

RELATIONSHIP BETWEEN YIELD AND SOME YIELD COMPONENTS IN COWPEA VARIETIES INFECTED WITH TWO COWPEA POTYVIRUSES

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ABSTRACT

Bean common mosaic virus –blackeye cowpea strain (BCMV-BIC) and cowpea aphid-borne mosaic virus (CABMV) belonging to the genus *potyvirus* are cosmopolitan and economically important pathogens of cowpea. This study analysed the linear relationship between yield and some yield related characters (numbers of pods per plant, number of seeds per pod, pod growth rate, etc) in 15 cowpea lines infected with BCMV-BIC and CABMV. Isolates of the viruses were mechanically inoculated into the cowpea lines; as a result of the effect of viruses, the cowpea lines were categorized as highly resistant, tolerant, susceptible and highly susceptible. The linear associations between yield and other characters in resistant and tolerant varieties were similar to the associations in susceptible and highly susceptible varieties. The similarity in the correlation coefficient regardless of the susceptibility status was caused by systemic spread of infections in susceptible cowpea varieties such that organs were uniformly reduced while there was minimal reduction in tolerant and no reduction in highly resistant varieties. Pod growth rate correlated ($p > 0.05$) positively and highly with the yield in seven susceptible varieties and in 5 of the 8 resistant varieties infected by CABMV and BCMV-BIC and the relationship between disease severity and yield showed that as disease severity increased cowpea yield decreased. BCMV-BIC reduced the seed yield between 62 to 87% and CABMV between 54 to 87% in some cowpea varieties.

KEYWORDS: Cowpea, *potyvirus*, virus infection, correlation, plant disease.

INTRODUCTION

Cowpeas (*Vigna unguiculata* (L) Walp.) are legume crop grown in the tropics and the sub-tropics of Africa, Central and South America, Asia, Europe and USA. They are an important means of livelihood for millions of relatively poor people in these regions because many rural families obtain food, feeds for their animals, income and other benefits such as manure through the cultivation of the crop. The world production of cowpea is about 2.7 million tonnes annually from about 12.5 million hectares of land (Quin, 1997). The value of cowpea lies in its high protein content (15 – 26%); it also contains carbohydrates, minerals and other important food components (Umoren, 1997).

Some of the major constraints to the production of cowpea are the infections caused by the cowpea aphid – borne mosaic virus (CABMV) and bean common mosaic virus – blackeye cowpea strain (BCMV-BIC) (also known as Blackeye cowpea mosaic virus (BICMV)). Both viruses belong to the *potyvirus* group; these are flexible filamentous viruses measuring about 750 nm in length. Both CABMV and BCMV-BIC are found worldwide, they cause severe loss of the cowpea crop; for example, Anderson *et al.* (1996) reported that BCMV-BIC caused as much as 82% reduction in total foliar fresh weight in some cultivars in USA while Kaiser and Mossahebi (1975) observed 87% yield reduction in Iran caused by CABMV infection. Both viruses are spread in three ways; (1) by several aphid species including *Aphis craccivora*, (2) through the sap and (3) through the seeds (Aboul Ata *et al.* 1982; Taiwo *et al.* 1982; Mali *et al.* 1983). Because the viruses can be transmitted through the seeds, infections may appear in areas where there were none previously if infected seed-lots are introduced into the areas.

Apart from the similarity in the geographical distribution and modes of transmission, BCMV-BIC and CABMV produce similar symptoms in their plant hosts range; the common symptoms they incite in cowpeas are mosaic patterns and mottling on the leaves, poor pod formation and defoliation. The viruses were misidentified as the same virus because of these similarities in symptoms expressions, separation of the viruses into two distinct serogroups was

successfully demonstrated by Taiwo *et al.* (1982) and Huguenot *et al.* (1993); who showed the dissimilarity through serological studies and digestion of the protein coat respectively. Taiwo *et al.* (1982) further showed that typical symptoms of CABMV consist of vein chlorosis, interveinal clearing, and dark green banding while those of BCMV-BIC were reddish lesions, yellowish mosaic patterns and vein necrosis.

The yield in crop plants can be improved by combining traits that contribute to the physiological efficiency and enhance the economic yield of the crop. Many studies have described virus infections in plant in terms of disease expression on the leaves and the effects on other organs but to better understand the virulence of the virus infections on certain plant characters, the association between infected characters should be examined. The objective of this study was to analyse the inter-relationship between yield and some yield related characters in cowpea lines infected by BCMV-BIC and CABMV.

