

V. Use of Wild Habitat in the Management of Cereal Stemborers (FOP-2)

Background, approach and objectives

This project was initiated in April 1994 as part of a novel programme in Africa for controlling stemborers in cereal crops. In view of the crucial importance of the cereal stemborers in reducing yields of maize and sorghum in Africa, in-depth studies are undertaken on the dynamic relationship between the population of stemborers and their natural enemies on wild hosts and cultivated crops.

The main objective of the project was to examine and understand the multiple interactions among cultivated crops, wild hosts, various stemborer species and natural enemies affecting the dynamics of pest populations and their pest status with a view to contributing to an integrated pest management package. The project is being undertaken in different agroecologies in Kenya.

During 1994–1995, the Project undertook studies to understand interactions among cultivated crops, wild hosts, various stemborer species, and natural enemies affecting the dynamics of pest populations. This information is now being used in the development of a sustainable integrated pest management approach through use of wild host and non-host plants.

The project relies on enriching the biodiversity of plants and the pests' natural enemies in and around the cropping environment. In particular, it has been demonstrated that several wild host plants buffer the crop against attacks by some stemborer species, and some plant species of economic importance could be used as 'trap plants' for management of stemborers. Based on the understanding of the volatile semiochemicals employed by the stemborers in locating suitable hosts and avoiding non-hosts, the project is developing a novel pest management approach utilising a 'push-pull' or stimulo-deterrent diversionary strategy. In this habitat management system, which involves combined use of trap and repellent plants, insects are repelled from the main crop, and are simultaneously attracted to a discard or trap crop.

This strategy fits in well with small- to medium-scale farmers in Africa practising mixed agriculture. It should also serve as a model for the management of other pests in Africa and beyond. Recommendations from this project are demonstrated to farmers through on-farm trials conducted in collaboration with the Kenya Agricultural Research Institute (KARI) and Ministry of Agriculture, Livestock Development and Marketing (MOADLM).

Several plants have been identified which, when planted in association with maize, lower the stemborer density. Particularly promising are the Napier grass, *Pennisetum purpureum*, the Sudan grass, *Sorghum vulgare sudanense*, the molasses grass, *Melinis minutiflora* and silverleaf, *Desmodium uncinatum*. Napier grass and Sudan grass are used as trap plants, whereas the molasses grass and the silverleaf repel the ovipositing stemborers. All the four plants are of economic importance to the farmers in eastern Africa as livestock fodder and have shown great potential in borer and striga management in on-farm trials.

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Donor: Gatsby Charitable Trust

Collaborators: • Kenya Agricultural Research Institute (KARI) • Ministry of Agriculture, Livestock Development and Marketing (MOALDM) • Government of Kenya • Integrated Approach to Crop Research (IACR)-Rothamsted, UK.

Work in progress

1. Role of the wild habitat in the invasion of cereal crops by stemborers in Africa with special reference to *Chilo partellus* and *Busseola fusca*

1.1 WILD HOST AND STEMBORER SURVEYS

In the 1994 *Annual Scientific Report*, we reported the host range of various stemborer species. Since then, significant progress has been made on the knowledge of host range and population dynamics of various stemborers on cereal crops and wild hosts. Thirty-three species of wild hosts belonging to three families—Gramineae, Cyperaceae and Typhaceae were recorded as hosts to one or more stemborer species in various agroecologies (Table 1.1).

1.1.1 *Development of sampling plan*

Based on our destructive sampling survey data, statistically valid sampling plans for cereal stemborers on wild hosts were developed. Such sampling plans will be useful in modelling and ecological research. The number of plant samples required for enumerative and binomial samplings were determined for various wild host plants and stemborer species.

