African Crop Science Journal
AFRICAN CROP SCIENCE SOCIETY
ISSN: 1021-9730 EISSN: 2072-6589
VOL. 7, NUM. 1, 1999, PP. 71-79

African Crop Science Journal,
Vol. 7 No. 1 1999 pp.71-79

Evaluation Of Pigeonpea Pod Borer And Pod Fly Tolerant Lines At Kabete And Kiboko In Kenya

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(Received 14 May, 1998; accepted 2 February, 1999)

Code Number: CS99007

ABSTRACT

Pigeonpea lines which have shown tolerance to pod borer and pod fly damage at ICRISAT, Patancheru, India, were tested in the field at Kabete and Kiboko, Kenya, and compared with five local checks. There were sprayed and unsprayed plots for each line. Endosulfan 35 E.C. was applied at 0.07% active ingredient (a.i.) starting at flower bud expansion stage, at 50% flowering, early podding, and full podding stages. At crop maturity, all pods from three plants plot^{-1} were sampled and seed damage by different insect pests determined. The results showed that seeds from all lines were damaged by pod borers and pod sucking bugs. Pod fly incidence was greater at Kabete than at Kiboko, and damage was lower on test lines than on checks. Spraying reduced seed damage from 57.6% to 9.3% and from 59.9% to 4.5% on pod borer lines and pod fly lines, respectively, at Kiboko, and from 19.9% to 5.4% on pod fly lines at Kabete. At Kiboko seed damage in unsprayed pod borer (57.6%) and pod fly (59.9%) lines was similar. Seed damage on pod fly lines at Kiboko (59.9%) was significantly higher than at Kabete (19.9%). Positive significant correlations were observed between seed mass and pod fly damage at Kabete (r = 0.31*) and Kiboko (r = 0.30*). The results indicated that although some lines showed tolerance to pod borer and pod fly damage, they were highly susceptible to pod sucking bugs, suggesting that such tolerance does not hold against other insect groups.

Key Words: Grain yield, insect pests, pod borer lines, pod fly lines, seed damage, tolerance

RÉSUMÉ

Des lignées de pois d=Angole qui se sont montrées tolérantes aux foreurs des gousses et aux mouches des gousses à l=ICRISAT-Patancheru, en Inde, ont fait l=objet des essais à Kabete et à Kiboko au Kenya et ont été mises en comparaison avec cinq témoins locaux. Pour chaque lignée, il y a eu des parcelles pulvérisées et non pulvérisées. On a appliqué l=endosulfan 35 E.C. à 0,07% de matière active d=abord à l=étape d=expansion des bourgeons florales, ensuite à 50% de floraison, au début et à la fin de la formation des gousses. Au stade de maturation, toutes les gousses prélevées sur trois pieds par parcelle ont été mises à l=échantillonnage afin de déterminer les dégâts causés aux grains par des insectes ravageurs différents. Les résultats ont révélé que les grains de toutes les lignées ont été atteints par des foreurs des gousses et des punaises suceuses de gousse. L=incidence des mouches des gousses a été plus élevée à Kabete qu=à Kiboko. Les dégâts dus aux mouches des gousses ont été plus faibles sur les lignées d=essais que sur les témoins. La pulvérisation a permis de réduire les dégâts aux grains de 57,6% à 9,3% chez des lignées tolérantes aux foreurs des gousses et de 59,9% à 4,5% chez des lignées tolérantes aux mouches des gousses à Kiboko. A Kabete, la pulvérisation a réduit les dégâts de 19,9% à 5,4% chez des lignées tolérantes aux mouches des gousses. A Kiboko, les dégâts aux grains chez des lignées non pulvérisées tolérantes aux foreurs des gousses (57,6%) et aux mouches des gousses (59,9%) ont été similaires. Les dégâts chez des lignées tolérantes aux mouches des gousses ont été significativement plus élevés à Kiboko (59,9%) qu=à Kabete (19,9%). Des correlations significatives positives ont été observées entre le poids des grains et les dégâts dus aux mouches des gousses à Kabete (r = 0,31*) et à Kiboko (r = 0,30*). Les résultats ont indiqué que certaines lignées se sont montrées tolérantes aux dégâts dus aux foreurs des gousses et aux mouches des gousses. Cependant, elles ont été très sensibles aux punaises suceuses de gousse, ce qui laisse suggérer que de telle tolérance ne pourrait pas résussir contre d=autres groupes d=insectes.

