FIELD GRAIN LOSSES AND INSECT PEST MANAGEMENT PRACTICES IN SUBSISTENCE AGRICULTURE: FARMERS' PERCEPTIONS

J. O. Ogendo[1], E. O. Omolo[2], A. L. Deng[3], J. C. Matasyoh[4] and I. M. Tabu[5]
[1,2,5]Department of Crop and Soil Sciences, Egerton University, P. O. Box 536, Egerton, Kenya.
[3]Department of Biological Sciences, Egerton University, P. O. Box 536, Egerton, Kenya.
[4]Department of Chemistry, Egerton University, P. O. Box 536, Egerton, Kenya.

ABSTRACT

A farm survey was conducted in subsistence farming communities to document the major grain crops, insect pests, indigenous pest control methods (PCM) and farmer perceptions of grain losses associated with identifiable pest species and perceived efficacies of the PCMs. Maize, beans and sorghum were identified as the major staple food crops, with the major pests being cutworm, stem borers, aphids, beanfly, pod borers, armyworms and termites. Statistical analyses revealed that the level of crop yield losses was dependent upon the area cropped, total yield and respondents' background. There was, however, a negative correlation between crop yield loss due to insect pests and the efficacy of PCM applied. Farmers lost, on average, 24.75% of their crop to insect pests with high value crops suffering the greatest insect pest attack in terms of species diversity and magnitude of damage incurred. The occurrence of field insect pests varied from season to season with most species reportedly occurring during the long rains. Most (72.6%) farmers never applied any PCM against all the insect pests of food crops. The use of synthetic pesticides and alternatives accounted for less than 10%. Seventy one percent of the respondents reported that the efficacy of the PCMs applied was unknown. Some of the indigenous PCMs reportedly used included crude powders and aqueous extracts of local botanical plants such as Tobacco, Tephrosia, and Basil. The study recommends that bioassay-guided investigations be instituted to develop and rationalise the use of identified PCM strategies compatible with the target user domains.

Keywords: *Farmer perceptions yield loss, indigenous pest control.*

1.0 INTRODUCTION

In Kenya, like many other developing countries, agriculture is the predominant economic activity. Most farmers are rural-based, with subsistence agriculture as the main source of livelihood. One of the main obstacles to increased food production is crop damage by insect pests in the field. Some of the field insect pests that attack the cereal/legume systems include; termites, cutworms (*Agrotis* spp, *Spodoptera* spp), aphids (*Aphis spp*), common whitefly (*Bemisia tabaci*), legume pod/seed feeders (*Maruca testulalis* Geyer, *Helicoverpa/Heliothis armigera* Hübner), shootfly (*Atherigona soccata* Rondani), stem borers (*Chilo partellus* Swin, *Busseola fusca* Fuller), beanfly (*Ophiomya phaseoli* Tryon) and African armyworm (*Spodoptera exempta* Walker) (Jaetzold and Schmidt, 1982; Teetes *et al.*, 1983; CIAT, 1994; Allen *et al.*, 1996). Yield losses resulting from insect pest damage on maize, sorghum, grams and beans range from 20–80% (Saxena *et al.*, 1990; Ogendo *et al.*, 2003a).

Control strategies for the insect pests include chemical, cultural and biological. The conventional control (use of synthetic pesticides) is, however, rarely used because most farmers in the Lake Victoria region are low in resource and lack the knowledge and skills for pesticide use (Saxena *et al.*, 1990; Ogendo *et al.*, 2004). Synthetic pesticides also contribute to environmental pollution. Research is, therefore, currently focusing on the search for bio-pesticides that are locally available, low cost and environmentally safe. The farmer perceived and laboratory evaluated pesticidal potency of local botanicals *Lantana camara* L., *Tephrosia vogelii* Hook, *Ocimum* spp., neem (*Azadirachta indica* L.) and *Tagetes minuta* L. have been reported and preliminary studies on isolation, identification and quantification of the bioactive compounds are in progress (Ogendo, 2000; Ogendo *et al.*, 2003a).

Despite the enormous potential that indigenous non-chemical bio-intensive pest management (BIPM) practices have demonstrated for controlling major field insect pests, little research has been carried out to identify and quantify the local pest management strategies. A study was carried out to inventory the major field insect pests, farmer-perceived field losses and management options and recommend the improved control strategies.

2.0 MATERIALS AND METHODS

Suba district is located at latitude 0° 30' S and longitude 34°30' E and an altitude of 1140-1700 m above sea level. It receives a mean annual rainfall of 800-1400 mm and

a mean annual temperature of 19.3-22.7°C (Jaetzold and Schmidt, 1982). Farming is mostly characterised by two distinct cropping seasons per year, where cereals and legumes are intercropped.

