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COMPONENTS FOR THE MANAGEMENT OF TWO INSECT PESTS OF PEARL MILLET IN SAHELIAN WEST AFRICA*

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Abstract—Pearl millet, *Pennisetum glaucum* (L.) R. Br. is attacked by over 100 species of insect pests, but only a few of these are of economic importance. The two major ones, the millet stem borer, *Coniesta ignefusalis* Hampson and the earhead caterpillar *Heliocheilus albipunctella* de Joannis have been the subject of research in the Sahel during the last decade. The various methods that have been suggested for the control of these species are briefly discussed. Generally, the control strategy adopted by farmers involves the use of cultural operations that will reduce insect damage. There are no control measures that have been developed for farmers. The more scientific methods that have been suggested are the results from research trials and experiments. These have several limitations. Future perspectives and considerations for developing sound and practical farmer-oriented practices are discussed.

Key Words: Pearl millet, Sahel, stem borer, *Coniesta ignefusalis*, ear head caterpillar, *Heliocheilus albipunctella*, control measures, pest management

Résumé—Le mil, *Pennisetum glaucum* (L.) R. Br. est susceptible d'être attaqué par plus de 100 espèces d'insectes ravageurs, mais ce n'est quelques espèces qui sont d'une importance économique. Les deux espèces principales, le foreur des tiges du mil, *Coniesta ignefusalis* Hampson et la chenille des chandelles, *Heliocheilus albipunctella* de Joannis, ont fait l'objet des travaux de recherche dans le Sahel au cours de la dernière décennie. Les diverses méthodes proposées pour la lutte contre ces insectes sont exposées brièvement dans le présente article. D'une manière générale, la stratégie de lutte adoptée par les paysans consiste à utiliser des opérations culturales permettant de réduire les dégâts causés par les insectes. Il n'existe pas de mesures de lutte mises au point pour les paysans en particulier. Les résultats des travaux de recherche et des expériences ont permis de proposer les méthodes plus scientifiques. Mais, celles-ci comportent plusieurs limitations. L'article présente finalement une analyse des perspectives de l'avenir ainsi que des facteurs à prendre en compte pour la mise au point de pratiques valables et efficaces et destinées aux paysans.

Mots Clés: Mil, le Sahel, foreur des tiges, *Coniesta ignefusalis*, chenille des chandelles, *Heliocheilus albipunctella*, mesures de lutte, lutte contre les ravageurs

INTRODUCTION

Pearl millet is more extensively cultivated and used in West Africa than in other regions of the continent and within West Africa, the major areas of production are in the Sudano-Sahelian and Sahelian zones. The number of insect species that have been reported on pearl millet in West Africa varies from country to country. Ajayi (1987) reported 161 species in Nigeria, Guevremont (1982) listed 84 from Niger and Ndoye (1979), 81

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in Senegal. The figures remain vague from Burkina Faso and Mali. However, of the many species that have been listed, only a few of these are of economic importance. The millet stem borer, *Coniesta ignefusalis* Hampson (=*Acigona ignefusalis*) and the earhead caterpillar *Heliocheilus albipunctella* de Joannis (=*Raghuva albipunctella*) are widely distributed in the Sahel and are considered the major pests of pearl millet (ICRISAT, 1984).

In earlier studies by Risbec (1950), Bowden (1956), Appert (1957, 1964), Harris (1962) and Brenière (1970), there was little specific information on the life histories and behaviour of a few target species. However, in recent years, the literature on insect pests of pearl millet, especially of the stem borer and the earhead caterpillar, has improved with studies on yield losses, population dynamics and control methods (Nwanze, 1985; Gahukar et al., 1986; Bhatnagar, 1987; Ndoye and Gahukar, 1987; Gahukar, 1988; Nwanze, 1988; Nwanze 1989; Nwanze and Sivakumar, 1991). Generally, control measures by farmers involve the use of some cultural operations that will reduce insect damage, with the occasional use of insecticides to reduce their numbers. These rare occasions are often the result of massive local government or international interventions such as is the case with grasshoppers.

The low commercial value of millet, the size and distribution of farm holdings and the unpredictability of rainfall in the Sahel, create both disincentives and limitations to local investment in the management of insect pests. The increased concern in the last decade over food production in Africa and the recognition that insect pests, diseases and weeds are a major constraint to the realization of self-sufficiency in food production in the Sahel, resulted in the USAID-financed Integrated Pest Management Project. Both the stem borer and the earhead caterpillar received considerable attention in the studies that were conducted during the life of this project.

In this paper, a brief account of the bioecologies and economic importance of the stem borer and earhead caterpillar is given. Currently suggested control practices, which are mainly the results from research trials and experiments, are summarized and the results of recent investigations into various components of pest management of these insect pests in the Sahel are presented.

