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Full Length Research Paper

Field evaluation of improved cowpea lines for resistance to bacterial blight, virus and striga under natural infestation in the West African Savannas

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The average productivity of cowpea in the existing traditional systems is low due to a complex of biotic and abiotic stresses. The biotic factors include insect pests, parasitic plants, and viral, fungal and bacterial diseases. Concerted efforts are being made to develop improved cowpea varieties with combined resistance to these constraints. Twenty five cowpea lines including two local land-races were grown at three locations in the first year (2002) and at six locations in the second year (2003) in Nigeria and Niger for field screening for resistance to Bacterial blight. Many of the improved varieties had significantly higher grain and fodder yields than the local checks. There was genotype x environment interactions for grain and fodder yields. About 44% of the varieties tested were resistant to bacterial blight while 20% showed moderate resistance and others were susceptible. Bacterial blight was more important in the Sahel, and several improved cowpea breeding lines, IT98K-506-1, IT97K-1113-7, IT97K-1069-6, IT97K-1092-2, IT97K-1069-5, IT98K-131-2 and IT97K-568-18 produced higher grain and fodder yields than the other varieties and showed combined resistance to the disease. These varieties should therefore be evaluated on-farm for onward release to farmers where there seed types meet the farmers preferred seed type other wise they can be used as parent lines as source of important genes for resistant to the diseases and high grain and fodder yields.

Key words: Bacterial blight, cowpea, virus, striga, grain yield, West Africa Savanna.

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the important source of vegetable protein in the daily diets of the rural and urban masses and also an important source of nutritious fodder for ruminant livestock in the dry savannas of West Africa. The overall grain yields of cowpea in the present traditional systems is low (0-300 kg/ha) (van Ek et al., 1997; Singh et al., 1997), due to a complex of biotic and abiotic factors. The abiotic factors that cause yield reduction include poor soil fertility, drought, heat, acidity and stress due to intercropping with cereals (Singh and Tarawali, 1997; Singh and Ajeigbe, 2002). The biotic factors include insect pests, parasitic flowering plants, as well as viral, fungal and bacterial diseases (Emechebe and Lagoke, 2002). Among the diseases, bacterial blight induced by *Xanthomonas axono-podis* pv. *vignicola* (Burkholder) Dye is probably the most widespread disease of cowpea, having been reported from all regions of the world where cowpea is cultivated (Emechebe and Florini, 1997). Symptoms of cowpea bacterial blight on leaves begin with small water-soaked spots, which remain small and, when the adjacent tissues die, gradually coalesce into large, irregular, brown, necrotic lesions surrounded by yellow haloes. The pathogen also invades the stem where it produces cracking with brown stripes and swelling (canker) and dark green water soaking on pods from where it enters the seeds and causes their discolouration (Vakili et al., 1975; Kaiser and Ramos, 1979). The pathogen is seed transmitted; while secondary spread occurs by wind-driven rain (COPR, 1981). Kishun (1989) reported grain

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yield loss of 2.7 - 92.2%, depending on susceptibility of the variety. Incidence and severity of the disease on cowpea is affected by cropping system and season (Ouko and Buruchara, 1987), rate and type of fertilizer applications (Rao and Hiremath, 1985) and time of planting (Kishun and Chand, 1989). Control options range from cultural practices to seed treatments and the use of resistant varieties. Emechebe and Shoyinka (1985) noted that host plant resistance is the most viable option for the control of cowpea bacterial blight and pustule. Sources of resis-tance to major diseases, including bacterial blight, insect pests and parasitic angiosperms have been identified and incorporated into improved varieties (Singh and Ntare, 1985; Singh et al., 1997; Singh and Ajeigbe, 2001). This paper describes the field performance and reaction to bacterial blight, virus and *Striga* in different agro-ecological zones of Nigeria and Niger Republic by im-proved cowpea breeding lines selected for resistance to bacterial blight at the International Institute of Tropical Agriculture (IITA).

