carried out to evaluate suitable weed management practices for a sorghum-based intercropping system. The trial was conducted under irrigated conditions at the Agricultural College and Research Institute, Killikulam during the summer and winter seasons of 1997. The soil in the experimental field was a sandy clay loam with a pH of 7.4, low in available nitrogen (153.6 kg N ha^{-1}), with a moderate level of available phosphorus (12.3 kg $P_2O_5ha^{-1}$) and high in available potassium (282.5 kg K_2O ha^{-1}). The weed flora found in the experimental field included the grasses: *Eleusine indica* L., *Dactylocatenium aegyptium* Beav., *Echinochloa colonum* L., and *Cynodon dactylon* L., the sedge *Cyperus rotundus* L., and the broadleaved weeds: *Trianthema portulacastrum* L., *Trianthema monogyna* L., *Boerhaavia diffusa* L., *Phyllanthus niruri* L., *Phyllanthus maderaspatersis* L., *Digera arvensis* Forsk, and *Cynotis cucullata* L. Experiments were laid out in a split-plot design with three replicates. Three cropping systems were the main plots and seven weed management practices the subplots.

Sole-crop sorghum cv CO 26 was sown at a spacing of 45 x 15 cm. For the intercrops, sorghum was sown in paired rows (60/2 x 15 cm). Black gram [*Vigna mungo* (L.) Hepper] cv CO 5 (30 x 10 cm) and cowpea *[Vigna unguiculata* (L.) Walp.] cv CO 4 (30 x 20 cm) were sown in between pairs of sorghum rows in an additive series at a ratio of 2:1. Fertilizer was applied at the recommended rate of 90 N:45 P:45 K kg ha^{-1}. Weed control treatments are indicated in Table 1. All herbicides were sprayed 3 days after sowing (DAS) with knapsack sprayers fitted with flood-jet nozzles using 500 L of water.

Results

Weed dry matter, weed control efficiency, yield parameters, and sorghum yields were significantly affected by both intercropping systems and weed management practices. Among the intercropping systems, intercropping of sorghum and cowpea in a 2:1 ratio caused a significant reduction in weed dry matter production and had a higher weed-smothering efficiency than other treatments (Table 1).

The sole sorghum crop recorded higher weed dry matter, lower weed-smothering efficiency, and such higher yield parameters as panicle length, number of grains $panicle^{-1}$, 1000-grain mass, and grain yield than the intercrops. Among the weed management practices, the unweeded control had higher weed dry matter, and lower crop yield parameters and yield than the other treatments. Metolachlor (1.0 kg ha^{-1}) plus hoeing at 40 DAS resulted in low weed dry matter, higher weed-smothering efficiency, and maximum crop yield parameters and yield. This treatment was followed by isoproturon (0.6 kg ha^{-1}) plus hoeing at 40 DAS. The interactions between intercropping systems and weed management practices were significant. Highest intercrop yields (black gram and cowpea) were recorded following the metolachlor (1.0 kg ha^{-1}) plus hoeing at 40 DAS treatment. The highest land equivalent ratio (LER) was recorded in the sorghum + black gram intercropping system. Applications of metolachlor (1.0 kg ha^{-1}) plus hoeing at 40 DAS resulted in a high LER. It can be concluded that an intercrop of sorghum with black gram treated with metolachlor is the best way to achieve maximum yield and monetary return under the conditions of the experiment.

