in determinate types of pigeonpea and also infested the neighboring winged bean (*Psophocarpus tetragonolobus*) crop. The farmers in this area recognize grasshoppers and *Maruca* as the prominent yield reducers in all legume crops. The details of location-wise pest occurrence and damage levels is presented in Table 1.

Conclusions

The cultivation aspects of pigeonpea were well understood by the researchers and farmers in all counties. However, the utilization and plant protection measures needs to be better adopted for the successful establishment of the crop. In areas where the crop is used as fodder the seed supply need to be backed with appropriate insect management. The involvement of private seed sector which has better pest management skills than the farmers to meet the seed demand would be of immense value for the rapid establishment of the crop. Pigeonpea is prone to insect attack which has remained a severe threat for crop productivity in several countries. Hence, countries like China, where this legume has been newly introduced, need to be very cautious in promoting this crop.

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Efficacy of *Tephrosia vogelii* Crude Leaf Extract on Insects Feeding on Pigeonpea in Kenya

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Pigeonpea (*Cajanus cajan*) is an important source of dietary protein, and is consumed as green peas, whole grain, or split seeds. Yields of pigeonpea vary across locations, seasons, and cropping systems. In most areas, insect pests are an important constraint in pigeonpea. The most important flower- and pod-feeding Lepidoptera in eastern and southern Africa are *Helicoverpa armigera*, *Maruca vitrata* (= *testulalis*), *Etiella zinckenella*, and *Lampides* spp and they account for 5–35% loss in grain yield (Minja 2001). The pod-sucking Hemiptera [dominated by *Clavigralla* (= *Acanthomia*) spp] cause 30–70% loss in yield (Minja 2001). The common seed-feeding Diptera is *Melanagromyza chalcosoma*, which accounts for 4–45% yield loss in mid- to high-altitude elevations.

The majority of pigeonpea-growing farmers are poor rural women, who cannot afford the high costs for insect pest control using commercial insecticides. *Tephrosia* *vogelii*, commonly referred as fish poison bean, has been widely used in the tropics to kill fish and in treatment of various animal ailments. It has a potential in eastern and southern Africa for biocontrol. The work reported here aimed at determining the effectiveness of *Tephrosia* in field insect pest control on pigeonpea.

The short-duration pigeonpea ICPL 87091 was planted at the Kenya Agricultural Research Institute (KARI) station at Kiboko, Kenya during 1998/99 short rain season (November/February). Field plots measuring 10 m × 20 m were used and seeds were sown at 30 cm × 10 cm spacing. *Tephrosia* plants were established in a separate plot during the long rains of 1998. There were eight treatments replicated three times in a randomized complete block design.

Tephrosia crude leaf extract was prepared by picking mature leaves, pounding them in a mortar, and soaking them in the appropriate amount of water (50, 100, and 200 leaves L^{-1} of water) for 10–12 hours under ambient conditions. Two liters of spray fluid was used in these experiments. The following morning or late afternoon the leaf extract was filtered through muslin cloth. The filtrate was mixed with the detergent Teepol® (2–3 ml L^{-1}) to assist in dispersion of the spray on the plant surface. The resulting mixture was sprayed on pigeonpea plants in the field. The first spray was applied at flower bud expansion stage, and subsequent sprays at 10- to 15-day intervals. Dimethoate (Rogor® E40) was used as a standard commercial insecticide. All plots were weeded by hand hoeing, and supplementary irrigation was given when needed.

Damage assessment was carried out at early podding (25% of pods with expanded seed), late podding (about 50% of pods with expanded seed), and maturity (about 75% of pods are mature but not dry) stages. Pods from 5 randomly tagged plants in the middle of each plot were sampled destructively. Each pod was later examined in the laboratory to determine the number of seeds damaged by different insect pests. The total number of damaged seeds was expressed as a proportion of total number of seeds $plot^{-1}$. Grain yields were recorded at harvest by harvesting all pods (excluding the outer row and one meter band at the edges of each plot). The pods were dried and shelled, and the grain separated into clean (usable) and unclean (unusable) seeds. The clean and unclean seeds were weighed separately. Yield gains in sprayed plots were based on the yield differences between sprayed and unsprayed plots, and expressed as proportion of the seed yield in unsprayed plots. All data was subjected to analysis of variance using Genstat 5.

Plots sprayed with Dimethoate and *Tephrosia* leaf extract showed significant reduction in seed damage compared to untreated control (Table 1). Differences in seed damage in plots with three and four sprays of *Tephrosia* were not significant. Although yield differences were not significant between sprays with 100 and 200 *Tephrosia* leaves, the latter gave higher yields. Seed mass was slightly improved by all the sprays.

