3. INTERCROPPING AND ITS USE IN CONTROLLING STEM BORER COMPLEX

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INTRODUCTION

Plant diversity has long been known to affect both the diversity (7,11,12) and stability (10,17,21) of the herbivore community. Studies comparing the abundance of specialist herbivores in simple and diverse communities have documented that the density of herbivores is greater in monocultures of host plants than in more diverse habitats (1,4,5,9,12,15,18).

In studies conducted at the International Centre of Insect Physiology and Ecology (ICIPE), by Amoako-Atta and Omolo, (3) and Omolo and Seshu Reddy (8) intercropping was found to be one of the major cultural components of a pest management package. They identified the best crop combinations to minimise stem borer populations and to stabilise productivity by reducing yield loss. The best was sorghum interplanted with cowpea. This was followed by maize intercropped with cowpea, then maize intercropped with cowpea and sorghum. The worst combination was maize intercropped with sorghum.

Smith (16) cautioned that the same kind of diversity can be harmful in one instance and beneficial in another. Therefore one cannot generalise unless tests have been conducted in different ecological zones for a number of seasons.

The objective of this study therefore was to demonstrate that intercropping was one of the major cultural methods of controlling pests and to test and/or confirm this in three different ecological zones representing major agricultural ecosystems in East, Central and Southern Africa.

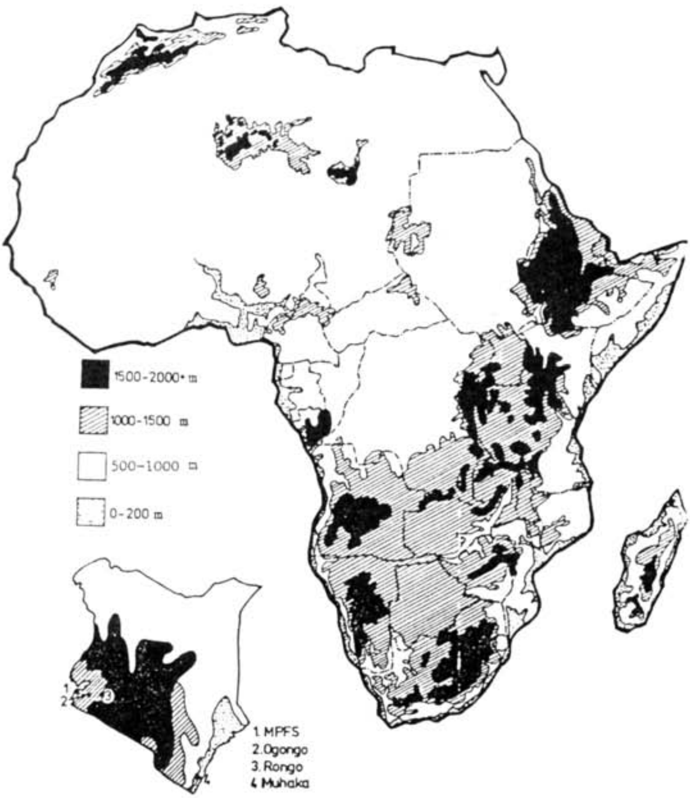
MATERIALS AND METHODS

Most of this research was conducted at the International Centre of Insect Physiololgy and Ecology (ICIPE), Mbita Point Field Station (MPFS) on the shores of Lake Victoria in Western Kenya, at $0^{o}26'$ 0^{o} 28' South and 34^{o}-14' -34^{o} 17' East at an altitude of 1170m. Eight different cropping systems were compared in a randomised block design. These consisted of monocrops of maize, cowpea and sorghum, intercrops of maize + cowpea, maize + sorghum, sorghum + cowpea and with all these crops interplanted in alternating rows and mixed within the row. The experiments were planted at the ICIPE - Mbita Point Field Station and also in farmers' fields at Kirindo and Ogongo in Lambwe. Each treatment plot measured 24 x 21 m with 3 m pathways between plots which were sub-divided into 56 sub-plots or sampling units of 9 m^2 each. A complete description of the experimental layout and sampling techniques have been reported elsewhere (Amoako-Atta _et_ _al_., 1982).

