TROPICULTURA, 1994, **12**, 1, 10-14

Compatibility of Intercropping Stem Borer Resistant Sorghum *Sorghum bicolor* Moench Genotypes with Cowpea *Vigna unguiculata* (L) Walp and its Effect on Flower Thrips.

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Keywords: Sorghum – Plant resistance – Intercropping compatibility – Stem borer – Cowpea – Flower thrips.

Summary

The compatibility of sorghum Sorghum bicolor *Moench genotypes with varying levels of resistance to stem borers for intercropping was studied in field experiments for two cropping seasons at the ICIPE in Kenya. Sorghum genotypes IS-18520, IS-1044, IS-2269, ICS 3, ICS 4, LRB6, 2K x 17 and Gaddam El Hamam were grown both as monocrops and as intercrops with cowpea. Intercropping reduced the* Chilo partellus *population density but there was no significant genotype x intercropping interaction. Intercropping significantly reduced the number of flower thrips* Megalurothrips sjostedti *in cowpea* Vigna unguiculata *(L) Walp. The stem borer resistance level of sorghum genotypes tested was not affected by intercropping. There were, however, differences in agronomic productivity. Grain yield of intercropped sorghum was positively correlated with the number of tillers per harvestable head. Sorghum genotypes with high tillering capacity, of intermediate plant height and intermediate leaf area were considered compatible for intercropping with cowpea.*

Résumé

La compatibilité des lignées de sorgho avec divers niveaux de résistance aux foreurs de tiges pour l'association culturale a été étudiée sur des expérimentations au champ pendant deux saisons culturales au Kenya. Les lignées de sorgho IS-18520, IS-1044, IS-2269, ICS 3, ICS 4, LRB6, 2K x 17 et Gaddam El Hamam ont été cultivées en monocultures ainsi qu'en association culturale avec le niébé. L'association culturale a réduit la densité de population du foreur de tiges sur IS-18520, IS-1044, ICS 3 et IS-2269, mais n'a pas eu d'effets sur les autres lignées. L'association culturale a réduit significativement le nombre de thrips des fleurs Megalurothrips sjostedti *sur le niébé. Le niveau de résistance au foreur de tiges des lignées de sorgho testées n'a pas été affecté par l'association culturale. Il y avait, néanmoins, des différences sur la productivité agronomique. Le rendement en grains du sorgho en association culturale a été positivement correlé avec le nombre de talles par épis récoltable. Les lignées de sorgho à haute capacité de tallage, de taille intermédiaire et de surface foliaire intermédiaire ont été considérées compatibles pour l'association culturale avec le niébé.*

1. Introduction

In many countries in Africa and Asia several lepidopterous stem borers inflict considerable losses to sorghum, maize, millet, rice and sugarcane (18). Intercropping, a common practice of the resource-limited small-scale farmer in these regions, tends to support lower insect pest levels than the corresponding monocultures (2,3,8) and has been recommended as part of an integrated pest management programme (11,14,15).

Stem borer tolerant genotypes have been suggested to be better suited as an adjunct to other management techniques (16). When combined with other methods, plant resistance lowers pest density and thereby lengthens the time to reach the economic injury level (EIL). The expression of resistance in cultivars is influenced by the environment. Temperature, relative humidity, light intensity, soil fertility and soil moisture have all been shown to affect the expression of insect resistance in plants (20).

Intercropping modifies host plant quality, plant size, leaf area, and nitrogen content (12,19). Intercropping also affects microclimate (e.g., air circulation, shade, relative humidity and temperature) and therefore may affect insect pest resistance levels in resistant cultivars. For implementability of plant resistance in integrated pest management (IPM), field research should be done to confirm that cultural control will not negate resistance in resistant genotypes (6). The need for identification of suitable genotypes which minimise intercrop competition and maximise complimentary effects (22) has also been stressed, as the behaviour in mixed stands is not predictable from behaviour in pure stands (10).

In the present study, the compatibility of eight sorghum *Sorghum bicolor* Moench genotypes with varying levels of resistance were assessed for intercropping compatibility with cowpea in terms of insect resistance and ideal plant characters in field experiments in Kenya.

2. Material and methods

The experiments were conducted at the field station of the

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Received on 25.07.93 and accepted for publication on 08.02.94.

International Centre of Insect Physiology and Ecology (ICIPE) located at Ungoye on the shores of Lake Victoria at latitude 00 36' 48.5" S and longitude 34°5'31"E and an altitude of 1240 m above sea level. The site has two rainy seasons (March-July and September-December) with average annual precipitation of 1000 mm and average daily temperatures of 19°C minimum and 31°C maximum and relative humidity of 60%. The soils are Vertic luvisols with the following characteristics: pH 6.1, cation exchange capacity 48.2 me/100g soil, N: 0.21%, C: 1.58%, P: 98 me/100g soil and K: 1.0 me/100g soil.