1.1.2 *Distribution patterns of stemborers*

To establish the relationships between wild host plants such as grasses and sedges and the level of stemborer infestation, each of the agroecologies was characterised according to the cropping system used, soil characteristics, and geo-climatic factors such as altitude and rainfall. The greatest diversity of grasses was found in the high altitude area of Trans Nzoia, with *Hyparrhenia rufa* and *H. cymbaria* the most important grasses in the region. At the Kenya coast, where stemborer damage is especially severe, there was the lowest plant diversity, with *Panicum maximum* the most common species. Wild sorghum, *Sorghum versicolor* was the most frequently encountered species at the lakeshore. Baseline data such as this will be used to determine how changes in the relative abundance of wild host species throughout the year affect stemborer infestation levels in the field. A highly significant relationship was found between *B. fusca* infestation in maize and the density of *H. rufa*. Also, for *S. calamistis* there was a highly significant relationship between *P. maximum* and *P. purpureum*. No significant relationship was found between *C. partellus* and *E. saccharina* and any of the alternate hosts.

1.2 BEHAVIOURAL AND PHYSIOLOGICAL RESPONSES OF STEMBORERS ON WILD HOSTS

As part of our effort to demonstrate that wild hosts may or may not be important in population dynamics of stemborers, we have investigated how selected wild gramineous plants commonly present near maize and sorghum fields could support various stages of the establishment of *B. fusca*. Various behavioural and

physiological responses involved in the establishment of maize stemborers on selected common African wild grass species were compared to a susceptible maize, a susceptible sorghum, a resistant maize, and a resistant sorghum variety in laboratory and greenhouse tests.

Wild sorghums were preferred over cultivated maize and sorghum for larval orientation and settling. In general, larvae fed better on the wild sorghums, and the efficiency of conversion of ingested food was higher on these wild hosts. In testing these and other parameters such as larval weight, longevity of adults, and ovipositional response, the data show that the wild sorghums are the most suitable for stemborer establishment. Such wild hosts can act as sources for stemborer colonisation on cereal crops, and could be good candidates as trap plants if managed properly.

Hyparrhennia rufa and *P. purpureum*, which were preferred for oviposition, were shown to be less suitable for larval orientation, settling, feeding and development. Hence, these species could be used to suppress insect infestation on cereal crops.

We discovered that different varieties of Napier grass differ in their attractancy to stemborers. Based on various behavioral and physiological responses involved in the establishment of maize stemborers on nine varieties of Napier grass, varieties suitable for stemborer oviposition but unsuitable for their development were selected. These varieties are now used as trap plants to suppress insect infestation on maize crops. One of the selected varieties, Bana Grass (Ex-Kitale), is well adapted to Trans Nzoia and is preferred by farmers as fodder, because of its smooth surface, high tillering and large biomass. Efforts are being made with KARI to multiply Bana Grass on a very large scale to distribute to participating and other interested farmers.

1.3 STEMBORER COLONISATION AND ESTABLISHMENT

Studies on colonisation and establishment of stemborers in different agroecological systems have revealed site-specific trap crop alternatives. To study stemborer colonisation processes on various host plants, field trials incorporating cultivated and selected wild host plants were undertaken in all the three ecological zones. The field plots consisted of 6 x 6 m plots arranged in a six by six quasi-complete latin square design (Figure 1.1). Observations were recorded for ovipositional preference, growth and development and parasitisation levels of stemborers on various host plants. The study revealed interesting aspects of multiple interactions among cultivated plants, wild hosts, various stemborer species and their natural enemies. Several wild hosts, such as *P. purpureum*, *H. rufa*, *Phragmites* sp., have high ovipositional preference, but low survival of stemborers, and were identified as trap plants. Similarly, host plants which have a high ovipositional preference and high survival of stemborers, such as *Sorghum arundinaceum*, *S. versicolor*, *S. vulgare sudanense* were also identified. Plants which also encourage multiplication of natural enemies, can be used as trap plants if managed carefully.