MATERIALS AND METHODS

Cowpea genotypes and locations

Twenty three improved cowpea breeding lines and two local checks were grown during the rainy seasons at three locations in the first year (2002) and six locations in the second year (2003) in Nigeria and Niger. The sites included: Toumnia (13°59`N 9°01`E) with a rainfall of 373 and 435 mm in 2002 and 2003, respectively and long term average rainfall of 430 mm; Minjibir (12°11`N 8°30`E) with a rainfall of 1156 mm in 2003 and long term average rainfall of 800 mm; Samaru (11°11`N $7^0$38`E) with a rainfall of 1008 and 1135 mm in 2002 and 2003, respectively and long term average rainfall of 1014 mm; Mokwa (9°18`N 7°38`E) in 2003 with a long term average rainfall of 1100 mm; Kubwa (9°12`N 7°20`E) in 2002 and 2003 with a long term average rainfall of 1500 mm; and Ibadan (7°26`N 3°38`E) with a rainfall of 1342 mm in 2003. The sites were chosen to represent the major agro-ecological zones of cowpea cultivation in West Africa and to provide diversity in respect of rainfall and related biotic and abiotic stresses. Thus, Toumnia is in the Sahel, Minjibir in the Sudan savanna and Samaru in the nor-thern Guinea savana, while Mokwa and Kubwa are in the southern Guinea savanna and Ibadan is in the derived savanna zone. With the exception of Toumnia (in Niger Republic) all other locations are in Nigeria.

Agronomic practices

In Nigeria, the plots were disc harrowed, fertilizer (NPK 15:15:15) was broadcasted at the rate of 100 kg/ha and ridged at 75 cm prior to planting, while planting was done on flat after fertilizer broad-casting in Toumnia Niger Republic. Three seeds were sown at a spacing of 20 cm within the rows and thinned to two plants/hill two weeks after planting. The plots were weeded manually at 3, 6 and 9 weeks after planting. Insect pests were controlled with three sprays of insecticide (250 ml cypermethrin + 30 g/l dimethoate) at the rate of 1 L in 200 L of water per ha. Sprays were applied using a knapsack sprayer at 100 ml of insecticide formulation per 20 litre of water during the pre-flowering, flowering and podding stages of the crop.

Experimental design and data collection

The trials were planted in a randomised complete block design with three replications. Each plot consisted of four ridges, 4 m long spaced 0.75 m apart at each location. At maturity (when about 90% of the pods were dry), pods from the two central rows (6 m^2) were harvested and sun dried. The dried pods were later manually threshed, the resulting grains per plot weighed and the values extrapolated to per hectare basis. Bacterial blight severity was scored using a descriptive scale of 1-10, where 1 means no dis-ease and 10 is maximum disease, including death as reported by Amatobi and Alabi (1994). The number of *Striga* stands that emerged per plot (6 m^2) was counted and recorded in Toumnia. The data recorded were analysed using computer program GenStat Discovery Edtion2 and Least Significant Difference (LSD) between the means was calculated at 5% level of probability; and regression analysis was undertaken for selected parameters.

RESULTS

The variance ratio for grain and fodder yields and bacterial blight scores are presented in Table 1. The differences among the locations, cowpea lines and the interaction between locations and cowpea lines were highly significant for grain and fodder yields as well as the bacterial blight scores. The performances of most of the cowpea lines were not consistent across locations indicating major genotype × environment interaction.