The variety of maize used was "Katumani", a local East African Variety which grows to approximately 180 cm at Mbita Point Field Station and matures in about 100 days. It is considered drought tolerant. The cowpea was "Ex-Luanda", a semi-erect local cowpea variety, well established in the Lake Victoria region, with a relatively short maturity period of about 70 days. It is a type particularly suitable for areas with erratic, short duration rainy seasons. The sorghum variety used was "Serena", a high tillering, drought tolerant population type suitable for lowland areas (below 1530m), which grows to approximately 120 cm with a maturity period of 110 to 120 days. In this study a "crop unit" of one maize plant was considered equal to two sorghum plants or to three cowpea plants (22). The plant populations with the different intercropping patterns were adjusted, using the substitutive model (23) to maintain a uniform carrying capacity per unit land area for each cropping system.

The experiments were conducted in three major ecological zones in Western Kenya: ICIPE, Mbita Point Field Station (low erratic rainfall with intensive stem borer population) as shown in Figure 1.

Figure 1: Maps Showing Testing Sites in Kenya and the Major Agricultural Zones in East, Central and Southern Africa.



The method of assessing yield loss under natural conditions was based on the procedure described by Judenko (6). In this the yields from sets of plants growing under identical conditions attacked or free from attack are assessed and compared. The land equivalent ratio (LER) was used as a yield index. The target pests studied were Chilo partellus (Swinhoe), Busseola fusca (Fuller), Sesamia calamistis (Hmps.) and Eldana saccharina (Wlk.) on sorghum and maize and Maruca testulalis (Geyer) on cowpea.

The parameters assessed were the percentage of plants attacked, yield per hectare expressed in terms of land equivalent ratio, and percentage yield lost due to stem borer infestation. The experiment was conducted during both the major season (March - July) and the minor season (September - December) in 1982, and during only the major season at Kirindo in 1981 and 1982.

RESULTS AND DISCUSSION

There were significant differences in the mean percentage of plants attacked, productivity and estimated yield loss due to stem borers between the different cropping systems. The intensity of attack of maize differed between the two seasons (Figure 2). The levels of borer attack on maize in the maize monocrop had already reached > 30% at 28 days after germination (DAG) in the minor season whereas it was not until the 56 DAG in the major season that such differences were observed (Fig. 2). The cropping pattern also affected the pest species composition (Fig 2). Stem borer colonisation and establishment on maize plants in the monocrop and maize-sorghum intercrop were earlier (> 28 DAG) and increased with time between 28 and 84 DAG (Fig. 2) but at 98 DAG the levels of borer attack within all cropping systems were not significantly different from each other. The incidence of Heliothis armigera coincided with maize cob setting (> 56 DAG) but no definite pattern emerged. Chilo partellus was consistently the dominant stem borer observed attacking maize. Although B. fusca, S. calamistis and E. saccharina were recorded (Fig. 2) their frequency of occurrence was not influenced by the cropping pattern. Attack by stem borers other than C. partellus was in all cases less than 20% of the overall borer attack. Intercropping systems of all cereal/cowpea combinations significantly reduced the level of C. partellus attacks (Fig. 1). This suggests that the presence of cowpea adversely affected the establishment of C. partellus up to 56 DAG resulting in reduced population build up or attack on maize.