A diagnostic farm survey was conducted in the smallholder farming communities of Suba district, Kenya, between June 2002 and June 2003 at joint meetings involving farmers, researchers and Ministry of Agriculture (MOA) extension staff. A stratified random sampling procedure involving 70 representative farmers was conducted in Lambwe (31) and Gwassi (39) divisions, according to Njuho (2000). Transects were established within the two divisions and then representative farmers identified. Participatory approaches such as ranking and transect walks were used during the interviews. Observations and rapid assessments of cereal (maize, sorghum and finger millet) and legume (beans, groundnuts, cowpea and green grams) crops in the field for visible damage by insect pests, estimated losses and the existing pest management options supplemented questionnaires.

The survey gathered data on major cereal (maize, sorghum and finger millet) and legume (beans, groundnuts, cowpea and green grams) crops, average yield and grain losses due to field insect pests, and the corresponding status, the farmers' control strategies and the diversity, potency and pest range of indigenous PCMs. With the help of sweeping nets, specimens of larvae and adult insect pests on the surface of crops were collected and preserved in plastic containers and vials with 70% alcohol and chloroform, respectively. Recognition and on-the-spot identification of the insect pest species was based on available expertise, pictorial aids and literature (Bohlen, 1973; Singh, 1990; Wightman and Ranga-Rao, 1993). Confirmatory identification was carried out in the laboratories of Department of Biological Sciences, Egerton University. Data generated was analysed by Chi-square test, Principal Component Analysis (PCA) and Tobit analysis.

For Tobit analysis the parameters were coded as:

0 represented no control.

1 represented use of organic pesticides.

2 represented synthetic pesticides.

3 represented use of both synthetic and organic pesticides.

3.0 RESULTS AND DISCUSSION

Results of the survey indicate that maize, beans and sorghum were the major staple food grain crops grown in Suba District. The crops were allocated higher land area and ultimately resulted in higher grain yield (Tables 1A and 1B). The fact that the crops identified as important in this study were similar to those listed by Jaetzold and Schmidt (1982) implies that the farming landscape has not changed much in terms of crop types. Of importance, however, is that the yield achieved by farmers was generally low. For example, although maize varieties with potential yield of 8 t/ha have been developed (Hassan *et al.*, 1998), farmers realised less than that 0.7 t/ha. The extremely low crop yields were attributed to use of unimproved crop varieties, poor pest and crop management practices. Crop losses ranged from 25% to 65%, but varied with crop.

More than 70% of the farmers never applied any pest control measure and where PCMs were applied, their perceived efficacies were neither known nor rating available. In a similar study, Tefera (2004) reported that majority of subsistence farmers in eastern Ethiopia never applied any chemical insecticides against field insect pests such as stem borers. Some of the botanicals identified included *T. vogelii* (fish poison bean), *A. indica* (neem), *Nicotiana tabacum* L. (tobacco), *T. minuta* L. (Mexican marigold), *Ocimum spp* (basil plant) and ashes. Similar botanical pesticides are in use in eastern and southern Africa regions (Berger, 1994; Songa *et al.*, 2002; Ogendo *et al.*, 2003b).

Analysis of the data using the Tobit model is shown in the Table 2. Age, farming experience and education influenced the pest management. Education is a major factor in technology adoption. Highly educated farmers are likely to be aware of the integrated pest control methods and associated benefits, hence the positive sign. Generally, farmers with wide farming experience are expected to easily adopt new technologies. However, the unexpected results were probably because most of the interviewees were old (40 to 70 years) and hence the negative sign.

Principal Component Analysis (PCA) identified four groups of factors that contribute to the pest control status (Table 3). Factor 1 could be described as land area under cultivation and crop yield. The positive relationship between the factors implies that the more the land cultivated the higher the crop yield realised.

Factor 2 represented crop value, in which case high value crops such as maize were allocated more land area and were relatively better managed [Tables 1(a) and

1(b)]. Assessment of crop and insect pest species showed that vegetative (43%) and reproductive (36%) stages were the most susceptible and contributed significantly to the field grain losses realised by farmers (Figure 1). High value crops suffered the greatest insect pest attack in terms of species diversity and magnitude. Factors 3 represented total crop loss and losses due to insect pests. The positive correlation indicates the need to control the field insect pests.

The major insect pest species (in descending order) identified in each of the food crops included stem borers, armyworm, cutworm and termites (maize); stem borers, cutworms, armyworm and termites (sorghum); beanfly, pod borer, aphids and cutworm (beans); whitefly, aphids (groundnut); aphids (cowpea) and aphids (green grams). Irrespective of crop, the magnitude of damage caused by the stem borers, armyworm, cutworms and aphids were considered by most farmers to vary from severe to very severe (Table 4 and 5). Similar field insect pests of cereal and legume grain crops have been reported in various agro-ecological zones (AEZs) in Kenya (Jaetzold and Schmidt, 1982; Karel and Autrique, 1989; Songa *et al.*, 2002). Hence, insect pests continue to be a major challenge to increased food production in the largely subsistence farming communities.