Mots Clés: Rendement en grain, insectes ravageurs, lignées tolérantes aux foreurs des gousses, lignées tolérantes aux mouches des gousses, dégâts aux grains, tolérance

INTRODUCTION

Insect pests are a major biotic constraint limiting pigeonpea (*Cajanus cajan* (L.) Millsp) production in southern and eastern Africa (Minja, 1997). More than 90 insect species attack pigeonpea in the region (Le Pelley, 1959; Lateef and Reed, 1990; Minja, 1997). Among the insect pests, the pod boring Lepidoptera (*Helicoverpa armigera* Hübner, *Maruca vitrata* (*testulalis)* Geyer, *Etiella zinkenella* Treitschke), pod sucking bugs (mainly *Clavigralla tomentosicollis* Stål) and pod fly (*Melanagromyza chalcosoma* Spencer) are widespread and common on the crop in the four main pigeonpea producing countries in the region, i.e., Kenya, Malawi, Tanzania, and Uganda (Minja *et al*., 1996; Minja, 1997).

Other than in Kenya, farmers do not use synthetic chemicals for pest management in pigeonpea. Growing resistant/tolerant plant genotypes is one of the most effective methods of managing pests and it is compatible with other management methods including cultural, biological, and chemical methods. Indeed, host-plant resistance is one of the most important and widely used components in integrated pest management. Pest resistant/tolerant genotypes, when available, provide a sustainable solution at relatively low cost to a wide variety of farmers (Ukwungwu, 1990; Shanower *et al.*, 1998). Host-plant resistance has significant advantages over other pest control strategies in situations where: an insect is exposed for only a brief period of its life cycle; the crop is of low economic value; the pest is continuously present and is the single most limiting factor in successful cultivation of a crop in a wide area; other controls are not available (Ortman and Peters, 1980). These four conditions apply to some of the pests on pigeonpea throughout much of their range in the region.

The availability of pigeonpea genotypes which are tolerant, or resistant to insect pests would be of particular importance to most farmers in southern and eastern Africa because the crop is grown mainly by farmers with limited resources and under unpredictable climatic conditions. Such farmers would not be able to provide inputs like conventional pesticides. The crop improvement programme at ICRISAT Asia Centre has been searching not only for resistance to pests and diseases but also for the ability of pigeonpea to compensate for early pod/seed losses and for high-yielding plants that will flower and mature when pest populations are low (Reed *et al.*, 1980). Pigeonpea lines which express some degree of tolerance to either pod borers or pod fly damage have been identified at ICRISAT. For example, the determinate types, in which pods are produced in bunches at the ends of the branches were found to suffer greater losses than the indeterminate types on which the pods are well spaced along the branches (Lateef and Reed, 1981).

Pod damage, or loss can greatly reduce crop yield. Thus, the pod- and seed-damaging insects are the most important pests on this crop. The ability of some pigeonpea genotypes to compensate for early pod/seed loss is substantial, provided soil fertility, moisture and climate remain favourable (Reed and Lateef, 1990). There is evidence that some genotypes perform as well in pesticide-free as in fully protected conditions (Reed and Lateef, 1990) but there are no records of genotypes which are not attacked by either pod borers, or pod fly, not even in the wild relatives of pigeonpea (Reed *et al*., 1980). Since pod borers and pod fly are among the economic insect pests causing major yield losses on pigeonpea in southern and eastern Africa, there is need to identify genotypes tolerant to these pests. The main objective of the study was, therefore, to evaluate pigeonpea lines identified by ICRISAT to have some degree of tolerance to pod borers (in particular *H. armigera*, *M. vitrata*, and *E. zinkenella*) and pod fly (*M. chalcosoma)* under local conditions in the region.