INSECT BIOECOLOGY

Coniesta ignefusalis is widely distributed in West Africa and is predominant in the Sahel and Sudanian zones as the major stem borer of millet. There are two to three generations a year with peaks in moth population in July and September. Six to seven larval instars are produced and pupation occurs in the stem. At the end of the crop season, larvae enter into diapause. Diapausing populations decline during the dry season from November to May (Nwanze, 1989). Sowing of pearl millet usually begins with the onset of rains in June. Damage symptoms appear within 4 weeks of crop emergence and is most characterized by the production of dead hearts in seedlings which results in profuse tillering. Stem tunnelling, chaffy heads and stem or peduncle breakage may result from late borer attack.

Heliocheilus albipunctella is reported to occur between latitudes 11 and 15°N, within the southern Sahel and Sudan bioclimatic zones. Eggs are laid in batches of 20–50 on the spikelets and floral peduncles of newly exserted heads and hatch in 3–4 days. Larval development is completed in 23–39 days. Peak moth emergence generally occurs in August when head exsertion occurs in most millets of the region. *H. albipunctella* is a univoltine species and off-season carryover, is through diapausing pupae in the soil. The majority of the pupae are found at 10–15 cm deep in heavy (clay/loam) and at 15–25 cm in sandy soil. Populations decline as the dry season progresses due to pupal mortality especially at the upper soil levels where maximum temperatures reach 50–55°C in April and May. The onset and continuity of rains, favourable soil moisture and temperature conditions are key factors in diapause termination, duration of post-diapause development and adult emergence (Nwanze and Sivakumar, 1991). Young larvae feed on the floral glumes, while older larvae cut the floral peduncles and produce the characteristic spiral mines on the earhead. Extensive damage may result in skeletonized panicles.

ECONOMIC IMPORTANCE

Stem borer damage to early-sown millet is usually low while late sowing is associated with severe losses from unproductive tillers. Losses are in the order of 5% in northern Nigeria with a few exceptions of upto 15% having been recorded in Kano (Harris, 1962). In some cases, borer damage has been associated with better growth, with low levels of infestation resulting in an increase in yield (Nwanze, 1989).

Losses due to the earhead caterpillar have been higher. During the sahelian drought of the 70s, losses of upto 25% of millet production in the Sine Saloum and Diourbel regions of Senegal in 1974 were attributed to this pest (Vercambre, 1978). Other figures have been provided by Gahukar et al. (1986) in the order of 3–82% in various regions of Senegal. In Niger Guevremont (1983) reported 6% in a local millet cultivar, IVSP. Recent studies in Niger have also estimated losses at between 8–41% on different cultivars (Nwanze and Sivakumar, 1991).

CURRENT CONTROL PRACTICES

Most of the methods in use for the control of the stem borer and the earhead caterpillar are cultural practices that have evolved with indigenous farming practices. They are usually aimed at reducing damage than numbers of insects. The commonest are the removal and destruction of dead hearts caused by borers and hand-picking of earhead caterpillars. Suggested control methods, usually the results of current research efforts, have stressed the development of pest management strategies that combine all possible methods (cultural, chemical, biological and varietal resistance). They, however, fall short of the realities of attainable goals based on the crop, the farmer, the agro-ecosystem and the socio-political environment of the Sahel. There is actually no control strategy that has been developed for farmers for the control of millet pests. The trend so far has been in the experimentation of individual components, the results of which have often been put together as parts of an integrated pest management strategy. The salient aspects of these studies are summarized.

Cultural practices

These include sowing date, intercropping, tillage, farm hygiene, and fertilizer application. While early planted millet may suffer less stem borer damage, the crop is more likely to suffer losses from *Heliocheilus* infestation. The effects of intercropping have not been consistent. Tillage practices such as deep ploughing (20–23 cm) have been shown to reduce pupal populations of *Heliocheilus* in Senegal (Vercambre, 1978) and in Niger (Nwanze and Sivakumar, 1991). Timing is crucial and this practice could on the other hand accentuate the problem of wind erosion on the soil. Residue removal or destruction reduces borer larval populations by 61–84% and 98–100% of pupal populations (Ndoye and Gahukar, 1987), but this practice also has the disadvantage of exposing the soil to wind erosion. Besides, millet stems are used for construction of fences and roofs, bedding for animals and as fuel for cooking. Increased fertilization results in better crop growth but has been associated with borer attack (Harris, 1962; Gahukar, 1983). In a cowpea/millet intercrop, while fertilization did not predispose the millet to higher borer attack, it resulted in twice as much leafhoppers on the cowpea (ICRISAT, 1984).