The intensity of stem borer attack on surghum in the different cropping systems was significantly higher in the minor season (Fig. 3) than in the major cropping season (Fig. 3). No stem borers were recorded in the 14 DAG sampling during the major cropping season. The stem borer colonisation and establishment in all the cropping systems was delayed in the major cropping season up to until 70 DAG (Fig. 3). After then the pest attack increased so rapidly that by that by 98 DAG, there was no significant difference between levels of borer attacks within the different cropping systems. During the minor season, the cropping systems with cowpea had stem borer infestation and colonisation significantly delayed. This again suggests that systems with cowpea had reduced borer attack (Fig. 3). Maruca testulalis attack was confined to within 30-70 DAG, corresponding to the period from flower bud initiation to pod maturation. Maruca attack of cowpea in the sorghum and cowpea dicrop was significantly less than the other cropping systems.

The overall pattern of stem borer attack on farmers' fields at Kirindo, was similar though considerably lower than that at the Research Station (Fig. 4).

Figure 2: Stem Borer Attacks on Maize at MPFS in 1982

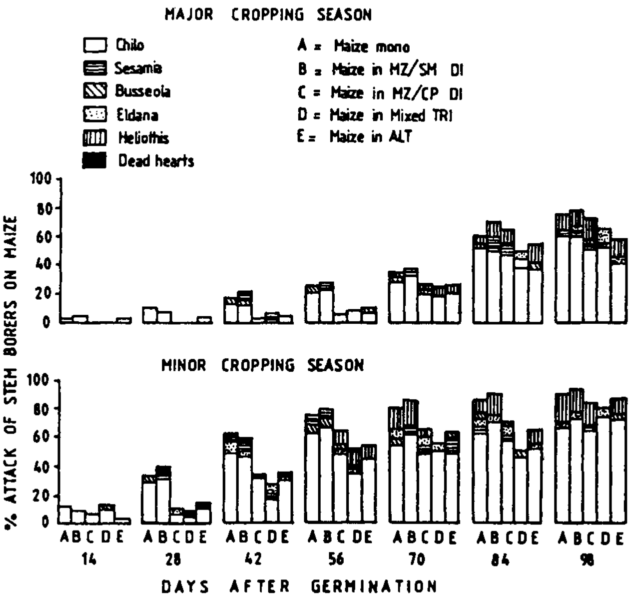


Figure 3: Stem Borer Attacks on Sorghum at MPFS in 1982

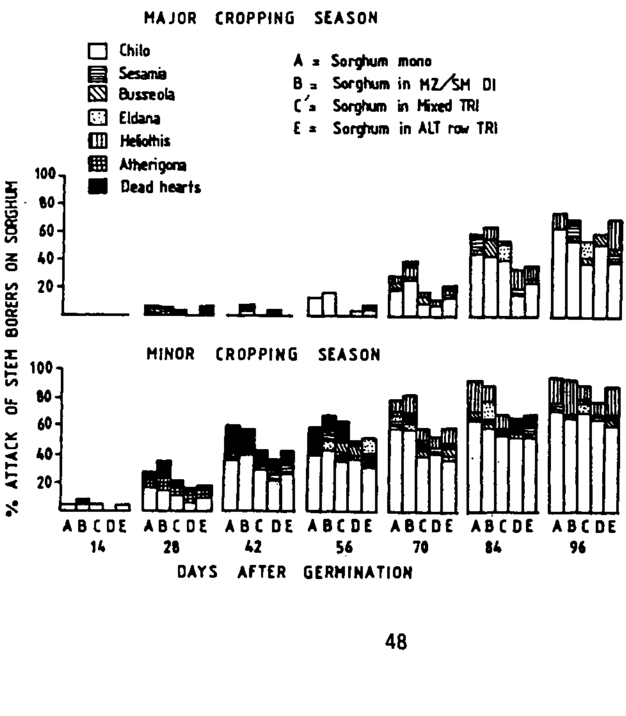


Figure 4: Stem Borer Attacks on Maize at Kirindo in 1981

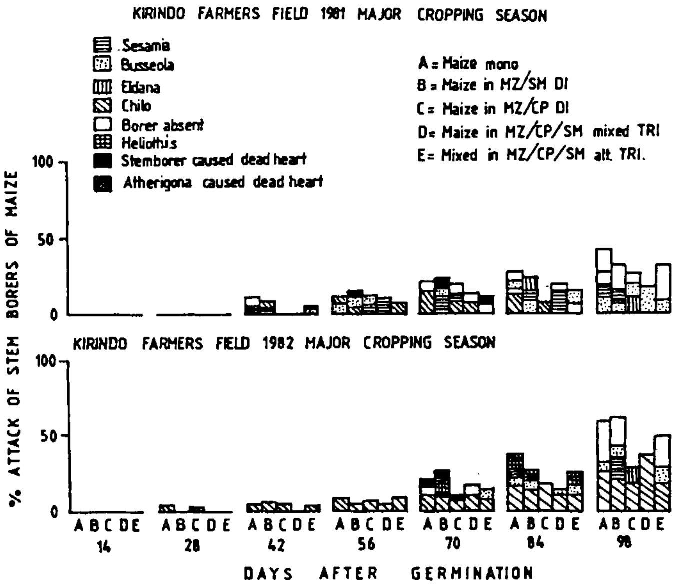


Table 1 gives the overall percentage borer attack of maize, sorghum and cowpea and land equivalent ratios (LER) for the three locations. The combined (for all locations) data show that maize as a sole crop (20.66%) and maize and sorghum grown together (21.45%) both suffered significantly more attacks than maize intercropped with cowpea (14.93%) or maize intercropped with sorghum and cowpea (15.09%). Similarly, sorghum sole crop and sorghum intercropped maize suffered 21.35% and 21.64% attack respectively, both significantly higher than sorghum intercropped with cowpea (14.76%) or sorghum intercropped