MATERIALS AND METHODS

The trials were conducted at Kiboko, which is in Eastern Province of Kenya, 160 km from Nairobi. The altitude for Kiboko is 940 metres above sea level. The second site was at Kabete campus farm (1825 metres above sea level), University of Nairobi, Kenya. At Kiboko, seven pod borer (PPE 45-2, ICPL 332, ICP 3615-E1, ICP 1811-E1, ICP 8094-2-S2, ICP 84060, MPG 537) and six pod fly tolerant lines (ICP 7946-E-EB, ICP 7176-5, ICP 10531-E3-9EB, ICP 7194-1-S4, ICP 8102-5-S1, ICP 1691-E1-5EB) were compared with six local checks (ICP 6927, ICEAP 00068, ICEAP 00777, ICEAP 00540, ICEAP 00020, ICPL 87091) in two separate experiments (one for pod borers and the other for pod fly) in the 1994/95 and 1995/96 cropping seasons. At Kabete, where pod fly is more important than pod borers, only pod fly tolerant lines were planted in 1994/95 and 1995/96 cropping seasons. Six pod fly tolerant lines (ICP 7646-E-EB, ICP 7176-5, ICP 10531-E3-9EB, ICP 7194-1-S4, ICP 8102-5-S1, ICP 1691-E1-5EB) were compared with six local checks (ICP 6927, ICEAP 00540, ICEAP 00068, ICEAP 00777, ICEAP 00020, ICPL 87091). Single lines were planted in plots each of 5 x 3 m in randomised complete blocks replicated three times. Plot size was determined by the available seed material. Two sets were grown separately under spray and no spray situations. Sprayed blocks were separated from unsprayed by planting six rows of maize at 0.8 x 0.3 m. Pigeonpea spacings varied according to the length of growing period (Table 1). All plots were weeded by hand hoeing, and supplementary irrigation was given when needed.

TABLE 1. Spacings for pigeonpea lines of different maturity periods

Maturity period	Genotype	Spacing
Short-duration genotypes	ICPL 87091, MPG 537, ICPL 84060, ICPL 332	0.4 x 0.1 m
Medium-duration genotypes	ICP 6927, ICEAP 00068, ICEAP 00777, ICEAP 00540, ICP 8094-2-S2, ICP 1811-E3, ICP 3615-E1, PPE 45-2, ICP 7946-E-EB, ICP 7176-5, ICP 10531-E3-9EB, ICP 7194-1-S4, ICP 8102-5-S1, ICP 1691-E1-5EB	1.0 x 0.3 m
Long-duration genotypes	ICEAP 00020	1.5 x 0.5 m

Endosulfan 35 E.C. (Thiodan7 35%) was applied at 0.07% active ingredient (a.i.) at flower bud expansion stage, at 50% flowering, early podding, and full podding, with an intention to provide full protection to the plants from insect damage as far as possible. At pod maturity, all pods from three plants plot^{-1} were sampled and examined in the laboratory to determine seed damage and the type of insect pests which caused the damage. Agronomic charateristics for the pod fly lines were not evaluated at Kabete because of poor crop stand in some of the test lines for both seasons. The data were subjected to analysis of variance using Genstat 5 (Genstat 5.0; Release 2.2).