Majority (65%) of the farmer-perceived losses due to insect pests ranged from 10.5 to 30%, with stem borers being the primary pest of maize. The pest was more prevalent during the long rains (Figure 2). As earlier observed, significant field grain losses occurred with the damage level being directly proportional to the pest species, season, stage of crop growth and pest control measures applied. Higher field grain losses were reported in all the food grain crops probably because of the crop diversity and higher land area under crop and ultimately higher yield. Under normal circumstances, short rainy season has higher pest pressure because the first generation pests establishes and build up before the short rains (Saxena *et al.*, 1990). Moreover, moisture stress during the short rainy season enhances crop loss due pests. Although farmers were able to identify and quantify the losses caused by diverse insect pests at different stages their control was low.

Factor 4 described as the use of crop, i.e., crops with multiple uses (food, cash and value) were highly valued and considered for crop protection. A negative correlation between food and cash crops implies that a crop mainly valued as staple food source contributed less towards a family's income. Most farmers, were, however mainly subsistence. In addition to the low crop yields, farmers sold their crops

immediately after harvest to generate income and avoid losses that could be incurred during storage. Sale of crop produce at harvest meant that the produce fetched poor prices.

Other studies have also shown a general similarity in farmers' perceptions regarding importance of insect pest problem (Berger, 1994; Heong *et al.*, 2002; Songa *et al.*, 2002; Candy, 2003). Hence, insect pest menace contributes substantially to the cyclic food deficits and ultimately to the high level of food and absolute poverty often associated with subsistence agriculture in the tropics. Revelations that over 70% of the farmers never applied any pest control measures implies future technological interventions must incorporate the farmer's resource base, indigenous knowledge and practices and pursue only those interventions with high technical simplicity, compatibility and affordability indices. Given the continued resistance / reluctance by rural subsistence farmers to integrate use of synthetic pesticides in their pest control practices, research efforts must be directed towards the scientific rationalisation and development of adaptable indigenous pest control measures with measurable efficacy ratings. Specifically, there is need to isolate, identify and characterise the active chemical constituents in test botanicals and evaluate their pesticidal potency against the major field insect pests of maize and beans.

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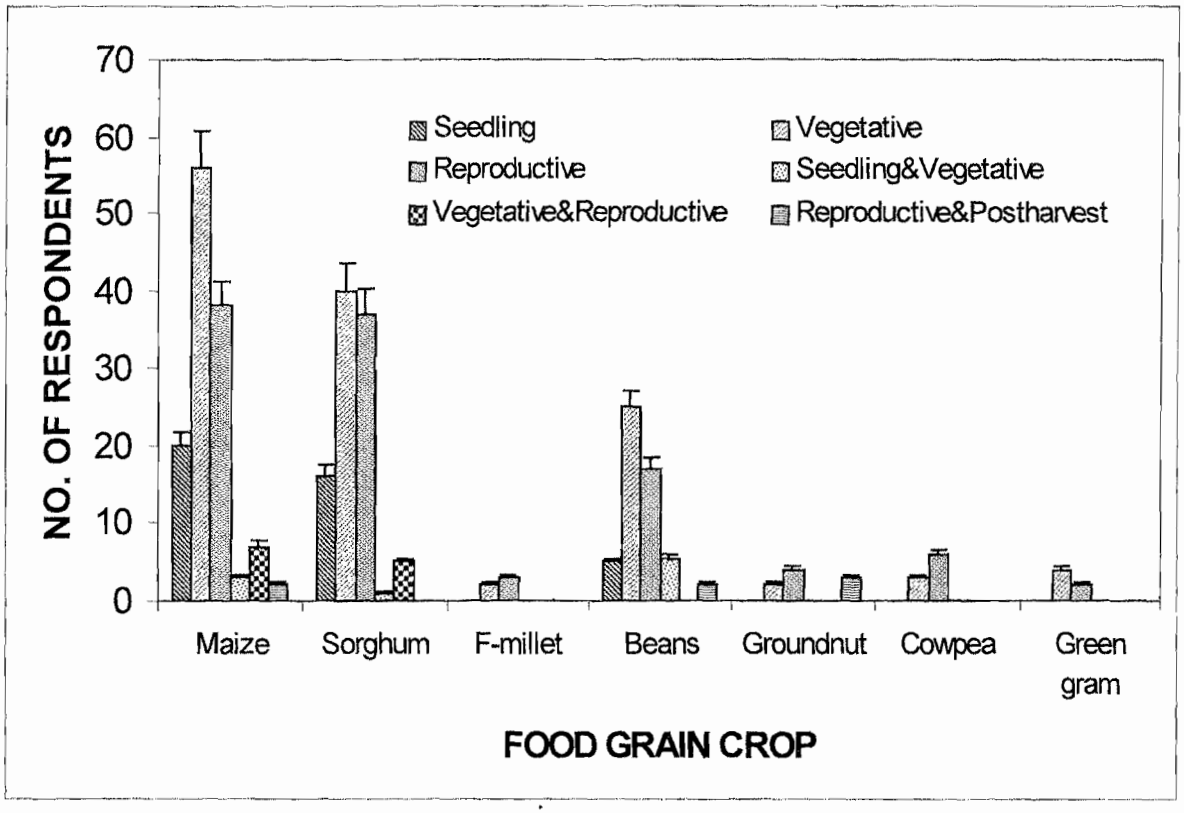