1.4 CONTROL OF STEMBORERS THROUGH TRAP PLANTS

Napier grass and Sudan grass, the two widely used commercial fodder grasses, can provide natural control to stemborers by acting as trap plants for stemborers, and as reservoirs for their natural enemies. Although the stemborers oviposit heavily on the attractive Napier grass, only very few larvae are able to complete their life cycles. Napier grass has its own natural defence mechanism against crop borers. When the larvae enter the stem, the plant produces a gum- like substance, which causes the death of the pest. Stemborer infestation on maize mono was several times more

than on maize crop surrounded by Napier grass or Sudan grass. However, stemborer infestation as well as larval parasitisation on Sudan grass was quite high, suggesting that Sudan grass can reduce stemborer infestation by buffering the crop against stemborer attack.

Sudan grass or Napier grass, when planted around maize fields, can decrease stemborer infestation on maize and can thus increase crop yield (Table 1.2). Planting Sudan grass around maize fields also increased efficiency of natural enemies. As compared to the maize field where only 4.8% *Chilo* and 0.5 % *Busseola* larvae were parasitised, 18.9 % *Chilo* and 6.17 % *Busseola* larvae were parasitised in maize + Sudan grass field (Figure 1.2).

1.5 STEMBORER CONTROL THROUGH NON-HOST PLANTS

Intercropping maize with non-traditional hosts and non-host companion plants showed a marked impact in reducing stemborer infestation on maize. Planting maize into an already-established crop of molasses grass, *Melinis minutiflora* and silverleaf, *Desmodium uncinatum* at ICIPE and KARI (Kitale), fields gave dramatic reductions in stemborer incidence (Table 1.3). Studies are underway to determine the density of the non-host plants required to protect maize crops as well as to avoid interspecific competition.

1.6 WILD GRASSES AS REFUGIA FOR NATURAL ENEMIES

Several wild grasses such as *Pennisetum purpureum*, *Echinochloa pyramidalis*, *Panicum* sp., *Cyperus* sp. and *Phragmites* sp., commonly growing near farmers' fields, provide important refugia to natural enemies of stemborers such as *C. flavipes* and *C. sesamiae* after the cereal crops are harvested. Three species of borers, *Bactra stagnicolana*, *Phragmataecia boisduvalii* and *Poanoma serrata*, associated with these perennial wild hosts can be important hosts for *Cotesia* spp. and other natural enemies of crop pests (Table 1.4). These host plants can be very important reservoirs of natural enemies. None of these 'wild' stemborer species infest cereal crops.

1.7 INCREASED PARASITISM BY INTERCROPPING MAIZE WITH MOLASSES GRASS

We reported that molasses grass, *Melinis minutiflora*, when intercropped with maize reduced infestation by stemborers. Surprisingly, intercropping with *M. minutiflora* also increased parasitism particularly by the larval parasitoid, *C. sesamae*, and the pupal parasitoid *Dentichasmis busseolae* (Figure 1.3). The plant releases volatiles that repel stemborers, but attract parasitoids without being damaged. Live plants of *M. minutiflora* and its volatiles were shown to attract *C. sesamae* in Y-tube olfactometer. This study opens up a new and intriguing possibility of using intact plants with inherent ability to release these stimuli. Such plants will have a useful role in ecologically-based crop protection.

1.8 CROPPING SYSTEM ALTERNATIVES FOR STEMBORER AND STRIGA CONTROL

In a field trial at ICIPE, intercropping maize with silverleaf, *D. uncinatum* and greenleaf, *Desmodium intortum* significantly reduced infestation by *Striga hermonthica* by 40 times. We have reported that intercropping with *D. uncinatum* also reduced stemborer infestation on maize. Development of maize: *D. uncinatum* intercrop will reduce yield loss due to both stemborer and *Striga* and yet improve soil fertility. This farmer-preferable land management approach could replace traditional

bush fallow rotation with a non-host nitrogen-fixing legume intercrop for *Striga* management. We are considering *Striga* germination-inhibitory effects of other species of *Desmodium*, and other food and fodder legumes. Efforts are now underway at ICIPE and IACR-Rothamsted to identify the allelochemicals produced by the root systems of *D. uncinatum* and *D. intortum*, which inhibit *Striga* in the soil.