RESULTS

The major insect pests observed on pigeonpea were the pod boring Lepidoptera *(Helicoverpa armigera* Hübner, *Maruca vitrata (testulalis)* Geyer, *Etiella zinkenella* Treitschke and *Exelastis crepuscularis* Meyrick), pod sucking bugs (dominated by *Clavigralla tomentosicollis* Stål), and pod fly (*Melanagromyza chalcosoma* Spencer). Among the pod borers, *H. armigera*, *E. zinkenella, Lampides boeticus* Linnaeus and *E. crepuscularis* Meyrick were commonly found at Kabete, whereas *H. armigera*, *M. testulalis* and *L. boeticus* were common at Kiboko. Seed damage by pod borers and pod sucking bugs was observed in all lines whether sprayed, or unsprayed. The level of damage, however, varied from one genotype to another, and there were significant (P=0.05) genotype/spray interactions. Pod fly incidence and damage was higher at Kabete than at Kiboko. In addition, pod fly damage was higher on the local checks than on the test lines. Significant (P=0.05) genotype/spray interactions were also observed on pod fly lines at Kabete. The environmental conditions and the nature of data generated for the two seasons at Kabete and at Kiboko were not widely different, thus the two season=s data were combined for analysis.

The results at Kiboko showed that all lines were susceptible to pod borer and pod sucking bugs damage. However, test lines were less susceptible to pod fly damage compared to local checks. Spraying significantly (P=0.05) reduced damage due to the three major insect pest groups on all pigeonpea lines (Table 2), and significantly (P=0.05) improved grain yields of all genotypes (Table 3). Seed damage in unsprayed conditions was highest on MPG 537 (54.8%) and lowest on ICEAP 00020 (15.0%).

In unsprayed plots at Kiboko, pod fly incidence and damage was generally low on test lines compared to local checks (Table 4). The short duration genotypes escaped most of pod fly damage. Insecticide spraying significantly (P=0.05) reduced seed damage due to the major insect pests on pod fly test lines. Furthermore, spraying significantly (P=0.05) improved seed mass and grain yields of the pod fly test lines at Kiboko (Table 5).

At Kiboko, sucking bugs accounted for 73% of the total seed damage and borers and pod fly 18% and 9%, respectively. Seed damage at Kabete was similar to that at Kiboko, with pod sucking bugs accounting for 69%, pod borers 16% and pod fly 15%. Spraying pod fly test lines significantly (P=0.05) reduced seed damage due to major insect pests at Kabete (Table 6).

TABLE 2. Seed damage (%) due to insect pests on pod borer tolerant lines at Kiboko in 1994/95 and 1995/96

Genotype	Sprayed				Unsprayed			
	Borers	Sucking bugs	Pod fly	Total	Borers	Sucking bugs	Pod fly	Total
PPE 45-2	1.3	1.5	0.8	3.7	4.9	21.3	0.5	26.7
ICPL 332	1.3	2.0	0.00	3.3	6.1	20.9	0.2	27.1
ICP 3615-E1	2.4	1.8	0.4	4.6	10.6	39.4	0.00	50.0
ICP 1811-E3	2.5	1.6	0.4	4.5	6.5	15.1	2.9	24.5
ICP 8094-2-S2	1.8	3.8	0.00	5.6	5.2	19.2	0.00	24.4
ICPL 84060	3.0	0.9	0.4	4.2	10.2	33.1	0.6	44.0
ICP 6927*	2.1	2.3	0.6	5.0	4.2	19.9	11.9	36.1
ICEAP 00068*	2.3	2.9	2.6	5.7	2.1	22.1	1.0	32.5
ICEAP 00777*	2.2	2.1	0.4	6.6	9.5	18.2	2.5	29.4
ICEAP 00540*	2.4	3.6	1.0	7.0	2.9	17.9	2.3	37.8
ICEAP 00020*	0.8	0.3	3.5	4.5	4.7	3.6	6.7	15.0
ICPL 87091**	0.4	3.8	0.5	5.7	9.1	27.6	5.3	42.0
MPG 537 (Maruca) **	0.5	3.1	0.00	6.7	11.5	33.4	0.3	54.8
Mean	1.7	1.7	0.7	4.2	6.8	23.2	4.2	33.3
SE(m)±								
(Genotype)***	1.42	3.53	0.61	4.54	-	-	-	-
(Protection)	0.26	2.38	0.43	2.24	-	-	-	-
(Interaction)	1.92	5.27	0.92	6.45	-	-	-	-
LSD at 0.05								
(Genotype)***	NS	NS	2.50	NS	-	-	-	-
(Protection)	4.85	43.49	7.87	40.88	-	-	-	-