MATERIALS AND METHODS

Isolates of CABMV and BCMV-BIC were obtained from the Virology unit, International Institute of Tropical Agriculture (IITA), Ibadan, and then were maintained in a plant culture (Ife brown variety) in the screen house. The 15 cowpea lines; Ife Brown, IT82D-716, IT82D-889, IT83D-442, IT84S-2246-4, IT86D-371, IT86D-880, IT90K-284-2, IT96D-774, CP-VAR8, TVu-11426, TVu-1190, TVu-12349, TVu-13686, TVu-66, were obtained from the Genetic Resource Unit (GRU), IITA, Ibadan.

The 15 varieties were planted in the field laid out in a split plot design with 3 replicates; the viruses (including the control) were the main-plot and the varieties were the sub-plot treatments. The size of each plot (containing a variety) was 10 x 1 m, a block contained each of the 15 cowpea lines, and was 1.5 m from the adjoining block. The plot was weeded twice; at the third and eighth weeks after planting and insects were controlled with Karate fortnightly.

The viruses were mechanically inoculated into the 15 lines; virus inoculum was prepared by grinding leaves infected with either BCMV-BIC or CABMV isolate into crude sap extract in about 10 drops of inoculation buffer; made of 1 g K₂HPO₄, 1 g KH₂PO₄, 0.1 g NaSO₃ in 100 ml distilled water at pH 7.5 (Walkey, 1985). The infected leaves were obtained from the plant culture (Ife brown) maintained in the screen house. Carborundum powder (600 mesh) was sprinkled on the leaves of the cowpea lines and the infected sap extract gently rubbed into two (2) leaves of each plant at the emergence of the first trifoliate leaf (5 – 8 days after planting); 20 plants were inoculated per plot. Excess inoculum was rinsed off with distilled water. Disease severity on each plant was scored visually using a 5 points scale used by Thottappilly *et al.* (1994).

- 1 Disease symptoms were not visible on the plants and enzyme linked immunosorbent assay (ELISA) serological test was negative.
- 2 Disease symptoms were not visible on the plants but ELISA result was positive or less than 11% of the plants per plot showed virus symptoms.
- 3 Disease symptoms appeared on 11 – 30% of the plants per plot.
- 4 Disease symptoms appeared on 31 – 60% of the plants per plot.
- 5 Disease symptoms appeared on more than 60% of the plants per plot.

Varieties whose disease severity was scored 2 or 3 were regarded as tolerant because the infection severity was moderate. The disease severity index (DSI) was the average disease severity of 10 plants per variety and the incidence of infection was the proportion of infected plants in the plot. The response of the variety to infection was based on disease severity index (DSI) and incidence of infection.

Variables measured were number of days from planting to 50% flowering, number of pods per plant, number of peduncles per plant, number of seeds per pod, pod growth rate (PGR) and the yield. The pod growth rate (Kg per ha per day) was calculated as suggested by Marfo *et al.* (1997); PGR = Seeds yield/reproductive duration; the reproductive duration is the number of days from flowering to maturity. The yield was calculated by dividing the dried seed weight from each sub-plot (grams per 10 m²) by 100 to obtain the weight in Kg per ha.

Comparison of the means was done with least square means (LSMeans) using the pair-wise differences (pdiff) of the means option and the correlation coefficients were computed with statistical analysis system (SAS), version 6.1 (SAS, 1995)

RESULTS

Table 1 shows the response of cowpea varieties to CABMV and BCMV-BIC infections and the disease severity index (DSI) of the viruses on the varieties. Seven varieties (Ife brown, IT82D-716, IT84S-2246-4, IT96D-774, CP-VAR8, TVu-13686 and TVu-66) were susceptible or highly susceptible to CABMV and BCMV-BIC and 8 varieties were moderately resistant to highly resistant to CABMV. IT82D-889, IT83D-442, IT86D-371 and TVu-11426 were tolerant to BCMV-BIC while, IT83D-442, IT86D-371, TVu-11426, TVu-1190, TVu-12349 and TVu-13686 were tolerant to CABMV infections. Two varieties (IT90K-284-2 and IT86D-880) were highly resistant to BCMV-BIC and 3 varieties were highly resistant to CABMV.