2. Genetic variation in stemborer populations

Studies on isozyme variation in *C. partellus* and *B. fusca* were undertaken in close collaboration with Rothamsted Experimental Station. Data on eight mendelian enzyme loci: *GlucO-oxaloacetate transaminase* (Got), *Hydroxybutrate dehydrogenase* (Hbdh), *Hexokinase* (Hk), *Phosphoglucose isomerase* (Pgm), *Mannose-6-phosphate isomerase* (Mpi), *Glucose-6-phosphate dehydrogenase* (G6pd) and *Isocitrate dehydrogenase* (Idh), suggest that *C. partellus* populations from both Lake Victoria and coastal ecological regions are homogeneous. However, geographical differentiation in this species was evident.

Allele frequencies in *B. fusca* revealed significant geographic differentiation in both Lake Victoria and Trans Nzoia populations, with some fixed Got and G6pd loci. Genetic differentiation in relation to host plant influence was not evident in both *C. partellus* and *B. fusca*, suggesting that there is free movement of borer populations among different host plants within their ecosystems.

3. Semiochemicals from host and non-host plants

Significant progress has been made in the analysis of airborne volatiles of host and non-host plants, to discover the compounds responsible for attractancy or repellency to stemborers. The volatile oil obtained by hydrodistillation of the molasses grass, *Melinis minutiflora* deterred oviposition of *C. partellus*, demonstrating that the volatile semiochemicals play a major role in oviposition deterrence of the grass to stemborers (Table 3.1). Coupled CG-EAG of volatiles of *M. minutiflora* with *C. partellus* and *B. fusca* showed the presence of a number of electrophysiologically active compounds in the sample. Two of the five compounds identified from airborne volatile collections of *M. minutiflora* were electrophysiologically active against *C. partellus* by deterring oviposition. Non-host avoidance in *B. fusca* and *C. partellus* may be mediated by different compounds: ? -terpenolene and ? -caryophyllene. The repellency of ? -terpenolene and ? -caryophyllene at low concentrations indicates the potential of these compounds in the development of novel pest control strategies. (E)-? -ocimene, one of the electrophysiologically active compounds identified from *M. minutiflora*, did not deter oviposition of *C. partellus* at the doses tested. Only (E)-? -ocimene and ? -terpenolene were found to be the major electrophysiologically active compounds in *M. minutiflora* airborne volatiles for *B. fusca*. Ovipositional bioassays against *B. fusca* are in progress. Significantly more eggs were laid by *C. partellus* on filter paper discs that were treated with eugenol and naphthalene, two electrophysiologically active compounds that were identified from the host plants, maize, sorghum and Napier grass. Nonanal, octanal, naphthalene, 4-allylanisole and eugenol are electrophysiologically active for *B. fusca*. In ovipositional bioassays, eugenol was found to stimulate oviposition by *C. partellus* and *B. fusca*, and in wind tunnel experiments, it was attractive to both *B. fusca* and *C. partellus*.

4. On-farm trials on management of stemborers and Striga through use of wild hosts and non-host plants

Farmer participatory trials on the management of stemborers and striga weed were

initiated during January 1997 in Trans Nzoia and Suba districts of Kenya, supported by a special funding from the Gatsby Charitable Foundation. These trials are undertaken in collaboration with small and medium-scale farmers who are expected to benefit from ICIPE's IPM technologies. The on-farm approach is a highly interactive process, characterised by interdisciplinary, participatory and collaborative approaches. Scientists from Kenya Agricultural Research Institute (KARI) and extension staff from Ministry of Agriculture and Livestock Development (MOALDM) also work very closely with ICIPE scientists in implementing on-farm trials. The on-farm trials were scientist-managed and consisted of 11 farmers in Trans-Nzoia district and seven in Suba district. The farmers were selected through nomination by the farming community.