Insecticides

Currently recommended insecticide treatments to control millet pests were probably developed for such crops as cotton, tobacco and groundnut. Studies that have been reported on the chemical control of *Coniesta* and *Heliocheilus* were designed for the assessment of yield losses or to determine the relative efficacies of different chemicals. Insecticide control of low infestations of *Coniesta* results in reduced yield. In the case of *Heliocheilus*, various results have been obtained. Endosulfan at 525–700 g/ha a.i. (Vercambre, 1978); chlordimeforn 750 g/ha a.i. (Ndoye and Gahukar, 1987); trichlorfon 1 kg/ha a.i (Guevremont, 1982), have been reported to control this pest. Similar successes have been reported with thuricide from *Bacillus thuringiensis* (Gahukar et al., 1986). Such problems as cost factors, technology of application, lack of trained personnel and the shortage of water in the Sahel underscore the use of insecticides.

Biological control

Studies by Harris (1962) in Nigeria; Vercambre (1978), Gahukar (1981), Bhatnagar (1983, 1984, 1987) and Gahukar et al. (1986) in Senegal; Guevremont (1982, 1983) and ICRISAT (1987) in Niger provide comprehensive inventories of the species of natural enemies of pearl millet in West Africa. They contain a large number of parasitoids of *Coniesta* and *Heliocheilus* which include egg, larval and pupal parasites. However, no concerted effort has been made to exploit them for the control of these pests. For example, parasitism of *Heliocheilus* by *Bracon hebetor* Say, the most promising candidate for biocontrol, can be as high as 95% in Niger and 64% in Senegal. Studies by Bhatnagar (1987) have also shown that this parasite can be effectively exploited in a traditional village environment. In Nigeria the parasitoid populations on stem borers vary from year to year, but overall parasitism hardly exceeds 10%, a level that is attained only towards the end of the season. Hyperparasitism, the long diapause period of *Heliocheilus* and *Coniesta* and the critical climate of the Sahel also negate the efficacy of natural enemies.

Varietal resistance

Data on varietal resistance studies in pearl millet from Mali, Niger and Senegal are restricted to *Coniesta* and *Heliocheilus* and a range of genotypes have been reported as resistant or showing low levels of pest damage (Doumbia et al., 1984; Gahukar, 1983; Ndoye, 1977; ICRISAT, 1984, 1986). Local genotypes have been more promising because breeding programmes have concentrated mainly on increasing the yield potential of improved cultivars and insect and disease resistance were not considered. The mechanisms of resistance have been attributed to tillering capacity and physico-chemical factors in the case of borer and physiological escape (pseudo-resistance) and nonpreference for oviposition against *Heliocheilus*. Antibiosis has also been implicated for both species, but this requires further investigation.

The results so far obtained show considerable variation between seasons and locations, because evaluation was done under natural infestation. The provision of adequate screening techniques for uniform and optimum infestation of test material is thus a primary requirement. Coupled with this is access to a broad and variable germplasm collection and an infrastructure for the multilocational testing of identified resistance source material. Until these conditions are met, resistance breeding programmes will continue to be hampered and results will remain in the most part, unreliable and need re-evaluation.

FUTURE PERSPECTIVES

Each of the currently suggested methods for the control of *Coniesta* and *Heliocheilus* has several limitations. Adherence tc age-old traditions, labour requirements, conflict of interest in the use of crop residues and soil conservation factors, make cultural practices less easily acceptable. Chemical insecticides are unlikely to play a major role in millet subsistence farming in the Sahel. Although there is an abundance of natural enemies of both pests, the species involved are apparently inefficient in controlling *Coniesta* or have not been adequately exploited as in the case of *H. albipunctella*. Varietal resistance is therefore of relevance in pearl millet improvement. But it must be seen as a component in the overall strategy for managing *Coniesta* and *Heliocheilus*. There is considerable scope for the management of these pests. For example, improving the efficacy of the parasitoid *B. hebetor* will accommodate a lower level of varietal resistance and a wider margin for improving the agronomic performance of a particular genotype. *Coniesta* and *Heliocheilus* spend substantial parts of their annual cycles in diapause in crop residues and/or in the soil. Cultural methods that reduce carryover populations should be exploited and sociological and organizational problems associated with their implementation should also receive equal attention. It is important to note that, while *Coniesta* may be important in one zone, *Heliocheilus* may be the predominant species in another and the various components for managing a particular pest species will vary between locations. What this means is the need to identify priority areas of research across zones and the creation of multi-disciplinary research teams that are oriented towards particular sets of problems. An implication of this statement is the need for increasing and diversifying the indigenous research capacity in the agricultural sector.

The identification of the stem borer and the earhead caterpillar as major pests of pearl millet is a step in the right direction. The information generated on their bio-ecologies especially with respect to their zones of occurrence is an essential component in the development of pest management strategies. Further research should be based on the relative importance of the crop in each zone, biotic and abiotic constraints to production, farmers' perceptions of the relative importance of each constraint and the socio-political aspects that are interwoven therein.

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