The correlation coefficients shown on Table 2 are the linear relationships between the seed yield and the other plant characters (number of days from planting to 50% flowering; number of pods per plant; pod growth rate etc.) of susceptible and highly susceptible varieties; while Table 3 shows the linear correlation coefficients of the tolerant and highly resistant varieties. The pod growth rate correlated ($p > 0.05$) positively and highly with the seed yield in all the varieties infected with

Table 1. COWPEA RESPONSE, DISEASE INCIDENCE AND INDEX TO BCMV-BIC AND CABMV INFECTION

VARIETY	BCMV – BIC			CABMV		
	RESPONSE	INCIDENCE (%)	DSI	RESPONSE	INCIDENCE (%)	DSI
IFE BROWN	Highly suscep.	100	4.3	Suscep.	100	4.0
IT82D-716	Suscep.	100	2.9	Suscep.	60	3.0
IT82D-889	Tolerant	20.6	1.4	Highly Resist.	0	1.0
IT83D-442	Tolerant	30.8	2.2	Tolerant	30	2.5
IT84S-2246-4	Highly suscep.	100	4.1	Suscep.	90	3.2
IT86D-371	Tolerant	12.5	1.1	Tolerant	18.3	1.2
IT86D-880	Highly Resist.	0.0	1.1	Highly Resist.	0	1.0
IT90K-284-2	Highly Resist.	0.0	1.0	Highly Resist.	0	1.0
IT96D-774	highly suscep.	93.3	4.0	Highly suscep.	100	4.6
CP-VAR8	Suscep.	71.4	3.3	Suscep.	73.3	2.9
TVu-11426	Tolerant	36.6	1.1	Tolerant	20.0	1.2
TVu-1190	Suscep.	100	3.8	Tolerant	11.1	2.7
TVu-12349	Suscep.	61.5	3.6	Tolerant	29.3	2.4
TVu-13686	Suscep.	90.9	3.5	Tolerant	12.0	1.2
TVu-66	Suscep.	100	3.4	Suscep.	100	3.0

Key: DSI = disease severity index; suscep. = susceptible; Resist. = Resistant

Table 2. LINEAR CORRELATION CO-EFFICIENTS OF YIELD AND YIELD RELATED CHARACTERS IN SUSCEP. AND HIGHLY SUSCEP. COWPEA VARIETIES INFECTED WITH BCMV-BIC AND CABMV.

VARIETY	CHARACTERS					
	DAYF	P/PLT	NPFD	SD/POD	PGR	YIELD
IFE BROWN						
DAYF	-	0.045	0.068	0.049	0.509	0.494
P/PLT	-0.01	-	0.362**	0.509**	-0.065	-0.065
NPFD	0.119	0.635**	-	0.493**	-0.155	-0.163
SD/POD	0.056	-0.208	-0.075	-	0.049	0.045
PGR	0.052	-0.01	-0.182	0.436	-	0.999**
YIELD	0.53	-0.04	-0.207	0.417	0.998**	-
ITR2D-716						
DAYF	-	-0.113	0.075	0.015	-0.418	-0.411
P/PLT	0.085	-	0.266	0.223	0.071	0.064
NPFD	0.075	0.364**	-	0.216	-0.453	-0.45
SD/POD	0.003	-0.057	0.172	-	0.524	0.523
PGR	0.568	0.199	0.389	0.414	-	0.991**
YIELD	0.559	0.182	0.381	0.414	0.999**	-
ITR4S-2246-4						
DAYF	-	-0.061	0.006	0.026	-0.174	-0.14
P/PLT	-0.087	-	0.475**	0.297	-0.312	-0.344
NPFD	-0.187	0.822**	-	0.204	-0.012	-0.029
SD/POD	-0.138	-	-0.445**	-	0.588	0.585
PGR	0.462	-0.410	-0.501	0.602	-	0.998**
YIELD	0.438	-0.393	-0.452	0.576	0.991**	-
IT96D-774						
DAYF	-	-0.051	0.159	0.073	0.221	0.493
P/PLT	-0.297	-	0.209	0.091	0.634	-0.145
NPFD	-0.175	0.548**	-	0.385**	0.296	0.448
SD/POD	0.114	-0.277	-0.134	-	-0.140	0.183
PGR	-	0.056	0.539	0.04	-	0.993**
YIELD	-	0.104	0.562	0.05	0.997**	-
CP-VARR						
DAYF	-	0.045	0.160	0.081	-0.880	-0.871
P/PLT	-0.022	-	0.516**	0.523**	-0.332	-0.313
NPFD	-0.255	0.272	-	0.121	-0.062	-0.081
SD/POD	-0.151	0.35	0.042	-	0.080	0.132
PGR	-0.686	0.209	-0.285	0.214	-	0.998**
YIELD	-0.674	0.182	-0.310	0.224	0.999**	-
TVU-13686						
DAYF	-	-0.279	0.212	0.295	0.172	0.171
P/PLT	-	-	0.391**	0.086	0.689	0.689
NPFD	-	0.551**	-	0.218	0.4189	0.419
SD/POD	0.310	-0.135	-0.159	-	0.809	0.810
PGR	0.031	0.217	0.495	0.342	-	1.00**
YIELD	0.032	0.217	0.495	0.342	1.00**	-
TVU66						
DAYF	-	0.137	0.258	-0.203	-0.492	-0.325
P/PLT	-0.251	-	0.281	0.10	-0.410	-0.011
NPFD	-0.182	0.505**	-	0.130	0.574	0.538
SD/POD	0.201	-0.194	-0.086	-	0.600	0.368
PGR	0.219	0.367	0.891	0.647	-	0.913
YIELD	-0.087	0.588	0.847	0.24	0.886	-