In Trans Nzoia, the project launched on-farm researcher-managed trials (OFRMT) in 1997 on the use of Napier grass as a method of stemborer control, in which it sought to involve farmers in field research activities. To achieve this, community mobilisation was undertaken with the help of KARI staff, agricultural extension agents and local administrative leaders. Meetings were convened at village levels in four villages. The primary objectives of these meetings were to create awareness on the use of the wild host for management of cereal stemborers and to organise and select farmers for participation in the OFRMTs. Those farmers who attended the meetings were given the criteria to use in selecting candidate participants.

In Suba District, the project launched OFRMT in 1997 on the use of *Desmodium uncinatum* as a method of stemborer and striga control, and the use of Napier grass for stemborer control. Similar selection processes were used to select trial farmers from three divisions of the district. Five farmers participated in the use of *D. uncinatum*, and two in the use of Napier grass.

In Trans Nzoia district, significant increase in maize yield was recorded in maize + Napier grass plots of all participating farmers. Unfortunately, because of the prevailing drought in Suba district during the 1997 long-rain cropping season, no reliable data could be collected except in one location where there was evidence of stemborer reduction and increase in yield (see Table 1.2).

A baseline diagnostic survey (embracing 150 subsistence farmers) in each of the two study areas is also being carried out to obtain a better understanding of socioeconomic circumstances of the farmers. This survey will be completed by December 1997. It is expected to provide the basis for the appropriate design of the farmer-managed trials and for the evaluation of the impact of the technology. Data are also being collected in collaboration with KARI on preliminary economic evaluation of the researcher-managed trials.

Output

Publications

Khan Z. R., Abenes M. L. P. and Fernandez N. J. (1996) Suitability of common graminaceous weed species as host plants for rice leaffolders, *Cnaphalocrocis medinalis* and *Marasmia patnalis*. *Crop Protection* 15, 121–127.

Khan Z. R. and Saxena R. C. (1997) Use of surrogate "stem" for eliciting ovipositional response of *Busseola fusca* (Lepidoptera: Noctuidae). *Journal of Economic Entomology* 90, 1426–1429.

Khan Z. R., Ampong-Nyarko K., Chiliswa P., Hassanali A., Kimani S., Lwande W., Overholt W. A., Pickett J. A., Smart L. E., Wadhams L. J. and Woodcock C. M. (1997) Intercropping increases parasitism of pests. *Nature* (London) 388, 631–632.

Khan Z. R., Chiliswa P., Ampong-Nyarko K., Smart E., Polaszek A., Wandera J. and Mulaa M. A. (1997) Utilisation of wild gramineous plants for management of cereal stemborers in Africa. *Insect Science and Its Application* 17, 143–150.

Conference papers and conferences attended

Chiliswa P., Khan Z. R., Loxdale H. D. and Brookes C. P. (1997) Allozyme variation in tropical cereal stemborers with particular reference to *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) and *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), pp. 89–102. In *Focus on Agricultural Research for Sustainable Development in a Changing Economic Environment*. Proceedings of the 5th KARI Scientific Conference, 14–16 October 1996, Nairobi, Kenya.

Khan Z. R. (1997) A review of entomological techniques and methods used to determine mechanisms and bases of stemborer resistance in maize, pp. 62–67. In *Insect Resistant Maize: Recent Advances and Utilisation* (Edited by J. A. Mihm) Proceedings of an International Symposium held at the International Maize and Wheat Improvement Centre (CIMMYT), 27 November–3 December 1994 at CIMMYT, Mexico, D. F.

Khan Z. R. International Workshop on the Management of Tropical Gramineous Stemborers, ICIPE, Nairobi, 14–16 May 1996.

Khan Z. R. Annual Meeting of the Entomological Society of America, December 8–12, 1996, Louisville, USA.

Khan Z. R. International Conference on Ecological Agriculture: Towards Sustainable Development, November 15–17, 1997, Chandigarh, India.