with maize and cowpea (14.49%). The attack on cowpea by Maruca was much higher on sole cowpea (35.45%) than on cowpea intercropped with sorghum (22.16%) or with maize and sorghum (27.12%). All the intercropping systems had an advantage over sole crops in terms of LER, which was > 1. This meant that intercropping sorghum or maize with cowpea increased productivity by 10% while the maize, sorghum and cowpea system improved production by 17%. The least productive combinations were sole cropped sorghum and maize, where the LER value was < 1. In general, the intercropping advantage in two crop combinations was lower than in previous experiments. This could have been due to low yields resulting from heavy borer attack at Mbita Point Field Station in those years. In summary, sorghum and maize in monculture or planted together suffered more borer damage than sorghum, maize or sorghum and maize intercropped with cowpea, suggesting that cowpea protected cereals from cereal stem borer attack. Similarly, the cereals also protected cowpea from pod borers.

Yield loss in maize was significantly less only when it was intercropped with both sorghum and cowpea (5.51%). Yield loss in sorghum intercropped with cowpea was significantly less (6.92%) than sorghum as a sole crop (16.67%) or intercropped with maize (21.12%). When intercropped with maize and cowpea,

Table 1: Mean Percentage Attack by Crop Borers*

Cropping Patterns	MAIZE				SORGHUM				COWPEA			Land Equivalent Ratio (LER)
	MPFS	OGONGO	RONGO	COMBINED	MPFS	OGONGO	RONGO	COMBINED	MPFS	RONGO	COMBINED	
Mz	39.37	19.32	3.28	20.66[a]								1.0[a]
Sm					40.41	21.50	2.14	21.35[b]				1.0[a]
Cp									60.3	10.6	35.45[c]	1.0[a]
MzSm	41.89	20.05	2.41	21.45[a]	40.76	22.5	1.66	21.64[b]				0.91[a]
MzCp	31.09	12.74	0.95	14.93[b]					50.5	5.22	27.86[b]	1.05[b]
SmCp					30.46	13.49	0.34	14.76[a]	41.0	3.32	22.16[a]	1.09[b]
Mz/Cp/Sm	30.85	13.14	1.28	15.09[b]	27.34	12.69	3.44	14.49[a]	48.4	5.85	27.12[b]	1.17[c]
Mean	35.80	16.31	1.98		34.74	17.54	1.89		50.05	6.26		

Mean values followed by same letter are not significantly different at P = 0.05.