Key: * and ** significant at 5% and 1% levels respectively. Above diagonal data show r values of varieties infected with BCMV-BIC, below diagonal data are those infected with CABMV. DAYF = Days from planting to 50% planting, P/PLT = number of pods per plant, NPFD = number of peduncles per plant, SD/POD = number of seeds per pod, PGR = pod growth rate.

Table 3. LINEAR CORRELATION CO-EFFICIENTS OF YIELD AND YIELD RELATED CHARACTERS IN TOLERANT AND RESISTANT COWPEA VARIETIES INFECTED WITH BCMV-BIC AND CABMV.

VARIETY	CHARACTERS					
	DAYF	P/PLT	NPED	SD/POD	PGR	YIELD
ITR27N.889						
DAYF	-	0.071	0.078	0.074	0.365	0.365
P/PLT	-0.29	-	0.659**	0.159	0.289	0.312
NPFD	0.098	0.565**	-	0.002	-0.642	-0.648
SD/POD	-0.119	0.092	-0.239	-	0.227	0.200
PGR	0.236	0.717	0.958**	0.849	-	0.998**
YIELD	0.189	0.728	0.959**	0.855	0.999**	-
ITR37N.442						
DAYF	-	-	-0.271	0.091	0.501	0.069
P/PLT	0.035	-	0.651*	0.122	-0.355	-0.235
NPFD	-	0.549	-	0.117	-0.441	-0.540
SD/POD	0.16	0.235	0.008	-	0.759	0.761
PGR	-0.655	0.662	0.643	0.016	-	0.891
YIELD	-0.488	-0.449	0.179	-0.174	-0.652	-
ITR67N.371						
DAYF	-	-0.052	-0.281	0.069	0.610	0.61
P/PLT	-0.167	-	0.814**	0.011	0.188	0.198
NPFD	-0.108	0.517**	-	0.061	0.569	0.523
SD/POD	-0.068	0.094	-0.072	-	0.357	0.416
PGR	-	0.149	-0.552	0.952**	-	0.995**
YIELD	-	0.172	-0.49	0.929**	0.996*	-
ITR67N.880						
DAYF	-	0.190	0.079	-0.341**	0.479	0.440
P/PLT	-0.186	-	0.709**	0.163	0.808	0.791
NPFD	-0.211	0.79**	-	0.036	0.69	0.68
SD/POD	-0.156	0.207	0.716	-	0.224	0.201
PGR	-0.038	-0.333	-0.194	0.119	-	0.999**
YIELD	-0.015	-0.326	-0.212	0.113	0.998**	-
IT90K.284.2						
DAYF	-	-0.152	0.179	-0.012	-0.008	-0.02
P/PLT	0.184	-	0.524**	0.302	0.525	0.522
NPFD	0.114	0.750	-	0.163	0.878	0.888
SD/POD	0.047	0.280	0.272	-	0.104	0.107
PGR	0.024	0.023	0.492	0.195	-	0.999**
YIELD	0.025	0.07	0.476	0.188	0.998**	-
TVL.11426						
DAYF	-	0.08	0.188	0.336**	0.832*	0.289
P/PLT	0.413**	-	0.479**	0.089	-0.788	-0.343
NPFD	-	0.651**	-	0.220	-0.385	-0.350
SD/POD	0.408**	-0.169	-0.149	-	0.264	0.595
PGR	0.840	-0.464	-0.103	0.207	-	0.686
YIELD	0.338	-0.582	0.06	0.196	0.78**	-
TVL.1190						
DAYF	-	-0.304	-0.086	-0.011	-0.616	-0.511
P/PLT	-0.224	-	0.475**	0.289	-0.069	-0.006
NPFD	-0.115	0.673**	-	0.436**	0.255	0.304
SD/POD	0.091	-0.122	0.063	-	0.031	0.174
PGR	-	0.194	0.218	0.609	-	0.978**
YIELD	-	0.150	0.123	0.641	0.987**	-
TVL.12320						
DAYF	-	-	-0.535**	0.506	0.544	0.434
P/PLT	-	-	0.410**	0.291	-0.416	-0.474
NPFD	-	0.758**	-	0.373**	-0.508	-0.507
SD/POD	0.379**	-	-0.408**	-	0.384	0.408
PGR	-0.336	0.396	0.319	0.439	-	0.975**
YIELD	-0.245	0.567	0.556	0.016	0.148	-