(Interaction)	NS	NS	2.50	NS	-	-	-	-

* Local checks
** Short-duration genotypes
*** In all tables SE and LSD values are for both sprayed and non-sprayed treatments

TABLE 3. Agronomic characteristics of pod borer tolerant lines at Kiboko in 1994/95 and 1995/96

Genotype	Sprayed				Unsprayed			
	1	2	3	4	1	2	3	4
PPE 45-2	59.0	120.5	9.6	1.0	59.5	123.0	3.7	0.2
ICPL 332	67.0	126.0	7.3	1.3	68.0	126.0	2.7	0.2
ICP 3615-E1	104.0	181.0	9.0	3.1	104.0	181.0	4.4	0.6
ICP 1811-E1	68.0	131.5	8.5	1.3	70.0	136.5	2.9	0.2
ICP 8094-2-S2	117.0	185.0	8.1	2.0	118.0	186.0	4.7	0.8
ICPL 84060	65.0	126.0	7.8	0.9	66.0	128.0	3.5	0.2
ICP 6927*	96.5	144.5	15.2	1.5	102.0	156.5	3.9	0.3
ICEAP 00068*	99.5	152.5	17.1	1.8	112.5	167.0	3.6	0.2
ICEAP 00777*	66.0	120.0	7.4	1.2	67.0	121.0	2.2	0.3
ICEAP 00540*	104.0	146.0	15.8	1.1	105.5	148.5	6.7	0.6
ICEAP 00020*	233.0	294.0	23.8	4.0	239.0	289.5	6.6	1.8
ICPL 87091**	72.0	121.0	12.7	1.1	72.0	124.0	9.7	0.1
MPG 537(Maruca) **	40.0	86.0	10.1	0.5	40.0	90.0	4.7	0.2
Mean	91.7	151.7	10.6	1.7	93.8	154.3	3.8	0.5
SE (m) ±								
(Genotype)	0.55	1.43	0.35	0.04	-	-	-	-
(Protection)	0.16	0.24	0.01	0.01	-	-	-	-
(Interaction)	0.77	1.98	0.49	0.06	-	-	-	-

LSD at 0.05								
(Genotype)	1.83	4.77	1.18	4.39	-	-	-	-
(Protection)	NS	NS	NS	17.7	-	-	-	-
(Interaction)	1.83	4.77	NS	4.39	-	-	-	-

* Local checks
** Short-duration genotypes
1= Days to 50% flowering, 2= Days to 75% maturity, 3= 100 seed mass, 4= Grain yield (t ha^{-1})

TABLE 4. Seed damage (%) due to insect pests on pod fly tolerant lines at Kiboko in 1994/95 and 1995/96

Genotype	Sprayed				Unsprayed			
	Borers	Sucking bugs	Podfly	Total	Borers	Sucking bugs	Podfly	Total
	1.2	0.2	0.0	1.4	14.0	26.0	0.9	40.9
ICP 7176-5	1.7	3.5	0.0	5.2	11.1	62.3	0.4	73.7
ICP 10531-E3-9EB	1.1	0.4	0.0	1.5	9.5	23.0	0.8	33.3
ICP 7194-1-S4	0.9	0.6	0.0	1.5	10.3	28.6	0.2	39.1
ICP 8102-5-S1	1.0	0.7	0.0	1.7	7.6	24.4	3.6	35.5
ICP 1691-E1-5EB	1.5	1.4	0.0	2.9	7.4	43.1	0.0	50.5
ICP 6927*	0.7	1.7	0.1	2.6	7.5	28.9	17.0	53.5
ICEAP 00068*	0.6	1.5	0.1	2.2	8.6	26.5	16.7	51.8
ICEAP 00777*	0.8	1.6	0.2	2.6	9.4	28.7	8.9	47.0
ICEAP 00540*	0.9	2.0	0.3	3.2	8.2	25.9	12.7	46.8
ICEAP 00020*	1.1	1.3	2.5	4.9	4.0	5.5	7.3	16.8
ICPL 87091**	0.5	1.2	0.0	1.7	11.4	42.0	1.3	71.7
MPG 537**	0.4	0.8	-	1.2	10.3	38.6	-	48.9
Mean	1.0	1.2	0.3	2.6	9.4	31.5	4.8	46.1
SE(m) ±								