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Pests and Diseases

New Sources of Resistance to Sorghum Midge in Burkina Faso

D Dakouo[1], G Trouche[2,4], A Ratnadass[3,4], M Ba[1], and S Da[1] (1. Institut d'etudes et de recherches agricoles (Burkina Faso) (INERA), Station de Farako-Ba, BP 910 Bobo-Dioulasso, Burkina Faso. 2. INERA/Centre de cooperation internationale en recherche agronomique pour le development (CIRAD), Station de Saria, BP 10 Koudougou, Burkina Faso. 3.ICRISAT-CIRAD, BP 320 Bamako, Mali. 4. CIRAD-CA, Programme CALIM, TA 73/09, 34398 Montpellier Cedex 5, France)

Introduction

Sorghum [*Sorghum bicolor*(L.) Moench] is the main cereal crop in Burkina Faso, with an average annual production during 1992-94 of 1.25 million tons (FAO and ICRISAT, 1996). The major biotic constraints to its cultivation are insect pests, diseases, and *Striga* spp. The sorghum midge (*Stenodiplosis sorghicola* Coquillett) is the most important pest of the crop in the southern, central, and eastern regions of the country (Bonzictal. 1984;Nwanze 1988). A survey conducted in eastern and central regions in 1999, revealed that farmers have to grow early-maturing red sorghum or other cereal crops maize (*Zea mays* L.) and pearl millet [*Pennisetum glaucum* (L.) R. Br.] in order to avoid the midge problems they experience on late-maturing sorghum. To reduce infestation and losses, the most appropriate and sustainable insect control strategy for subsistence farmers is based on insect-resistant cultivars combined with cultural practices. However, resistant varieties developed on other continents by scientists, including those working at international agricultural research centers, have not solved midge problems in most African countries. Such resistant varieties turned out to be susceptible to such other biotic constraints as foliar diseases, grain molds, and head bugs *(Eurystylus oldii* Poppius) that eventually translated into poor grain quality for traditional dishes like *to.* In addition, breakdown of resistance to sorghum midge in such varieties has been reported from Kenya (Sharma et al. 1999). It is therefore critical to develop midge-resistant varieties that are well-adapted to African conditions, and tolerant to other biotic constraints. Alternative ways of breeding for midge resistance include crossing exotic or local sources of resistance with high-yielding and well-adapted varieties. This paper reports the results of a search for new sources of midge resistance among local sorghum cultivars, carried out from 1996-99 in Burkina Faso.

Materials and methods

More than 200 local landraces from Burkina Faso and other West African countries were screened under natural midge infestation. The best 40 varieties selected for their low midge damage scores, were tested along with 10 susceptible and resistant controls during the 1999 rainy season, in a randomised complete-block design with two replications. The experiment was carried out at two locations known to be midge 'hot-spots', namely Kouare (eastern region) and Farako-Ba (western region). The varieties were sown in 10-m long, single-row plots. Spacing between rows was 0.8 m and within rows, 0.40 m. Border lines of a susceptible variety were sown 15 days before the test cultivars as 'infestor rows', in order to increase natural midge populations. Local landrace 439 and improved variety Sariaso 10 were used as susceptible controls while ICSV 745 (Sharma et al. 1992) was used as a resistant control. Plots were thinned to one plant per hill. Fertilizer was applied as follows: 100 kg ha^{-1} of a complex NPK (14:23:14) at thinning, and 50 kg ha^{-1} of urea (46% N) at panicle initiation. Time to 50% anthesis was recorded. Midge damage was evaluated as described by Sharma et al. (1992). Data was expressed as the percentage of midge-damaged spikelets based on the observation of 500 spikelets per plot. At crop maturity, midge damage was evaluated by visually rating five plants per plot, using a 1-9 scale (Sharma et al. 1992) where 1 = less than 10%, and 9 = more than 80% chaffy spikelets. Data were subjected to analysis of variance after arcsine transformation, using STATITCF software (ITCF 1991).