Key: * and ** significant at 5% and 1% levels respectively. Above diagonal data show r values of varieties infected with BCMV-BIC, below diagonal data are those infected with CABMV. DAYF = Days from planting to 50% planting, P/PLT = number of pods per plant, NPED = number of peduncles per plant, SD/POD = number of seeds per pod, PGR = pod growth r

BCMV-BIC but two tolerant (IT83D-442 and TVu-11426) and one susceptible variety (TVu-12349). Also, the number of pods per plant correlated ($p > 0.05$) positively with the number of peduncles per plant in 7 varieties infected by CABMV and 6 varieties infected by BCMV-BIC among the susceptible and highly susceptible varieties. Similar trend was observed in the linear correlation between the number of pods per plant and the number of peduncles per plant in the tolerant and resistant varieties infected by both viruses. The number of pods per plant correlated ($p > 0.05$) with number of seeds per plant in 6 varieties infected with CABMV and 8 varieties infected with BCMV-BIC.

The percentage reductions in yield and yield related characters as consequence of infections caused by BCMV-BIC and CABMV are shown in Table 4. BCMV-BIC significantly ($p > 0.05$) reduced yield and other characters in more varieties of cowpea than CABMV. BCMV-BIC reduced the yield in the susceptible varieties ranging from 62 to 87% and CABMV reduced the yield in 8 varieties between 54 to 87%. There was no significant difference ($p < 0.05$) between BCMV-BIC and CABMV in their effects on the number of days from planting to 50% flowering. There was no difference ($p < 0.05$) in the response of the seed yield and other characters in the highly resistant varieties (IT82D-889, IT86D-880 and IT90K-284-2).

Table 4. REDUCTION (%) IN YIELD AND YIELD RELATED CHARACTERS IN COWPEA VARIETIES INFECTED WITH BCMV-BIC AND CABMV.