The results indicated that plots sprayed with extracts from 200 leaves of *Tephrosia* applied three to four times had acceptable levels of insect control. Similar observations have earlier been reported from Uganda (Kyamanywa et al.

Table1. Seed damage by insect pests at three pod developmental stages and seed characteristics of the short-duration pigeonpea variety ICPL 87091 sprayed with *Tephrosia* extracts at Kiboko, Kenya (1998/99 short rains).

Treatment	Seed damage (%) Early podding	Late podding	Pod maturity	100-seed mass (g)	Total seed yield (kg ha^{-1})	Usable seed (kg ha^{-1})	Usable seed gain (%)
Tephrosia 50 leaves, 3 sprays	8.9	15.3	18.2	11.8	1767	1620	19.6
Tephrosia 50 leaves, 4 sprays	8.1	14.0	13.0	11.6	1868	1769	30.5
Tephrosia 100 leaves, 3 sprays	5.1	12.5	8.8	11.7	2079	1858	37.1
Tephrosia 100 leaves, 4 sprays	6.1	11.0	15.6	11.9	1950	1816	34.0
Tephrosia 200 leaves, 3 sprays	4.4	13.3	12.1	11.5	2229	2123	56.7
Tephrosia 200 leaves, 4 sprays	4.6	9.9	8.9	11.5	2287	2188	61.5
Dimethoate at 0.05% ai[1]	2.2	8.4	6.2	11.2	2120	2030	49.8
Untreated control	18.9	16.6	26.9	10.8	1455	1355	0.0
Mean	7.3	12.6	13.7	11.5	1970	1845	
SE ±	2.45	2.52	3.15	0.28	48.63	63.31	

1. ai = Active ingredient.

2001). Anti-feeding effects of *Tephrosia* have also been reported on spotted cereal stem borer (*Chilo partellus*) (Machocho 1992). There were significant (P = 0.05) increases in grain yield in the sprayed plots and a concomitant improvement in grain quality. Kyamanywa et al. (2001) observed similar yield increases through the application of *Tephrosia* leaf extract in Uganda. Application of *Tephrosia* leaf extract has shown beneficial effects on grain yield and quality when used appropriately. These applications have to be effected either very early in the morning or late in the evening to avoid degradation of this bio-pesticide due to exposure to light and air. Farmers are now being encouraged to establish their own plants for quick accessibility when they need the leaves. These farmers can prepare their own crude extracts and apply them in their fields.

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Biotechnology

Efeect of Feeding Legume Proteinase Inhibitors on *Helicoverpa armigera* Gut Proteinase Activity

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Legumes rank second after cereals as a source of human and animal feed. Pigeonpea (*Cajanus cajan*), chickpea (*Cicer arietinum*), mung bean (*Vigna radiata*), and soybean (*Glycine max*) are the most common legumes grown in India. They are a valuable source of proteins, minerals, and vitamins. However, they also contain some antinutritional factors such as oligosaccharides, proteinase inhibitors, and phenols (Singh 1988). Proteinase inhibitors are common natural products in plants and have been studied as phytochemical resistance factors against herbivorous insects (Broadway 1996). The legume pod borer *Helicoverpa armigera* is a major pest of several legume crops. The larva is a voracious feeder and damages buds, flowers, pods, and seeds. The objective of this study was to examine the effect of proteinase inhibitors extracted from different legumes on *H. armigera* gut proteinase (HGP) activity.

The seeds were procured from the Agricultural Research Station, Gulbarga, Karnataka, India. The chemicals N-α-benzoyl-DL-arginine-p-nitroanilide (BApNA), tosyllysinechloromethylketone (TLCK), TLCK-treated chymotrypsin, bovine serum albumin, pheynylmethylsulfonylfluoride (PMSF), and tosyl-phenylalaninechloromethylketone (TPCK) were purchased from Sigma Chemical Co., St. Louis, MO, USA. All other chemicals were of analytical grade.

The flour of seeds of various legumes was defatted by washing it with acetone (thrice) and hexane (twice), and air-dried. The defatted flour was stirred with 50 ml of 0.1 M sodium phosphate buffer (pH 7.1) for 4 h at room temperature (28°C). The resulting mixture was centrifuged at 12,000 rpm for 15 min at 4°C. The supernatant was dialyzed with distilled water and used as an inhibitor source. Protein concentration was assayed by Bradford method (Bradford 1976). The proteinase inhibitory activity and HGP activity were assayed by incubating the seed extract/gut extract with 15 μg of trypsin at room temperature (28°C). One ml of 1 mM BApNA solution was added and incubated at 37°C for 10 min. The