Results and discussion

Results obtained on the best 10 varieties, namely those combining a midge incidence of less than 10% damaged spikelets, and a visual score of less than 2 at both locations, are given in Table 1. Time to 50% anthesis varied with locations and ranged from 49 days (cultivar 533) to 92 days (G 1645). The average percentage of midge-damaged spikelets varied at Kouare' from 0% (ICSV 745) to 45.3% (susceptible control landrace 439). At Farako-Ba, the percentage of damaged spikelets ranged from 0.4% on ICSV 745 to 31.8% on the improved variety Sariaso 10 used as a susceptible control. Visual scores varied from 1 (ICSV 745) to 2.6 (G 1645) on resistant entries at Kouare, while at Farako-Ba, they ranged from 1 (ICSV 745) to 1.7 (Tenlopieno). On susceptible controls, visual scores varied from 7 to 9 at Kouare and from 3.9 to 4.3 at Farako-Ba. Tenlopieno (originating from eastern Burkina) showed the highest percentage of damaged spikelets both at Kouare and Farako-Ba with an average of 15.5% over 3 years of tests (1996-98). However, this cultivar showed low visual midge damage scores (1.2 and 1.7); in addition, it is tolerant of *E. oldii* damage. Wanmiougou and G 1647 showed low and stable midge damage scores across locations. In 1999, their damage ratings were 0.5% for Kouare, and 1.5% and 3.5% at Farako-Ba; the average damage ratings over 3 years were 1.1% at Kouarte and 0.1 % at Farako-Ba. Visual scores varied from 1 to 1.4 at both locations. It should further be noted that sources of resistance to midge were identified within various sorghum races. These results obtained over 4 years of tests under high natural midge infestations constitute an important step in breeding for resistance to midge using local sources of resistance. Further investigations will be conducted under artificial infestation to elucidate the mechanisms of resistance to sorghum midge that are involved in each variety.

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Table 1. Midge damage on new sources of resistance to sorghum midge (*Stenodiplosis sorghicola*) under natural conditions, Burkina Faso, 1996–99

Variety	Race	Origin[1]	Time to 50% anthesis (days) Kouaré 1999	Time to 50% anthesis (days) Farako-Bâ 1999	Damaged spikelets (%)[2,3] Kouaré 1999	Damaged spikelets (%)[2,3] Farako-Bâ 1999[4]	Average 1996–98	Visual score[5] Kouaré 1999	Visual score[5] Farako-Bâ 1999
Wanmiougou	durra	BKF	82	73	0.5 (3.85)	1.5 (7.03)	1.1	1.3	1.4
G1647	guinea-caudatum	CMR	90	81	0.5 (2.87)	3.0 (9.92)	0.1	1.4	1.0
841	guinea	BKF	60	61	0.7 (4.68)	5.6 (11.83)	4.7	2.3	1.2
G1645	guinea	CMR	92	77	2.0 (8.13)	1.5 (7.00)	1.5	2.6	1.0
971	caudatum	BKF	68	61	3.2 (7.33)	7.2 (15.35)	4.5	1.4	1.3
Tenlopieno	guinea	BKF	77	66	7.7 (15.87)	8.5 (16.94)	15.5	1.2	1.7
Kabega 1	durra	BKF	84	ne	1.5 (4.99)	ne	0.2	1.2	ne
533	durra	BKF	49	ne	1.6 (3.63)	ne	6.9	1.0	ne
495	guinea	BKF	70	ne	3.7 (9.48)	ne	5.4	1.0	ne
Fada 1	guinea	BKF	81	76	4.1 (11.27)	8.0 (16.43)	6.6	1.9	1.2
Controls									
ICSV 745[6]	caudatum	IND	66	68	0 (0)	0.4 (3.63)	–	1.0	1.1
Sariaso 10[7]	caudatum	BKF	72	63	29.5 (32.80)	31.8 (32.75)	36.2	7.0	4.3
439	guinea-caudatum	BKF	72	63	45.3 (42.30)	29.2 (32.70)	82.7	9.0	3.9
SE[8]			±3.1	±3.74	(±9.21)	(±6.81)		±1.26	±0.90

1. BKF= Burkina Faso, CMR= Cameroon, IND= India
2. Percentage of midge-damaged spikelets in 500 spikelets sampled 15 days after anthesis
3. Means in parentheses are arcsine-transformed values
4. ne= no emergence at Farako-Bâ
5. Damage scored on a 1–9 visual rating scale, where 1 = <10% , and 9 = > 80% chafty spikelets
6. Resistant control
7. Susceptible control
8. SE, mean, and CV resulted from analysis of variance carried out on results of 40 test varieties and 10 controls.