VARIETY	DYS TO FL		PODS/PLT		PED/PLANT		SEEDS/POD		P G R		YIELD	
	BCM V	CAB M	BCM V	CAB M	BCM V	CAB M	BCM V	CAB M	BCM V	CAB M	BCM V	CAB M
IFE BROWN	1.4 ^a	0.1 ^a	69.1 ^b	33.0 ^a	32.8 ^b	7.2 ^a	46.2 ^b	18.7 ^a	71.2 ^a	71.6 ^a	76.8 ^a	75.4 ^a
IT82D-716	0.5 ^a	0.5 ^a	32.9 ^b	25.3 ^a	16.6 ^b	10.3 ^a	24.6 ^b	7.7 ^a	75.5 ^a	78.5 ^a	78.7 ^a	80.1 ^a
IT82D-889	0.1 ^a	0.3 ^a	10.1 ^a	7.2 ^a	14.3 ^b	1.3 ^a	12.2 ^a	11.2 ^a	8.6 ^a	8.7 ^a	8.6 ^a	6.5 ^a
IT83D-442	0.0 ^a	0.6 ^a	38.5 ^b	24.5 ^a	11.8 ^b	18.0 ^a	16.1 ^b	5.1 ^a	73.5 ^a	86.3 ^a	73.1 ^a	83.5 ^a
IT84S-2246-4	0.7 ^a	0.3 ^a	58.7 ^b	23.3 ^a	41.2 ^b	14.6 ^a	13.4 ^a	9.5 ^a	73.6 ^a	76.3 ^a	77.8 ^a	77.7 ^a
IT86D-371	0.8 ^a	1.5 ^a	23.7 ^b	1.8 ^a	18.2 ^b	+2.0 ^a	12.2 ^a	13.4 ^a	87.5 ^a	87.3 ^a	87.7 ^a	87.7 ^a
IT86D-880	3.2 ^a	4.0 ^a	20.2 ^b	1.8 ^a	11.9 ^a	11.56 ^a	6.9 ^a	0.7 ^a	9.6 ^a	+3.7 ^a	11.2 ^a	2.1 ^a
IT90K-284-2	0.6 ^a	2.3 ^a	4.4 ^a	6.8 ^a	0.7 ^a	5.5 ^a	8.0 ^a	2.3 ^a	+1.0 ^a	+2.2 ^a	0.0 ^a	0.3 ^a
IT96D-774	1.4 ^a	1.5 ^a	56.2 ^b	21.3 ^a	22.3 ^b	1.5 ^a	27.1 ^a	23.1 ^a	84.4 ^a	80.3 ^a	84.9 ^a	81.7 ^a
CP-VAR8	0.5 ^a	1.6 ^a	22.5 ^b	1.6 ^a	6.8	+3.3 ^a	25.8 ^b	9.0 ^a	63.1 ^a	55.8 ^a	62.6 ^a	54.8 ^a
TVu-11426	2.1 ^a	2.6 ^a	5.8 ^a	5.8 ^a	4.4 ^a	3.5 ^a	17.0 ^b	7.9 ^a	5.0 ^a	3.0 ^a	10.4 ^a	10.6 ^a
TVu-1190	0.1 ^a	0.7 ^a	66.4 ^b	30.9 ^a	43.8 ^b	17.1 ^a	32.7 ^b	21.5 ^a	86.0 ^a	78.9 ^a	86.9 ^a	78.9 ^a
TVu-12349	1.7 ^a	0.8 ^a	29.9 ^b	17.6 ^a	11.2 ^b	4.4 ^a	9.1 ^a	9.1 ^a	62.2 ^b	34.1 ^a	67.2 ^b	30.9 ^a
TVu-13686	2.8 ^a	1.7 ^a	54.6 ^b	17.7 ^a	34.9 ^b	2.0 ^a	16.5 ^b	6.3 ^a	69.0 ^b	10.2 ^a	72.8 ^b	20.2 ^a
TVu-66	2.7 ^a	4.5 ^a	62.8 ^b	26.2 ^a	30.1 ^b	8.3 ^a	35.5 ^b	14.1 ^a	79.5 ^b	10.3 ^a	81.4 ^b	12.4 ^a

Key: ^a Pairs of numbers with the same letters across the rows are not significantly different at 5% probability (LSMean)

Figure 1 illustrates the relationship between seed yield in cowpea and severity of disease, yield declined as CABMV and BCMV – BIC infection severity increased.

DISCUSSION

Bean common mosaic virus – blackeye cowpea strain (BCMV-BIC) and cowpea aphid-borne mosaic virus (CABMV) are important pathogens of cowpea in Africa and other cowpea growing areas of the world. Anderson *et al.* (1996), Kaiser and Mossahebi (1975) and others had earlier reported that while these viruses cause stunting, reduction in yield and death of susceptible varieties, they incited little or no symptom in tolerant and resistant varieties. Therefore, the variations in the performance of cowpea genotypes infected with BCMV-BIC and CABMV necessitated a study of the association between yield and some yield components in order to elucidate the response of the varieties to virus infections in terms of the resistance or susceptibility level.