(Genotype)	1.77	2.27	0.90	2.54	-	-	-	-
(Protection	0.79	2.61	0.45	1.91	-	-	-	-
(Interaction)	2.48	4.00	1.28	3.89	-	-	-	-
LSD at 0.05								
(Genotype)	NS	9.28	3.65	10.38	-	-	-	-
(Protection)	14.35	47.60	8.27	34.81	-	-	-	-
(Interaction	NS	9.28	3.65	10.38)	-	-	-	-

* Local checks
** Short-duration genotypes

TABLE 5. Agronomic characteristics of pod fly tolerant lines at Kiboko in 1994/95 and 1995/96

Genotype	Sprayed				Unsprayed			
	1	2	3	4	1	2	3	4
ICP 7946-E-EB	84.0	170.0	7.6	1.5	84.0	171.0	1.4	0.2
ICP 7176-5	117.0	180.0	10.6	3.7	117.5	181.0	5.2	1.6
ICP 10531-E3-9EB	72.0	130.0	7.4	2.2	72.5	132.0	2.2	0.3
ICP 7194-1-S4	75.0	128.0	7.0	1.0	77.0	130.0	2.3	0.3
ICP 8102-5-S1	120.0	187.0	10.7	2.1	121.5	187.0	4.7	0.7
ICP 1691-E1-5EB	63.0	122.0	7.4	1.0	64.0	124.0	3.3	0.3
ICP 6927*	96.5	144.5	15.2	1.5	102.0	156.5	3.9	0.3
ICEAP 00068*	99.5	152.5	17.1	1.8	112.5	167.0	3.6	0.2
ICEAP 00777*	66.0	120.0	7.4	1.2	67.0	121.0	2.2	0.3
ICEAP 00540*	104.0	146.0	15.8	1.1	105.5	148.5	6.7	0.6
ICEAP 00020*	233.0	294.0	23.8	3.9	239.0	289.5	6.6	1.8
ICPL 87091**	72.0	121.0	12.7	1.2	72.0	124.0	9.6	0.2

MPG 537 (Maruca)**	40.0	86.0	10.1	0.5	40.0	90.0	4.7	0.2
Mean	95.5	152.4	11.8	1.7	98	155.5	4.3	0.5
SE (m) ±								
(Genotype)	0.55	1.43	0.35	0.04	-	-	-	-
(Protection)	0.16	0.24	0.01	0.01	-	-	-	-
(Interaction)	0.77	1.98	0.49	0.06	-	-	-	-
LSD at 0.05								
(Genotype)	1.83	4.77	1.18	4.39	-	-	-	-
(Protection)	NS	NS	0.33	6.00	-	-	-	-
(Interaction)	1.83	4.77	1.18	4.38	-	-	-	-

* Local checks
** Short-duration genotypes
1= Days to 50% flowering, 2= Days to 75% maturity, 3= 100 seed mass, 4= Grain yield (t ha^{-1})

TABLE 6. Seed damage (%) due to insect pests on podfly tolerant lines at Kabete in 1994/95 and 1995/96

Genotype	Sprayed				Unsprayed			
	Borers	Sucking bugs	Pod fly	Total	Borers	Sucking bugs	Pod fly	Total
ICP 7946-E-EB	0.7	0.2	0.0	1	14.0	26.0	0.9	40.9
ICP 7176-5	0.5	3.6	0.0	4.1	11.1	62.3	0.4	73.8
ICP 10531-E3-9EB	0.2	0.4	0.0	0.7	9.5	23.0	0.8	33.3
ICP 7194-1-S4	0.5	0.8	0.0	1.4	10.3	28.6	0.2	39.2
ICP 8102-5-S1	0.7	0.7	0.3	1.7	7.6	24.4	3.6	35.6
ICP 1691-E1-5EB	0.2	1.6	0.1	2	7.4	43.1	0.2	50.8
ICP 6927*	0.6	1.7	1.2	3.5	7.5	28.9	17.0	53.4
ICEAP 00540*	0.4	1.2	0.6	2.3	6.8	25.7	14.6	47.1