Proposals written

Utilisation of Wild Host and Non-Host Plants for Management of Cereal Stemborers in Africa (1996–1998)—Funded by Gatsby Charitable Foundation.

New Integrated Stem Borer and *Striga* Management Systems in Subsistence Maize Farming for Africa' (1998–2001)—Funded by Gatsby Charitable Foundation.

Conservation of Gramineae and Associated Arthropods for Sustainable Agricultural Development in Africa. PDF-Block A. Funded by Global Environment Facility.

Capacity building

Training has been a very strong component of the Gatsby-funded Project. Several MSc and PhD students from different countries have worked or are working under the project.

J. J. Randriamananoro from Madagascar, a student at Rivers State University of Science and Technology, Nigeria, finished his PhD degree. The title of his thesis was 'Behavioural and physiological responses of cereal stalk borer, *Busseola fusca* Fuller (Lepidoptera: Noctuidae) to selected cultivated and wild host plants'.

Nicholas Hutter from UK, a student at the University of Newcastle-upon-Tyne,

completed his MSc research project at Mbita Point on ovipositional preference and development of *Chilo partellus* on selected varieties of Napier grass, *P. purpureum*.

Mohamed Hassan Mohamud from Somalia, a student at Kenyatta University, completed his MSc degree on suitability of different wild graminaceous plants for the survival and development of *C. partellus*.

J. Patrick Mbugi from Kenya, is working for his PhD degree on the movement of *C. partellus* and *B. fusca* between cultivated and wild hosts.

Linnet S. Gohole from Kenya will be working for her PhD degree on effects of molasses grass, *M. minutiflora* on parasitisation of cereal stemborers in cereal-based cropping systems.

Muniru K. Tsanuo from Kenya will be working for his PhD degree on *S. hermonthica* seed germination stimulant/inhibitors exuded by roots of selected fodder legumes.

During the on-farm trials, the project also organised several training activities in Trans Nzoia and Suba districts. The main objective was capacity building in terms of knowledge, skills and ability to apply the technology. The training also involved visits to on-station technology trials. The views expressed by the farmers during the training session were taken into account and variations incorporated where appropriate. The following training workshops were undertaken in close collaboration with MOALDM and KARI. Some of the training workshops and exchange of MOALDM staff from the two districts was facilitated to allow exchange of experiences.

1. Workshop for farmers including participating farmers in April 1997 at KARI, Kitale (22 participants).
2. Workshop for extension staff of Trans Nzoia district in May 1997 at KARI, Kitale (30 participants).
3. Combined workshop for extension officers and farmers including participating farmers of Suba district in July 1997 at ICIPE Mbita Point Field Station (MPFS) (33 participants).
4. Combined workshop for secondary school agricultural teachers, area chiefs and district agricultural committee members at MPFS (60 participants).

In addition to the training sessions, field days were also held in each on-farm trial site of Trans Nzoia to give an opportunity to a large cross-section of farmers in the project areas to observe and assess the technology under evaluation. Over 200 farmers from the project sites took part in field days.

The majority of the farmers interviewed during the field days observed the effectiveness of using Napier grass as a stemborer control method, and indicated their willingness to take part in the farmer-managed trials (FMTs) during the 1998 season. Significantly, the farmers' impact rating of stemborer infestation in on-farm trials are consistent with biological data.

Impact

The Project has demonstrated the benefits of biodiversity of gramineous and leguminous plants in the cultivation of maize and sorghum and their management in order to reduce stemborer infestation and increase parasitisation by natural enemies. The research has provided a better understanding of the relationship between habitat diversity and habitat resilience to pest challenge, as well as scope

for habitat modification to contain this challenge.

The proposed strategy of stemborer control, manifests important features which render it distinctively more advantageous than some other methods. In this proposal, the full integration of several crop protection approaches, i.e. trap crops and increased parasitism of pests, prevents high selection pressure on any single approach, thereby creating a sustainable system by obviating rapid development of resistance/ adaptation by pests, which is a feature common to single control measure, e.g. pesticides or genetically-based resistance.

