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African Insect Science for Food and Health

Integrated Systems for the Humid Tropics (Humidtropics)

Determining the effect of stemborers on yields of cereal crops, principally maize and sorghum

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December 2013

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Background

Cereal crops are a major staple and cash crops for millions of smallholder farmers in sub-Saharan Africa. In Kenya maize is a staple food for most households in and is grown in most agroecologies, with smallholder farmers forming about 70% of growers of the commodity. The national food security in Kenya is, therefore, often pegged to availability of adequate supplies of maize to meet domestic demands. Production of cereal crops is however constrained by a number of factors, biotic and abiotic. Insect pests form the most important biotic constraints to efficient production of cereals in the country. The most injurious pests of cereals are the lepidopteran stem borers, with the crambid spotted stem borer (Chilo partellus Swinhoe) and noctuid African stem borer (Busseola fusca), being the most economically important field insect pests in maize cultivation in Africa. Others that are of economic importance, albeit minor in a number of locations in Kenya include Sesamia calamistis, Eldana saccharina and Chilo orichalcociliellus. The larvae feed on the leaves and bore tunnels inside maize stems, thus destroying the pith and weakening the plant and reducing grain yield, with losses ranging between 10-88%, depending on crop cultivar, stage and severity of attack among other factors.

Humidropics, a CGIAR research program on integrated systems for the humid tropics, seeks to transform the lives of rural poor in the humid lowlands, moist savannas, and tropical highlands in tropical Americas, Asia and Africa where the bulk of the rural poor reside. The program focuses directly on rainfed smallholder farming systems (associated with poor household nutrition and soil fertility depletion) and their opportunities for sustainable intensification. Implemented within selected action sites, of which western Kenya is one such, the program provides a new integrated agricultural systems approach, a single research-for-development plan, and a unique partnerships platform for better impact on poverty and ecosystems integrity.

Because cereal crops represent the cornerstone of production systems in the action sites in the East and Central Africa action area, constraints to their effective production are an important entry point for program intervention in order to unlock their productivity. Yield losses caused by cereal stemborers must thus be addressed. The protocols described herein were compiled based on stakeholder views gathered in workshops in western Kenya between March and September 2013, and verified using published reports and papers. They aim to provide a stepwise guide in evaluating effects of pests on crops with a view to developing management approaches for the same.

Methodologies

There are two ways of evaluating the direct effect of stemorer damage on crop growth and yields

(i) Natural pest infestation
(ii) Artificial infestation of plants.

It is always important to combine both methods if resources permit.

Natural infestation methods

This is conducted under field conditions, either under researcher or farmer management. It involves growing the test cereal crops under open field conditions and allowing the test pests to naturally infest the plants. Determination of the impact of the pests on plant growth and yield is then carried out. There are a number of advantages of this method

(i) It provides realistic measure of pest pressure that exist in the target area
(ii) It allows for natural mixing of pest species that is often difficult to achieve under artificial infestation
(iii) It is easier and can also be carried out by farmers themselves

Some of the disadvantages of the natural infestation method include

(i) The pest population varies greatly in nature, spatially and temporally and therefore results may not be conclusive
(ii) One cannot determine the number of insects per plant
(iii) It is highly influenced by weather
(iv) Other factors such as pests' natural enemies complicate interpretation of results

Methods

Plot size and design: Depending on availability of land, and whether the screening is being done in a research station or under farmers' fields, plot sizes could vary from 10 m by 10 m to ideally 30m by 30m. It is important to allow for a realistic number of plants for sampling. If the plot is too small the results will not be realistic; but again if the plots are too large, the results will not be easy to interpret due to differential pest levels in different parts of the plot. It is therefore important to select an easy to manage and realistic plot size. The plot size will also have a direct influence on your study design; therefore watch out! Two aspects that must be considered are randomization

and replication. At minimum have at least three replications, and this is also always influenced by the number of treatments one has. A completely randomised design works very well for such studies, although other designs such as lattice square design and others are equally effective. Key though is to ensure each treatment has equally chance of being reached by the attacking pests from all sides of the field. In the design there must always be one referred to as a control, which will provide a baseline measure, and could be farmers' variety or management approach against which the treatments are compared. Ideally control should be one where the insect pest is controlled, if possible through use of chemical pesticides.

Crop genotype: insect pests including stemborer pests attack different crop genotype differentially. Some genotypes are preferred to others; while others are susceptible and others are not. It is therefore critical to select genotypes that are either popular with farmers, or are being introduced to address the issue of pests. Whichever is picked, it must be clearly known the reason for the choice. It is always important to include more than one genotype

Plot preparation: As a standard practice, prepare a fine tilth that will allow ease of planting, seed germination and ease of management. Ensure there are no remains of the previous crop as these may act as pest sources and might unduly influence your results. Also, there should be no weeds and other plants at planting.

Soil sampling: collect soil samples, using a soil auger, upto 15 cm of top soil randomly and diagonally at five different points of the plot, the fifth point being the centre of the plot. Mix these to have a composite soil sample, ideally 500g, for chemical analysis and other analyses including striga seed count. These components are known to influence pest attack on the crops.

Planting and weeding: Maize should be planted at the recommended spacing i.e. 75 x 30 cm, 2 seeds per hill then thinned to 1 plant per hill. For a 10m by 10m plot, DAP (18% DAP, 20% P at 50 kg per ha) and CAN (21.67% N at 25 kg ha) will suffice. Following seedling emergence, thin maize to the recommended spacing, note any gaps and replant as required. Follow normal farm practice including weeding twice. Ideally the plots should be protected from neighbouring fields by planting at least three guard rows of the cereal around the periphery of the field. These guard rows help to minimise influence including the chance of pesticidal drift from neighbouring fields.