Eight sorghum genotypes (IS-18520, IS-1044, IS-2269, obtained from the International Crops Research Institute for the Semi-Arid Tropics; LRB6, ICS3, ICS4 from ICIPE; Gaddam El Hamam from Sudan; and 2Kx17 from Kenya) with varying levels of resistance to the spotted stem borer *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) were planted in the first and second cropping seasons of 1990-91 under field conditions. All the eight genotypes were combined in a factorial combination with two cropping patterns: as a monoculture or intercropping with cowpea, *Vigna unguiculata* (L) Walp cv ICV 2 (from ICIPE). The plant arrangement for the intercropping was single alternating rows with a sorghum spacing of 90 cm inter-row and 30 cm intra-row, and for the cowpea, 90 cm inter-row and 20 cm intra-row. The corresponding spacing in the monocrop was 60 cm x 30 cm for sorghum and for the cowpea 60 cm x 20 cm. The sorghum and cowpea were planted simultaneously. The 16 treatments were in a randomised complete block design with four replicates with plot size of 20 m x 10 m. At planting, P at 45 kg/ha and N at 18 kg/ha was applied as the diammonium phosphate. An additional 70 kg N/ha as calcium ammonium nitrate was spot-applied to the sorghum 4 weeks after emergence.

Entomological assessments were done both visually and destructively. Visual assessments were carried out in a 5m x 5m fixed quadrat in which the total number of plants and plants with stem borer damage symptoms such as leaf lesions and dead hearts were counted. Bi-weekly samplings of stem borer larvae, pupae and tunnelling length were measured on 10 plants per plot between 3 weeks after emergence until harvest. In cowpea, the number of flower thrips (*Megalurothrips sjostedti* Trybom Thysanoptera: Thripidae) per 20 flowers were counted at flowering. Plants were sampled at 5 and 7 weeks after emergence to determine the dry weight and leaf area on 15 plants per plot. Leaf area was determined by using an automatic leaf area meter (L1-3000-3050A Licor, USA). Light photo flux density (400-700 nm) was determined with a point sensor (Li-185B, LiCor, USA) at 50 cm above ground level five times per plot. Relative light intensity (light transmission ratio, LTR) was calculated against a reference light above the canopy for each plot. At harvest the number of productive tillers, plant height and grain yield were determined from the central 5m x 5m per plot. Grain moisture was determined using a moisture tester (1175 15302, Dicky-John Corporation, Auburn, USA) and expressed to 12%.

Data for each parameter was subjected to analysis of variance (two-way), with intercropping and genotype as main factors. To stabilize variance the data on stem borer pupal and larval density, and flower thrips were transformed to logarithms (x + 1) before analysis. Per cent plants damaged were transformed to arcsin-square root transformation. Mean separation was obtained using Tukey's Studentized Range Test. Regression analysis was carried out on plant characters and grain yield. A sorghum genotype was considered compatible in terms of resistance when the level of insect resistance/tolerance was not altered in intercropping or was lower in intercropping. In agronomic terms, compatibility was calculated as

$$\left.\begin{array}{l}\text{Intercropping}\\ \text{Compatibility}\\ \text{index}\end{array}\right\} = \frac{\text{Yield of any test genotype in intercrop}}{\text{Highest yielding genotype of monocrop in the trial}}$$

The closer the value to unity, the more compatible the genotype is for intercropping.

3. Results and discussion

3.1. Plant resistance

The main stem borer observed was the spotted stem borer, *C. partellus*. The sorghum genotypes varied in their resistance/susceptibility to stem borers, with IS-1044 being resistant, IS-18520, and ICS 3 being tolerant as indicated by the percentage of plants attacked by borers (Fig. 1).

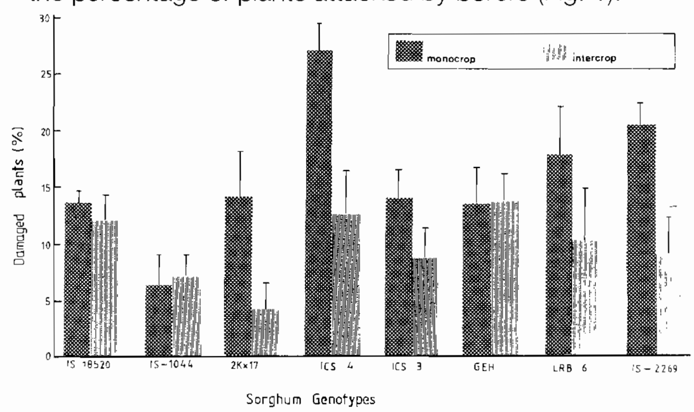

Figure 1. Percentage of plants damaged by stem borers 9 weeks after crop emergence in different sorghum genotypes grown as monocrops and as intercrops in the second cropping season. Bars indicate s.e. of means with 3 df, P≤0.05.