Productivity (grain and fodder yields)

The mean number of days to flowering and maturity, grain and fodder yields of the different cowpea lines at three locations in 2002 and six locations in 2003 are given in Table 2. Days to flowering ranged from 41 to 52 days after planting while days to maturity ranged from 68 to 85 days with significant differences among the cowpea lines for both days to flowering and maturity. Significant differences were found among the cowpea lines for grain productivity in both years. The mean grain yield from the three locations in 2002 was 1106 kg/ha, with the best varieties yielding over 1500 kg/ha. The best varieties were IT98K-506-1, IT98K-1069-6, IT98K-131-2, and IT97K-1113-7. The mean grain yield from the 6 locations in 2003 was 995 kg/ha, with the best variety (IT97K-1113-7) yielding 1360 kg/ha. The mean grain yield from the nine environments (three in 2002 and six in 2003) was 1032 kg/ha with IT98K-506-1, IT97K-1113-7, IT98K-1069-6 and IT98K-1092-2 as the highest yielding lines. The two local varieties (Dan Ila and Aloka) were much poorer in respect of grain yield compared to the improved varieties.

Significant differences were observed among the cowpea lines in respect of fodder yields. In 2002, mean

Table 1. Variance ratio of testing differences for grain fodder yields bacterial blight score.

Source of Variation	Grain yield	Fodder yield	Bacteria blight score
Location	30.83**	56.41**	38.95**
Variety	15.28**	16.24**	36.25**
Location x Variety	3.09**	3.4**	7.35**

**Significant at 1% probability.

Table 2. Mean days to maturity grain fodder yields (kg/ha) of cowpea varieties in 2002 and 2003.

Variety	Days to		Grain			Fodder		
	Flowering	Maturity	2002	2003	Mean (9 environments)	2002	2003	Mean (5 environments)
IT98K-506-1	42	68	1559	1342	1415	1197	1767	1577
IT97K-1113-7	44	70	1255	1360	1325	1099	2359	1939
IT97K-1069-6	49	75	1483	1197	1292	1447	2825	2366
IT98K-1092-2	45	71	1173	1285	1248	1086	2401	1962
IT97K-1069-5	48	76	1244	1232	1236	2018	2762	2514
IT98K-131-2	48	75	1447	1056	1186	1127	1788	1568
IT97K-568-18	45	70	1078	1203	1161	710	1801	1438
IT98K-205-10	42	69	1202	1124	1150	1113	1322	1253
IT97K-556-4	44	70	1229	1056	1114	1308	2331	1990
IT98K-452-1	42	70	1235	1052	1113	1127	1754	1545
IT98K-1092-1	46	72	1187	1053	1098	1851	2415	2227
IT98K-422-2	47	73	1086	1000	1029	974	2776	2176
IT98K-128-4	47	72	1062	994	1016	835	1795	1475
IT98K-589-2	43	70	1071	975	1007	974	2349	1891
IT99K-1060	44	71	1181	915	1003	807	2192	1730
IT97K-497-2	42	69	1036	921	960	807	1169	1048
IT98K-1079-11	45	74	888	989	955	1225	1795	1605
IT86D-719	44	70	967	894	918	682	1538	1253
IT98K-205-8	42	68	1006	864	911	946	1315	1192
IT97K-494-3	45	70	988	846	893	974	1232	1146
IT97K-1101-5	41	69	1038	810	886	793	1566	1308
IT98K-503-1	41	68	958	844	882	779	1607	1331
DANILA	52	85	922	729	793	1322	2498	2106
IT98K-428-3	42	69	727	643	671	404	1468	1113
ALOKA	44	70	621	496	538	710	852	804
Mean	45	71	1106	995	1032	1053	1907	1622
LSD (5%)	1.4	1.4	254	176.9	144.8	603	192	311.5
Cv	4	2.5	24	27.1	26.2	50	23	29

fodder yield ranged from 404 kg/ha in IT98K-428-3 to 2018 kg/ha in IT97K-1069-5 with a mean of 1053 kg/ha. The highest mean fodder yields were produced by IT97K-1069-6, IT98K-422-2, IT97K-1069-5 and Dan Ila in 2003. The mean fodder yield from the nine environments was 1622 kg/ha, with IT97K-1069-5, IT98K-1069-6, IT98K-1092-1 and IT98K-422-2, as the highest yielding lines.