Determing stemborer colonization: Insect pests, including stemborers attack the new crop from the surrounding environment. Therefore to determine colonization of the new crop, it is ideal to begin at the third week after crop emergence for cereal crops.

This is because it is at this stage that the plants are most attractive for colonization by the stemborer pests. Here, one ought to have decided on the frequency and number of plants to sample per plot. If a sample number of plants are to be picked per plot, they should be tagged before start of observations. Colonization is determined through the following processes

(i) Observe all the foliage (leaves and stems) of the cereal for stemborer eggs. Chilo partellus deposits eggs in batches on the stems and leaves of crops and therefore easy to spot (see below). However, Busseola fusca oviposits under the leaf sheaths of the plants and therefore cannot be easily observed. It is therefore advisable to run finger tips on the leaf sheath and presence of a 'bump' suggests presence of eggbatches. The sheath is then opened and eggs recovered/observed.

(ii) Count the number of eggs using magnifying glass. However, with time it becomes easy to count these eggs with the naked eye. Alternatively, these eggbatches can be cut out with parts of the leaf or stem and kept in petri-dishes until they get darker (black head stage) and then counted using the same method.

(iii) Repeat weekly/biweekly the observation of stemborer eggs in the field. Subsequent observations can be carried out on a sample of plants rather than all the plants in a plot

IMPORTANT: Properly label each eggbatch according to plant and plot.

(iv) Stemborer eggs hatch from the fourth day following oviposition. The emerged larvae then begin to feed on the leaves causing window-paning marks on the leaves. Therefore from the fourth week following crop emergence, and again depending on the number of plants per plot, observe either all of the plants or sampled number for presence of damage caused by stemborer larval feeding (the window-pane marks). Also, observe growing tip of the plant (heart) for any sign of larval feeding and count the number of plants with dead hearts. Record the number of plants with leaf damage and those with deadhearts in provided data sheets. This should be repeated as above weekly/biweekly.

(v) During the observation above, randomly pick from those with leaf damage caused by stemborer larval feeding (ideally at least 20 plants per plot). Rate the extent of leaf damage per plant in a scale of 1-5, with 1 showing less than 25% damage and 5 indicating 100% leaf damage per plant per plot

(vi) From the fourth week after crop emergence a given number of plants should be sampled weekly/biweekly for what is referred to as destructing sampling. Randomly pick plants per plot (10 onwards); observe these for any visible

damage caused by feeding by larvae of stemborers and record in provided data sheets. Once this has been done, remove carefully all the plant leaves and then sheaths, noting any visible marks of stemborer feeding on the stem and looking out for stemborer eggs and larvae that might be in/on the various plant parts. As the plants advance in age, pupae will be observable in addition to the eggs and larvae. Count the number of any observed stemborer life stages and record in the provided data sheets. Keenly observe the entire stem and count any stemborer larval entry or exit holes and record in the data sheets.

Note: If the study is researcher managed in a research station then it is an easier process, but if this is in a farmers' field then there should be compensation for the destroyed plants.

Stemborer larval feeding on the leaves

(vii) The next stage is to split the stems of the plants open with a sharp blade carefully to recover any stemborer larvae and pupae. Please note the stage of any larva, health status and location. These larvae should then be put in petri-dishes, each, with some plant stem as feed. Pupae should also be recovered but should be given no plant material as they do not feed. These data should be appropriately entered.

Stemborer larva in a stem, also showing tunnel length caused by its feeding

(viii) Measure the tunnel length caused by stemborer larval feeding and enter the data appropriately

(ix) Measuring grain yield: There are different methods of determining yield of crops in such screening work. The most common and simplest method is to tag plants at emergence, and following physiological maturation take measurements of plant height, foliar damage using a 1 - 5 scale as above, number of leaf blades, stem diameter, number of exit holes, tunnel length and number of stemborers; also collect data on the length of the cob with husk, length of the cob without the husk, cob weight and grain weight per plant. Also important is data on plants lost during the season due to factors other than stemborers, such as termite damage. Such should not be included in analyses

Note: as a general rule data should be taken of agro-climatic conditions at the study site

Artificial infestation methods

This involves artificial infestation of the plants with stemborer eggs and/larvae without the natural infestation. It can be done both for plants growing in an enclosure or under natural field conditions. The protocols provided here are for plants growing in an enclosure. It has its advantages

(i) It is easy to control the number of insects per test plant

(ii) It is an easy process since it is always carried out in an enclosed area, such as a screen house

(iii) There is not much influence of weather conditions as plants are often artificially watered and managed.
(iv) It is accurate and allows manipulation
(v) Screening period is shorter

Disadvantages include

(i) It doesn't provide a realistic depiction of natural pest attack and impacts as happens in nature
(ii) The enclosed environment may unduly influence results
(iii) The plants in such set-ups tend to receive unnatural treatment which might again influence results.
(iv) Requires insect mass rearing facility to produce and maintain insect cultures for the exercise

Methods

Artificial infestation process involves growing plants in an enclosure, either in containers or plots protected from natural infestation by other insects. It involves artificially intruding a given number of pest life stages on the plant and monitoring their survival, development, damage to the plants and grain yields. The measurements are as described above.

With the data above, one can then determine economic injury level, or threshold level at which population of the pest begins to cause economic damage to the cereal. Using statistical procedures

Also attach

1. Pictures of stemborer life stages and damage caused due to larval feeding
2. Damage scoring details
3. Data sheets