Table 2: **Yield Loss Assessment in Farmers Fields on Maize Sorghum and Cowpea**

	Percent yield loss in maize due to stem borer	Percent yield loss sorghum due to stem borer	Percent yield loss in sorghum tillers due to stem borer	Percent yield loss in cowpea due to pod borer
maize	10.22[a]			
sorghum		16.67[c]	30.2[a]	
cowpea				30.5[c]
maize/sorghum	12.0[a]	21.12[c]	15.85[b]	
maize/cowpea	10.56[a]			23.05[b]
sorghum/cowpea		6.92[a]	11.95[b]	14.22[b]
maize/cowpea/sorghum	5.51[b]	11.35[b]	24.0[a]	18.85[b]
Mean	9.57	14.01	20.5	21.65

Mean values followed by same letter are not significantly different at $P = 0.05$

sorghum losses were significantly less (11.35%) than as a sole crop or when intercropped with maize. Sorghum tiller damage showed significant differences as well. In sorghum intercropped with cowpea, tiller loss was significantly less (11.95%) than in sorghum as a sole crop (30.2%) or intercropped with maize and cowpea (24.0%). In the case of cowpea pod borers, yield loss was significantly greater under monoculture (30.5%) than when it was intercropped with sorghum (14.22%), maize (23.05%) or with both sorghum and maize (18.85%) (Table 2).

Intercropping has always been an important component of small farm agriculture in the tropics. Sorghum and legumes grown together are among the most important traditional systems of tropical agriculture. With the introduction of maize, particularly the new high yielding hybrids, intercrops of maize and beans or of maize and sorghum are often planted. Lower susceptibility to pests and diseases is among the several advantages attributed to these systems (19,20). Altieri et al (1) reported that intercropping maize with beans reduced pest populations compared to monocultures of the same crops. Similarly, Singh and Singh (13,14) reported that the presence of the legumes green gram, black gram and pigeon pea reduced the succession and build up of insect pests in sorghum and pearl millet. These findings are supported by the results of this study, where the presence of cowpea reduced stem borer incidence on maize and sorghum, an advantage not shown by any cereal intercrops lacking the cowpea component.

In summary, the incidence of stem borers is increased when maize and sorghum, both of similar plant type and host range for stem borers, are intercropped. On the other hand, intercropping with cowpea, which is not a host of stem borers, considerably reduced the incidence of stem borers on both maize and sorghum. The presence of both cereals also reduced pod borer incidence in cowpea. This study has confirmed its main objective which was to show that, in accordance with Amoaka-Atta et al (1983), insect pest colonisation, population build-up and establishment was related to the cropping system and the cropping season.

CONCLUSION

Crop combinations of sorghum and maize appeared to promote whereas sorghum and cowpea hampered colonisation and build-up of insect pest populations. Within a cropping system, similarity of plant type and host range for a particular insect pest appear to increase the incidence of that pest. Intercropping has pontential as an important cultural method of insect pest management in tropical agriculture.

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LITERATURE CITED

1. Altieri, M. M. Francis, C. A., van Schoonhoven, A. and Doll J. D. (1978). A review of insect prevalence in maize (Zea mays L.) and beans (Phaseolus vulgaris L.) polycultural system. Field Crop Res. 1, 33-49.

2. Amoako-Atta, B., Omolo, E. O. and Kidgega, E. K. (1982). Influence of maize, cowpea and sorghum intercropping systems on stem/pod-borer infestation. Insect Sci. Applic. 4, 47-57.

3. Amoako-Atta B., and Omolo, E. (1983). Yield losses caused by the stem/pod borer complex with maize-cowpea-sorghum intercropping system. Insect Sci. Applic. 4. 39-46.