The scaling up of the technology will involve both application of the technology in larger areas within the farm, as well as extension of the present on-farm trials to larger number of farms. Scaling up within the farm will involve scientist-managed trials in small pieces of land in the first year, farmer-managed trials on larger pieces of land (at least half of the maize area) in the second year, to application of the technology possibly to all the maize planted on the farm. For example, all the 10 farmers who participated in 1997 on-farm trials are interested in expanding the technology to more than half of the maize area in 1998. Similarly, the new farmers to be recruited in 1998 are expected to scale up the technology in 1999 and 2000 (see figure below).

5. Socioeconomic Aspect of Utilising Wild Host Plants for the Management of Stemborers in Africa

Background, approach and objectives

The biological aspect of this project which has been under implementation in Trans Nzoia and Suba Districts aims *inter-alia* to investigate interactions between cultural crops and wild hosts of stemborers with a view to contributing to integrated pest management. The Social Sciences Department has been participating in the research project since early 1997.

The objectives of the research are to generate diagnostic information relating to the problem of stemborers, to develop a farmer participatory approach of technology evaluation, and to undertake socioeconomic assessment of the appropriateness of stemborer management by the use of wild host plants.

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Donor: Gatsby Charitable Foundation

Collaborators: • Kenya Agricultural Research Institute (KARI) • Ministry of Agriculture, Livestock Development and Marketing (MOALDM)

Work in progress

5.1 SOCIOECONOMIC DIAGNOSTIC SURVEY

A diagnostic survey methodology was designed in early 1997 and a questionnaire prepared for interview of randomly selected household heads, stratified by gender as well as farming communities. A total of 151 farmers were interviewed (Table 5.1). The data obtained by the interviews included information on household size and composition, land use and production, farming practices, pest problems, livestock

production and various related factors. The data are currently being analysed with assistance of the Biostatistics Unit.

5.2 SELECTING PARTICIPATING FARMERS

A number of criteria were used for the selection of farmers for participation in the on-farm researcher-managed trials. The main criteria were: (a) total land size owned; (b) size of land offered for trials; (c) farmer's willingness to participate in the project; (d) number of heads of cattle owned; (e) production of Napier grass; and (f) the extent of stemborer problem faced.

Based on household data collected relating to these criteria, and by means of farmer participation, 50 farms were selected for the on-farm trials. Additionally, a total of 27 farmers were identified to participate in the technology evaluation process. The field trials have been completed and the analyses of the results are in the final stage of completion.

5.3 SOCIOECONOMIC EVALUATION OF TECHNOLOGY

Two types of evaluations were undertaken in 1997. The first was based on farmers' observations and perceptions of the on-going trials, and the second was an economic evaluation, based on data collected from researchers'-managed trials.

Preliminary results of farmers' evaluation indicate overwhelming interest in the project. About 95% of the farmers interviewed expressed their desire to participate in on-farm trials in 1998.

Farm input and output data were collected in collaboration with a KARI staff member, under the supervision of the principal investigator. Data analysis has been in progress, and a final report is expected from the KARI collaborator during the early part of 1998.

Capacity building

Several training activities were conducted for farmers and the extension staff. Initially, the emphasis of the training was to increase awareness and facilitate participation and collaboration. The training activities then focused on the methods of technology application and evaluation. The training activities have contributed significantly to stimulating interest and active participation by farmers and the collaborating institutions.

Output

Proposals written

A major project proposal has been prepared for research during 1998–2000. The proposal is entitled 'A Harvest of Biodiversity: Socio-Economic Evaluation of the Use of Fodder Plants in an Integrated Strategy of Stemborer Control and Livestock Management in Maize-Based Cropping System'. The objectives of the proposed research *inter-alia* include evaluation of farmers' managed trials and the potential for adoption and sustainability of the IPM technologies. The continuation of the socioeconomic research in Trans Nzoia District will critically depend on a grant in support of the proposed project.