Diseases

The reactions of the selected cowpea lines to some biotic stresses at the test sites are presented in Table 3. Significant differences existed among the varieties for the different diseases and also significant differences were observed among the different test sites (Table 1). There were also significant locations × variety interactions. Some biotic stresses were important in specific locations. Bacterial blight and *Striga* were more devastating at Toumnia than other locations.

Based on their bacterial blight scores the cowpea lines can be grouped into three classes. Class A are those

Table 3. Mean reaction of cowpea lines to bacterial blight, virus and Striga.

Variety	Bacteria blight		Virus		Strigano/plot
	severity	class	severity	incidence	
IT98K-128-4	1.9	A	0.9	2	47
IT97K-494-3	1.9	A	1.3	12	26
IT97K-1113-7	2.0	A	0.7	0	28
IT97K-1069-5	2.1	A	1.4	20	24
IT98K-131-2	2.2	A	1.4	10	45
IT98K-428-3	2.2	A	1.1	7	2
IT98K-1092-2	2.3	A	1.6	18	46
IT98K-589-2	2.3	A	1.6	15	43
IT97K-1069-6	2.4	A	3.3	50	29
IT97K-568-18	2.4	A	1.6	23	44
IT97K-556-4	2.4	A	0.8	0	14
IT97K-497-2	2.5	B	1.2	7	8
IT98K-1092-1	2.7	B	1.3	8	8
ALOKA	3.1	B	2.7	58	9
IT98K-452-1	3.4	B	1	12	0
IT86D-719	3.4	B	1.1	2	36
IT98K-503-1	3.4	B	1.2	13	1
IT99K-1060	3.5	C	1.4	20	54
IT98K-1079-11	3.7	C	1.2	13	29
IT98K-506-1	3.8	C	1.2	8	13
IT98K-422-2	3.9	C	1.9	28	17
IT98K-205-8	4.6	C	1.8	22	0
DANILA	4.9	C	3.9	72	30
IT98K-205-10	5.0	C	1.9	25	0
IT97K-1101-5	5.1	C	1.1	2	8
Mean	3.1		1.5	17.9	22
LSD (5%)	0.47		0.44	5	24
CV	28.3		30.3	68	90

lines that had a mean bacteria blight score of 2.4 or lower across the nine environments, these lines can be regarded as resistant. These include 11 of the 25 lines tested. Class B, is made up of six lines which had a mean bacterial blight score of 2.5 to 3.4 across the nine environments and can be said to be moderately resistant. Class C is made up of eight lines that had a mean bacterial blight score greater than 3.4 across the test environments, and are classified as susceptible to highly susceptible to the disease. On this basis 44% percent of the varieties tested consisting of 11 lines were resistant to bacteria blight while 24% (six lines) were moderately resistant and 32% (eight lines) were susceptible to the disease across locations. Significant differences were observed among the varieties for virus incidence and severity. Ten varieties (IT97K-1113-7, IT97K-556-4, IT86D-719, IT98K-128-4, IT97K-1101-5, IT98K-428-3, IT97K-497-2, IT98K-131-2, IT98K-1092-1 and IT98K-506-1) exhibited field resistance to virus. They had virus incidence of less than 20% and severity score of less than 2.5. Some of these varieties (IT97K-11069-5, IT98K-589-2, and IT97K-1069-6) were also resistant to bacterial blight. The parasitic weed, *Striga gesnorioides*, was a serious biotic constraint in Toumnia. However, significant differences were observed among the varieties for number of emerged *Striga*. Some varieties (IT98K-452-1, IT98K-205-8, IT98K-205-10, IT98K-503-1 and IT98K-428-3) appeared to be completely resistant to *Striga* having supported no *Striga* emergence in the two years, while some varieties (IT97K-497-2, IT98K-1092-1 and IT971101-5) had low number of emerged *Striga* and may also have low level of resistance.