TABLE 1
Number of larvae and pupae of *Chilo partellus* at 8 weeks after emergence of sorghum as affected by intercropping with several sorghum genotypes.

Sorghum	Cropping pattern	
	Monocrop	Intercrop
IS-18520	7.8 ab	4.6 abc
IS-1044	3.3 abc	1.3 abc
2Kx17	1.3 abc	0.6 abc
ICS 4	6.0 abc	5.3 abc
ICS 3	8.0 ab	6.6 ab
GEH	2.0 abc	1.3 abc
LRB6	3.3 abc	4.6 abc
IS-2269	6.6 abc	0.0 c

Means followed by the same letter are not significantly different at P≤0.05 Tukey's Studentized Range.

[1] Analysis after log (x+1) transformation.

Intercropping significantly (P≤0.05) reduced stem borer pupal and larval density but differences among genotypes were not significant (Table 1 and Fig. 2) and there was no significant genotype x intercropping interaction. Not all crop combinations bring about reduced herbivorous pest loads and

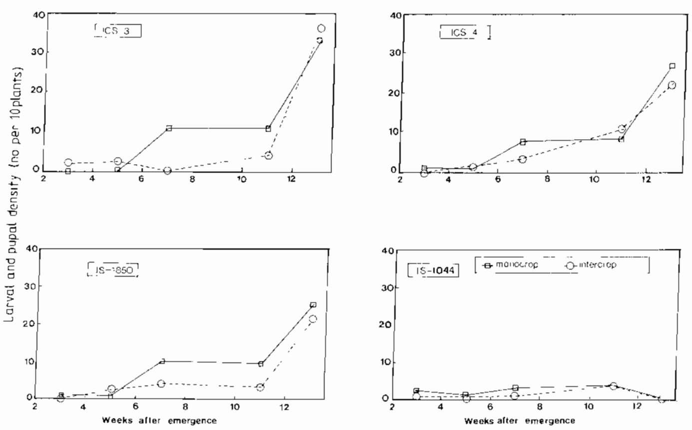

Figure 2. Number of stem borer larvae and pupae at different crop growth stages of several sorghum genotypes grown as monocrops and as intercrops with cowpea in the first cropping season.

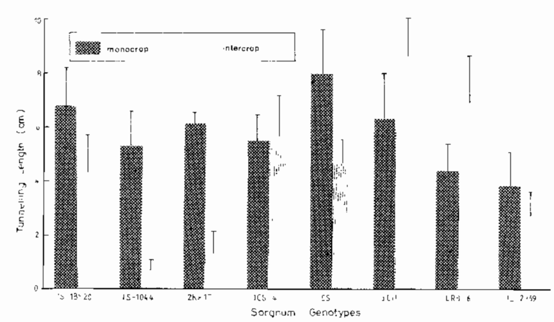

Figure 3. Stem tunnelling length at harvest in different sorghum genotypes grown as monocrops and as intercrops with cowpea in the second cropping season. Bars indicate s.e. of means with 3 df, P≤0.05.

perhaps more importantly, a given herbivore may show a variable response to the same crop combination (4,17). The pattern for stem tunnelling length varied among sorghum genotypes with LRB 8 having the greatest tunnel length and 2Kx17 the least (Fig. 3). Intercropping significantly reduced the tunnel length as compared to the monocrops. Here again there was no significant genotype x intercropping interaction. It is usually assumed that host plant resistance is generally compatible with IPM (1,5,9,13). In this study, the effect of intercropping on the sorghum genotypes varied from no effect to additive. The extent of environmental modification resulting from intercropping was not adequate to alter the basis of resistance. Since detailed information on the mechanism of most crops' resistance to a given insect is limited, it is not always possible to depict what comprises compatibility (6). Intercropping also significantly reduced the number of flower thrips in cowpea in both seasons (Table 2).

3.2. Plant characters appropriate for intercropping

The sorghum genotypes differed in several plant characters with ICS 3 having the highest leaf area index (LAI) at flowering, and IS-18520 the lowest. The genotypes also varied significantly in plant height and tillering capacity (Table 3). There was a significant (P≤0.05) genotype x intercropping interaction on plant height. Sorghum yield varied widely among the genotypes and between seasons (Tables 4 and 5). Intercropping compatibility in terms of grain yield was ranked in the order IS-18520 > Gaddam El Hamam > LRB 6 > ICS 3 = ICS 4 > 2Kx17 > IS-1044 > IS-2269 (Tables 4 and 5).

Sorghum plant characters such as leaf area, plant height and number of productive tillers, differed in their contribution to

TABLE 2
Number of cowpea flower thrips (per 10 flowers) as affected by intercropping with several sorghum genotypes.