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Inheritance of Resistance to Sorghum Midge and Leaf Disease in Sorghum in Kenya

H C Sharma[1], S Z Mukuru[2], H Gugi[2], and S B King[2] (1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India; and 2. ICRISAT PO Box 39063, Nairobi, Kenya)

Introduction

Sorghum [*Sorghum bicolor*(L.) Moench] is one of the most important cereal crops in the semi-arid tropics (SAT). Of the over 150 species of insects that damage the sorghum crop, the sorghum midge *(Stenodiplosis sorghicola* Coquillett), is the most important pest in the Lake Victoria basin area of eastern Africa. Leaf diseases such as anthracnose [*Colletotrichum graminicola* (Cesti.) Wilson], zonate leaf spot [*Gloeocercospora sorghi* (Bains and Edgerton)], leaf blight *[Exserohilum turcicum* (Pass.) Leonard and Suggs.], and rust (*Puccinia purpurea* Cooke) also constitute important constraints to increasing the production and productivity of sorghum in this region.

Nearly 15,000 sorghum germplasm accessions have been screened for resistance to sorghum midge at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India; and 25 lines have been found to be resistant across seasons and locations in India (Sharma et al. 1993). Most of the high-yielding, midge-resistant lines derived from cv DJ 6514 have shown a susceptible reaction to sorghum midge at Alupe, Kenya (Sharma et al. 1998). To investigate the interactions between midge-resistant and midge-susceptible cytoplasmic male-sterile (cms) lines and restorers for expression of resistance to sorghum midge and leaf diseases, a set of 36 F_1 hybrids and their parents [12 restorers showing resistance to sorghum midge in India, and three cms lines (ICSA 88019 and ICSA 88020—resistant to sorghum midge in India, and ICSA 42—a susceptible control)] were tested at Alupe, Kenya in 1994 to determine whether the restorers showing resistance to sorghum midge/leaf diseases combined with the cms lines to produce hybrids with resistance to these pests. Such information is important when selecting parents for transferring resistance into high-yielding varieties and hybrids to increase the production and productivity of sorghum in eastern Africa.

Materials and methods

Gene action for sorghum midge resistance was studied on two midge-resistant (ICSA 88019 and ICSA 88020) (Agrawal et al. 1996) and one commercial midge-susceptible (ICSA 42) cms lines. Twelve genotypes identified as resistant to sorghum midge in India (Sharma et al. 1993) were used as restorers. Thirty-six F_1 hybrids and their parents were sown in a randomized complete block design at Alupe, Kenya during the 1994 short rainy season, in three replications. Each entry was sown in a 4-m long, two-row plot. The experiment was sown twice at an interval of 10 days to avoid escapes, and maximize insect/ disease incidence on the crop. The crop was raised following normal agronomic practices. No insecticide was applied during the reproductive phase of the crop. At maturity, the panicles were evaluated visually for sorghum midge damage (damage rating, DR) on a 1 to 9 scale (1 = <10%, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = 51-60%, 7 = 61-70%, 8 = 71-80%, and 9 = >80% midge-damaged spikelets). Leaf disease (anthracnose, rust, leaf blight, and zonate leaf spot) severity (LDS) was evaluated on a 1 to 9 scale (1 = <10%, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = 51-60%, 7 = 61-70%, 8 = 71-80%, and 9 = >80% of the leaf area infected). Overall LDS was recorded in both the sowings, while individual LDS was recorded only in first sowing, when the LDS was greater than that in the second sowing. The material was also evaluated for agronomic desirability (agronomic score, AS) on a 1-5 scale (1 = agronomically desirable phenotype with high yield