4. Bach, C. E. (198). Effects of plant diversity and time of colonisation on an herbivore plant interaction. Oecologia 44, 319-326.

5. Dempster, J. P., Coaker, T. H. (1974). Diversification of crop ecosystem as a means of controlling pests. In: Biology in Pest and Diseases Control (D P Jones and M E Solomon eds) pp.106-114. Blackwell Scientific Publications, London.

6. Judenko, E. (1973). Analytical method for assessing yield losses caused by pests on cereal crops with and without pesticides. Tropical Pest Bulletin 2,31 pp.

7. Murdoch, W. M., Evans, F. C., Peterson, C. H. (1972). Diversity and pattern in plants and insects. Ecology 53, 819-829.

8. Omolo, E. O. and Seshu Reddy, K. V. (1985). Effects of different sorghum-based cropping systems on insect pests in Kenya. Proc. International Sorghum Entomology Workshop, 15-21 July 1984. Texas A & M University College Station, Texas, U.S.A.

9. Pimentel, D. (1961b). Species diversity and insect population outbreaks. Ann. Ent. Soc. Am 54, 76-87.

10. Pimentel, D. (1977). The econological basis of insect pest pathogen and weed problems. In: Origin of Pest, Parasite Disease and Weed Problems (J N Cherrett and G R Sagar, eds.) pp. 3-31. Blackwell Scientic Publications, London.

11. Price P. W. Waldbauer, G. P. (1975). Ecological aspects of pest management. In: Introduction to Insect Pest Management (R L Metcalf and W H Luckman, eds.) pp.37-73. John Wiley and Sons, New York.

12. Root, R. B. (1973). Organisation of a plant arthropod association in simple and diverse habitats: the fauna of collards (Brassica oleracea). Ecol. Monogr. 43, 95-124.

13. Singh, K. M. and Singh R. N. (1974). The population build-up of Pyrilla perpusilla Walker on sorghum and pearl millet under dryland conditions at Delhi. Indian Journal of Ecology 1: 12-16.

14. Singh, K. M. and Singh, R. N. (1977). Succession of insect pests in green gram and black gram under dryland conditions at Delhi. Indian Journal of Entomology 39: 365-370.

15. Smith J. G.(1976). Influence of crop background on aphids and other phytophagous insects on Brussels sprouts. Ann. appl. Biol. 83: 1-13.

16. Smith, R. F. (1970). Pesticides: Their use and limitations in pests management. In: Concepts of Pest Management (R. L. Rabb, and F. E. Guthrie, pp. 103-113 eds.) North Carolina State University. Raleigh, North Carolina, U.S.A.

17. Southwood, T. R. E., Way, M. J. (1970). Ecological background to pest management. In: Concepts of Pest Management (R L Rabb and F E Guthrie, eds) pp. 6-29. North Carolina State University, Raleigh, North Carolina, USA.

18. Tahvanainen, J. O., Root, R. B. (1972). The influence of vegetational diversity on the population ecology of a specialised herbivore, Phyllotreta cruciferae. Oecologa 10, 34-346.

19. Theunissen, J. and Den Ouden, H. (1980). Effects of intercropping with Spergula arvensis on pests of Brussels sprouts. Ent. exp. & app. 27: 260-268.

20. Trenbath, B. R. (1976). Plant interactions in mixed crop communities. In: Multiple Cropping. (R. I. Papedick, P. A. Sanchez & G. B. Triplott, eds.) American Society of Agronomy, Special publication No.27, Wisconsin.

21. Van Emden, H. F., Williams, G. F. (1974). Insect stability and diversity in agroecosystems. Ann. Rev. Ent. 19, 455-475.

22. Wiley, R. A. and Osiru, D. S. O. (1972). Studies on mixtures of maize and beans (Phaseoeis vulgaris L.) with particular reference to plant population. J Agric. Sci. 79: 517-529.

23. Wit, C. T. de (1960). On competition Versen Landbouwk Onderz. Wageningen N R 668.