Sorghum genotype	First Season	Second Season
IS-18520 inter	152 b	37 b
IS-1044 inter	157 b	49 b
ICS 4 inter	110 b	58 b
ICS 3 inter	136 b	29 b
2Kx17 inter		52 b
GEH inter		37 b
LRB6 inter		52 b
IS-2269 inter		40 b
Cowpea mono	269 a	85 a

Means in a column followed by the same letter are not significantly different at P≤0.05 by Tukey's Studentized Range Test.

TABLE 3
Number of tillers and plant height of different sorghum genotypes grown as monocrops and intercrops with cowpea.

Sorghum genotypes/ Cropping pattern	Tillers (no/per plant)	Plant height (cm)
IS-18520 mono	3.5 a	126 de
IS-18520 inter	3.1 ab	123 de
IS-1044 mono	1.5 fgh	174 b
IS-1044 inter	1.8 defgh	146 c
2Kx17 mono	1.4 gh	110 ef
2Kx17 inter	1.6 efgh	94 f
ICS 4 mono	1.7 defgh	256 c
ICS 4 inter	2.0 cdefg	241 c
ICS 3 mono	2.4 bcd	125 de
ICS 3 inter	2.6 bc	129 de
GEH mono	2.5 bcd	94 f
GEH inter	2.4 bcd	94 f
LRB6 mono	2.2 cdef	137 d
LRB6 inter	1.6 efgh	129 de
IS-2269 mono	1.1 h	294 a
IS-2269 inter	1.6 h	234 d

Means in a column followed by the same letter are not significantly different at P≤0.05 by Tukey's Studentized Range Test.

TABLE 4
Grain yield and intercropping compatibility index of sorghum genotypes intercropped with cowpea (first cropping season).

	First cropping season	
Sorghum genotypes/ Cropping pattern	Grain yield (kg/ha)	Compatibility index
IS-18520 mono	2906 a	
IS-18520 inter	1962 abc	0.70
IS-1044 mono	1230 c	
IS-1044 inter	1160 c	0.40
ICS 4 mono	2437 ab	
ICS 4 inter	1432 abc	0.49
ICS 3 mono	2104 abc	
ICS 3 inter	1511 abc	0.52

Means in a column followed by the same letter are not significantly different at P≤0.05 by Tukey's Studentized Range Test.

TABLE 5
Grain yield and intercropping compatibility index of sorghum genotypes intercropped with cowpea (second cropping season).

Sorghum genotypes/ Cropping pattern	Grain yield (kg/ha)	Compatibility index
IS-18520 mono	5678 a	
IS-18520 inter	4279 bc	0.75
IS-1044 mono	2291 fgh	
IS-1044 inter	2208 fgh	0.39
2Kx17 mono	2908 defg	
2Kx17 inter	2708 efg	0.48
ICS 4 mono	5431 ab	
ICS 4 inter	2910 defg	0.51
ICS 3 mono	2672 efg	
ICS 3 inter	2916 defg	0.51
GEH mono	5416 ab	
GEH inter	3541 cdef	0.62
LRB6 mono	3750 cde	
LRB6 inter	3333 cdefg	0.59
IS-2269 mono	2016 gh	
IS-2269 inter	1250 h	0.22

Means in a column followed by the same letter are not significantly different at P≤0.05 by Tukey's Studentized Range Test.

the intercrop sorghum grain yield. There was a highly significant positive correlation (y=427+118x, r^2=0.51) between the number of productive tillers and intercrop grain yield but no significant correlation between the other plant characters and grain yield was observed. This is particularly important as plant densities of sorghum in traditional intercropping is low, the ability of the plant to compensate for low plant density is critical for high yields. The yield of cowpea was significantly reduced by intercropping irrespective of the genotype and there was no significant genotype x intercropping interaction. There was also a non significant negative correlation between the light transmission ratio and leaf area index of the different sorghum genotypes (y=0.95-0.05x, r^2=0.24) but a significant positive correlation between plant height and leaf area (y=0.20+0.0078x, r^2=0.52). The amount of light reaching the cowpea canopy is influenced by the total leaf area above the horizon as photo flux density attenuates through the leaf canopy, following Lambert-Beer's Law (21). In our study no protection was given to the cowpea against insects. When this is done it is expected that grain yield will be reduced more in intercropping in sorghum with tall leafy genotypes than short genotypes. Other important plant characters for intercropping include photoperiod insensitivity, appropriate maturity periods, plant morphology, population density responsiveness (7), vigorous early season growth, and resistance to pests and diseases.

The micro-environment modification under intercropping is such that it would not affect the inherent resistance level of cultivars, but environmental modifications arising out-of-site may be important.

Acknowledgements

We thank the director of the ICIPE, Professor Thomas R. Odhiambo for providing support and permission to publish. We are also grateful to Mr. Isaiah Odhul for his assistance in the field.

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