The pod growth rate associated positively ($p > 0.05$) with the yield in 7 susceptible, 4 tolerant and 3 resistant varieties, indicating that selection of the varieties for fast pod growth rate will meet corresponding selection for high yield. The association between the yield and the yield components did not respond to the severity of viral infection in the cowpea varieties. The correlation pattern in the resistant varieties (IT90K-284-2, IT82D-889 and IT86D-880) was similar to the pattern in the varieties susceptible or highly susceptible to BCMV-BIC and CABMV. Anderson *et al.* (1996) had observed that symptoms expression in BICMV (BCMV-BIC) did not correlate with the level of virus accumulation. The similarity in the correlation coefficient irrespective of the susceptibility status is due to the systemic spread of the viral particles in cowpea into all the organs, this is inferred from the fact that only two leaves per plant were inoculated with the sap extract infected with the viruses. Systemic spread of viruses' infection in cowpea is supported by Ittiah (2004). It therefore means that the tissues and organs in susceptible lines, such as pods,

leaves etc. were evenly reduced by disease whereas the viruses did not multiply in the resistant varieties, as such did not incite infection in them.

SUMMARY AND CONCLUSION

Two very important pathogens of cowpea, BCMV-BIC and CABMV were inoculated into 15 varieties of cowpea. The aim of the experiment was to determine the linear relationship between the yield and other yield components, also to study the inter-relationship among the traits.

Depending on the incidence of infection and severity of the disease expression, the 15 varieties were highly

resistant, tolerant, susceptible and highly susceptible. The linear relationship analysis showed that the pod growth rate correlated ($p > 0.05$) positively and highly with seed yield, which implies that selection for fast pod growth rate will result in selection for high yield in cowpea, similar result was observed between number of peduncles per plant and the number of pods per plant. However, the disease severity related negatively with the yield which should result in contrary expectation if lines with high disease severity are selected.

The linear relationship between yield and other characters was similar irrespective of the severity of the infection; this is the consequence of systemic spread of viral disease in cowpea.

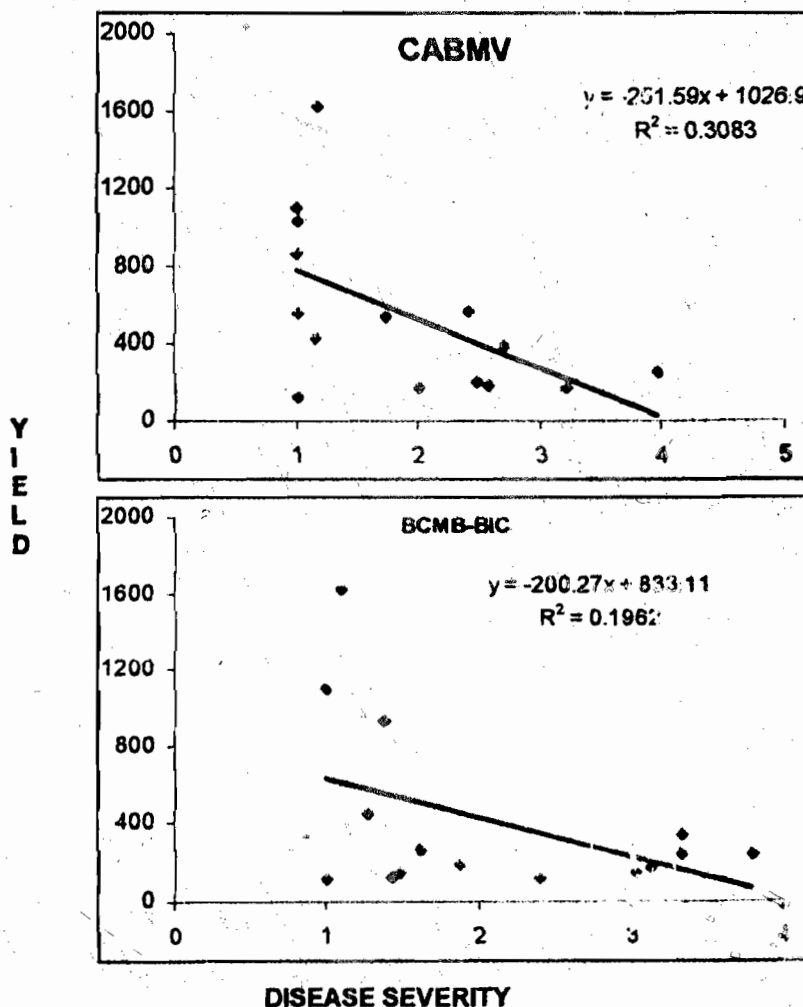


FIGURE 1. RELATIONSHIP BETWEEN COWPEA YIELD AND DISEASE SEVERITY

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