Table 4 shows the regression analysis of selected parameter on grain yield in the different locations. At Toumnia, virus score and *Striga* count had significant P values (0.01 and 0.05, respectively) while bacterial blight did not show significant value in any of the locations. However bacterial blight showed a negative correlation with grain yield in all the locations except Ibadan, which is in the derived savanna. On the other hand fodder yield and virus score showed significant P values in all location.

Table 4. Regression analysis of grain yield and selected variables in different locations.

Parameter	Coefficients	Standard Error	t- Stat	P-value
Toumnia				
Intercept	882.21851	105.72509	8.34446	0.00000
Fodder yield	0.05673	0.03751	1.51225	0.13265
Bacteria blight	-18.10334	12.16300	-1.48839	0.13882
Virus severity	-86.54143	36.61231	-2.36373	0.01942
Striga emergence	2.16120	1.13951	1.89660	0.05987
Minjibir				
Intercept	1077.33140	164.29264	6.55739	0.00000
Fodderkg	0.16884	0.04877	3.46172	0.00092
Bacteria blight	-22.25958	30.21086	-0.73681	0.46370
Smut	48.67797	53.31358	0.91305	0.36435
Virus severity	-5.49462	2.20392	-2.49311	0.01503
Samaru				
Intercept	290.32883	96.06636	3.02217	0.00296
Fodder yield	1.03241	0.09994	10.32982	0.00000
Bacteria blight	-2.81281	19.45596	-0.14457	0.88525
Ibadan				
Intercept	907.70255	146.33664	6.20284	0.00000
Fodderkg	0.12596	0.04053	3.10762	0.00271
Bacteria blight	10.46649	22.72782	0.46051	0.64655
Virus severity	-106.21644	41.12562	-2.58273	0.01186

DISCUSSION

Many of the improved varieties tested (17 or 68%) produced grain and fodder yields that were significantly higher than those of the local varieties. Cowpea being a high value and nutritious crop with beneficial effects on soil fertility, such high grain and fodder yields are driving increased cultivation of the crop in the dry savannas where rainfall as well as soil fertility are low. The results of this trial have also indicated the importance of testing varieties in many locations in the cowpea improvement programme. Genotype × environment interactions were significant for many of the variables recorded, including yields, showing the importance of multi-location testing of varieties to select those with adaptation to specific areas as well as those with wider adaptations.

Many of the top yielding varieties (IT97K-1113-7, IT97K-1069-6, IT98K-1092-2, IT97K-1069-5, IT98K-131-2 and IT97K-568-18) were also found to have resistance to bacterial blight. IT97K-1069-6 and IT97K-1069-5 that showed resistance to bacterial blight, in this trial are sister lines to IT97K-1069-8 that was reported by Singh et al. (2002) to have combine resistance to bacteria blight, Septoria leaf spot and scab. These varieties produced significantly higher grain yields than the local varieties, Dan Ila and Aloka, which were found to be susceptible to these pathogens. IT97K-1069-5 and its sister lines IT97K-1069-6 and IT97K-1069-8, can play an important role in integrated management of cowpea diseases. These varieties should be used as parent lines for improvement of local as well as other improved varieties in Nigeria and Niger Republic, or where they already posses the seed characteristics demanded by the market as in countries East Africa they can be evaluated for released directly to the farmers for cultivation.

Compared to the other locations, bacterial blight was a more serious problem in Toumnia and this was reflected in its high negative correlation with grain yield. The varieties tested in this trial, with exception of the checks, were selected based on previous rating of resistance/tolerance to bacterial blight and this may have account for the relatively non-significant P values of the regression with yield. But the importance of other stresses (virus and *Striga*) shows the importance of breeding for combined resistance to the stresses. Fodder yield is also important and varieties which high fodder yields are not only desirable by farmers but are also likely to produce high grain yield as shown by the significant positive correlation of grain and fodder yields. The cowpea breeding programme based in IITA must therefore continue to evaluate improved lines across the different agro-ecological zones to be able to select varieties with wide adaptations and combined resistance to the common abiotic and biotic stress factors.

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