. In that case, the distance from rice fields to

difference in terms of the number of eggs laid by

places where houses are located had no impact on the initial infestation on S. cerealella. Nevertheless, the hypothesis which states that some of the weevils which infest the cowpea in the fields come from others wild plants that host them should not be neglected.

From the three cowpea varieties used for study, all of them were infested. However, it is noticed that weevils prefer to lay more eggs on the Mame Fama cowpea pods and the Baye Ngagne cowpea pods than on the Ndiaga Aw variety where they lay few eggs. So, the level of infestation on cowpea pods depends on the cowpea variety. According to Doumma et al. (2006), data collected from both the egg-laying process on cowpea fields and the process of emerging weevils from the cowpeas, have enabled them to identify some cowpea varieties which have shown some resistance both in the cowpea fields and during the period of storage, with a very low level of contamination contrary to the other cowpea varieties which are the most infested. The difference in terms of infestation between the cowpea varieties may be explained either by the length of some cowpea pods which are longer with the Mame Fama and Baye Ngagne varieties and consequently provide the most important quantity of resources for the larval development, or by the fact that the Ndiaga Aw cowpea pods contain substances less preferred by the female egg-layers. Among the three cowpea varieties studied, the Ndiaga Aw cowpea variety is the most resistant one or otherwise the least preferred by weevils for the laying of their eggs. This is why it is the most cultivated cowpea variety in all over the visited villages.

If the number of eggs laid on the cowpea pods in the field is more numerous with the Baye Ngagne cowpea variety, the rate for emerging species is on the other side more important with the Mame Fama cowpea variety. But, with the Ndiaga Aw cowpea variety, this rate is very few compared to those of the other cowpea varieties. This difference in terms of the number of emerging species may prove the reason why the weevils lay their eggs more on the Baye Ngagne cowpea and the Mame Fama cowpea varieties. Like any living creature, these weevils prefer laying their eggs on egg substrata in which a high rate of survival will be ensured for their descendants. Thus, concerning the Ndiaga Aw cowpea variety, it is quite clear that the weevils have a limited activity. This cowpea variety seems to have cowpea pods and/or cowpea seeds of which the integument does not seem to form an egg substratum favourable to weevils as the same as those of the Mame Fama cowpea and the Baye Ngagne

cowpea varieties. Kogan & Ortman (1978) consider this kind of resistance as an antixenosis resistance which is proved by Cuthbert & Davis (1972) on the Chinese cowpea. According to Pathak & Saxena (1976), the fastest and most effective way to fight against devastators and infestations is the resistance by variety.

The regular examination of cowpea pod samples collected from the different visited localities has enabled us to identify two kinds of Bruchidae species named as: the Bruchidius atrolineatus species (Pic) and the Callosobruchus maculatus (F) species. This identification is in phase with the one done by Doumma et al., (2006). According to them these two species of Bruchidae Beetles grow up to the detriment of the cowpea pods and seeds (Vigna unguiculata) in the Sahelian area. In addition to these two species, Amevoin et al., (2006) have identified a third kind of species named as the Callosobruchus rhodesianus species (Pic) from samples of cowpea seeds collected in the Guinean area in Togo.

The significant difference in terms of the number of emerging adults for the B. atrolineatus species according to the cowpea fields shows that the flock of this species lay their eggs on the first available cowpea pods. Contrary to that, with the flock of C. maculatus the number of emerging adults is statistically not significant though in terms of absolute magnitude it is superior in the cowpea fields located near the places where the cowpeas are stored. It is also noticed that with *B. atrolineatus* the most important infestations were obtained from the cowpea samples collected on 1st September contrary to what happened with the C. maculatus of which the most important infestations were obtained from the cowpea samples collected on 30th September. Therefore, it can be said that C. maculatus choose to lay only a few eggs on the first formed cowpea pods contrary to the *B. atrolineatus* which lay massively their eggs as soon as the resource is available. For Alzouma (1986, 1987), the B. atrolineatus female egg-layers are opportunistic species which lay their eggs on the most abundant stages of cowpea pods evolution in the fields whereas the C. maculatus female egg-layers seem to choose the place where they lay 60 % of their eggs on the vellowing cowpea pods. This is in phase with the identifications that are made, because the most important number of emerging adults for the C. maculatus species is obtained from the cowpea pods of the third sample where 100 % of them were dried. In Senegal, the flock of C. maculatus species are the main

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responsible for damages made on the stored cowpea. This is understood since the first formed cowpea pods where the flock of *B. atrolineatus* species dominate, are supposed to be used for immediate consumption. On the other hand, most of the dried cowpea pods coinciding with the harvest period and where the flock of C. maculatus species dominate, are supposed to be stored. This may also be explained by the fact that the B. atrolineatus adults stay only for a few weeks in the stored cowpeas and then disappear. Amevoin et al. (2006) have demonstrated that in Togo if the three

CONCLUSION

From this study, it is proved that there is a relation between the infestation on cowpea in the field and the position of the places where the cowpeas are stored. The most important infestations occur in the fields which are closer to the places where the cowpeas are stored. It is also shown that, among the three cowpea varieties used for study, the Ndiaga Aw cowpea variety which is the most cultivated one is the least fragile to weevils. This study should be widely extended to other

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species of Bruchidae are put together with the stored cowpea, only the flock of C. maculatus species stay there for the 6 or 8 months of the storage, the other species such as C. rhodesianus and B. atrolineatus disappear around 2 to 3 months after the cowpea are stored in the cowpea garret. These identifications are different from those made by Doumma et al. (2006). According to them, the conditions in which the cowpeas are stored in Niger, seems to reveal that the most important damages are caused by the B. atrolineatus species.

cowpea fields and also to a bigger number of cowpea varieties in order to confirm the relation that exists between the level of infestation on cowpea pods and the position of the places where the cowpeas are stored, and also to identify some cowpea varieties which are more resistant to weevils than others and make them accessible for cultivators who face many problems to conserve their cowpea crops.

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