ICEAP 00068*	0.3	1.4	0.3	2.2	7.2	28.3	11.5	47
ICEAP 00777*	0.7	0.8	0.2	1.7	8.1	24.5	6.8	39.5
ICEAP 00020*	0.6	1.4	2.6	4.6	4.0	5.5	7.3	16.8
ICPL 87091*	0.2	1.6	0.1	2.1	11.4	42.0	18.3	71.7
Mean	0.5	1.7	0.4	2.6	9.3	31.8	6.8	45.8
SE (m)±								
(Genotype)	1.75	2.32	0.91	2.4	-	-	-	-
(Protection)	0.83	1.32	0.42	1.6	-	-	-	-
(Interaction)	2.49	3.63	1.27	3.8	-	-	-	-
LSD at 0.05								
(Genotype)	NS	9.84	3.85	9.58	-	-	-	-
(Protection)	7.43	11.73	3.74	11.45	-	-	-	-
(Interaction)	NS	11.73	3.74	11.45	-	-	-	-

* Local checks

Relationship between seed mass and seed damage. The results reported here are for pod fly lines at Kabete in 1994/95 and pod borer lines at Kiboko in 1994/95. There was a significant (P=0.05) positive correlation between 100-seed mass and pod fly damage on seeds at Kabete (r = 0.31*). Correlations between seed mass and seed damage were negative and insignificant for pod borers (r = -0.18) and pod sucking bugs (r = -0.24). Similarly at Kiboko, there was a significant (P=0.05) positive correlation between 100-seed mass and pod fly damage (r = 0.30*) and highly significant (P=0.01) negative correlations between 100-seed mass and damage by pod borers (r = -0.37**) and pod sucking bugs (r = -0.43**).

DISCUSSION

The results reveal that pod sucking bugs and pod borers caused substantial damage to pigeonpea seed at Kiboko and Kabete in Kenya. Pod fly damage was relatively higher at Kabete than Kiboko. The three insect pest groups are major pests on pigeonpea elsewhere in the world (Lateef and Reed, 1990). All pod borer and pod fly test lines showed some degree of tolerance to pod fly damage compared to the checks in unsprayed plots. The four medium-duration local checks are either selections from ICP 6927, or from medium-duration landraces in the region. The long-duration landrace ICEAP 00020 is a selection from Kenya. All medium-duration genotypes were more susceptible to pod sucking bugs compared to the long-duration landrace. On the other hand, the long-duration landrace was more susceptible to pod fly at Kiboko where it matured later than the medium-duration genotypes. Short-duration genotypes escaped pod fly damage at Kiboko while at Kabete they were susceptible. The results indicated that pod fly preferred cool temperatures, hence the higher incidence of the pest at Kabete than at Kiboko.

In Kenya, the medium- and long-duration landraces mature during cool and dry weather when there are low populations of *Helicoverpa* (they undergo diapause in cool and dry weather conditions) and *Maruca* (prefers warm and humid weather). Similarly, Reed and Lateef (1990) observed that long-duration genotypes had less damage from pod borers compared to pod fly in India. These two authors suggested that at the time the long-duration genotypes are maturing, there were low populations of the major pod borer, *H. armigera,* which preferred to feed on chickpea in India. Pod fly was, however, an important pest on the long-duration genotypes. In eastern Kenya, pod fly accounts for high seed damage on the traditional landraces and during the

August 1995 season it accounted for 44.7% of total seed damage on pigeonpea in farmers= fields (Minja, 1997).

The traditional landrace ICEAP 00020 appeared to tolerate damage from both pod borers and pod sucking bugs compared to pod fly. Seed damage on ICEAP 00020 under unsprayed conditions appeared low in both experiments and grain yields were higher than in the other tested lines. This could be an indication that the landrace may escape damage because of its slow growth and delayed maturity compared to other lines.

Most farmers in Kenya synchronise their pigeonpea sowing with the onset of the rains. This practice help in reducing the build-up of pests on early sown crops which would infest late sown crops. Reed and Lateef (1990) observed that where all pigeonpeas in an area are simultaneously attractive to a pest the available population is diluted across the area and pest-caused losses are minimised.

Some of the test lines could be useful in the management of pod fly and pod borers if other qualities including seed size and colour are acceptable to farmers. Most of the test lines appeared to have qualities that were suitable to escape pod fly infestation (Lal *et al*., 1986). T hey flowered when pod fly populations were low and completed their podding in the shortest possible time such that there was little opportunity for the pest to complete more than one generation in the crop.

Among the pod fly lines, ICP 7946-E-EB, ICP 10531-E3-9EB, ICP 8102-5-S1 and ICP 7194-1-S4 flower between 98 to 100 days at Kabete and Kiboko, and mature in 150 to 160 days. These lines had the shortest flowering and maturity periods among the medium-duration genotypes tested. The seed and pod sizes of these lines were small, and some had dark coloured seed compared to local checks. Correlation analysis on the data indicated that as seed size increased pod fly damage increased. Studies in India (Veda *et al*., 1975) have shown positive correlation between pod width and the percentage of infested grain. In another study (Thakur *et al.*, 1989), strong correlations were recorded between both pod width (r=0.98) and pod length (r=0.99), and per cent grain damage. Lal *et al.* (1988) noted that small pods had less pod fly damage than larger pods. The implication from these studies are that the locally available landrace materials preferred by farmers in the region, and which have wide and long pods with large seeds, are likely to be more susceptible to pod fly damage.

Early flowering and fast maturity appeared to be important characteristics to pod borer test lines in relation to pod fly damage. However, other factors including arrangement of pods on branches and orientation of flowers to leaflets on the branch seemed important in relation to pod borer damage. All medium-duration and the long-duration genotypes had pods that were well spaced along the branches (indeterminate type) and there was less pod borer damage compared to ICPL 87091, where pods were bunched (determinate type) at the ends of branches. The pods on MPG 537 were in a bunch on each branch but they were positioned far away from the leaflets. There were indications that *H. armigera* could cause some damage on MPG 537, but *M. testulalis* incidence was low probably due to difficulty of forming webs between leaflets and flowers/pods. Lateef and Reed (1981) reported that pod bunches offer niches in which pests such as *H. armigera* and *M. testulalis* can conceal themselves. Consequently, they are not exposed to predation when moving from pod to pod and they pose difficulties in targetting insecticide sprays.

Trials on large field plots are required to establish the performance of pod borer and pod fly tolerant lines. There is also a need to incorporate more landrace materials in the tests to explore the potential of the available landraces being grown by farmers in the region. For example, some farmers in Uganda grow pigeonpea landraces (e.g. Apiyo-Elina) which have small pods/seeds, and dark seed colour. In addition, farmers in Kenya, Malawi, Tanzania and Uganda grow different early maturing medium-duration landraces.

Pod sucking bugs attacked all the test lines including the local checks, accounting for more than 50% of the total seed damage in the present study. Research efforts should therefore emphasise pod sucking bugs in addition to pod borers and pod fly which are common and widespread in the region (Minja, 1997). Furthermore, there is a need to conduct studies on factors responsible for regulating the populations of pod sucking bugs, pod borers and pod fly in the region.

ACKNOWLEDGEMENTS

The first author is grateful to the African Development Bank (AfDB) for financial support, and to the Executive Director, ICRISAT Southern and Eastern Africa Region for availing the funds. We are thankful to O.M. Karuru for supervising the field work. V. R. Bhagwat and H. C. Sharma made valuable comments on the draft manuscript.

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