Figure 1: Farmers' perception of crop stage most susceptible to insect pest attack

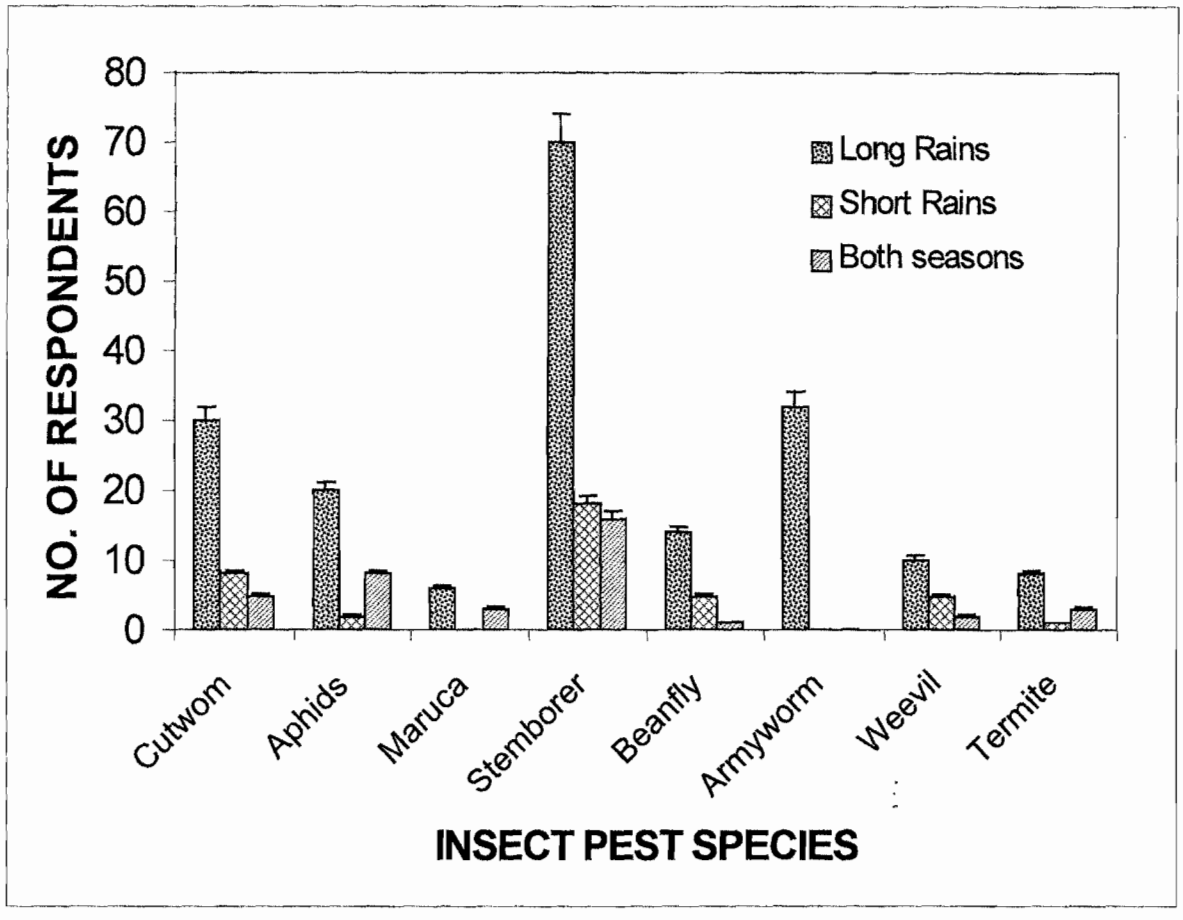

Figure 2: Farmers' perceived seasonal occurrence of field insect pests

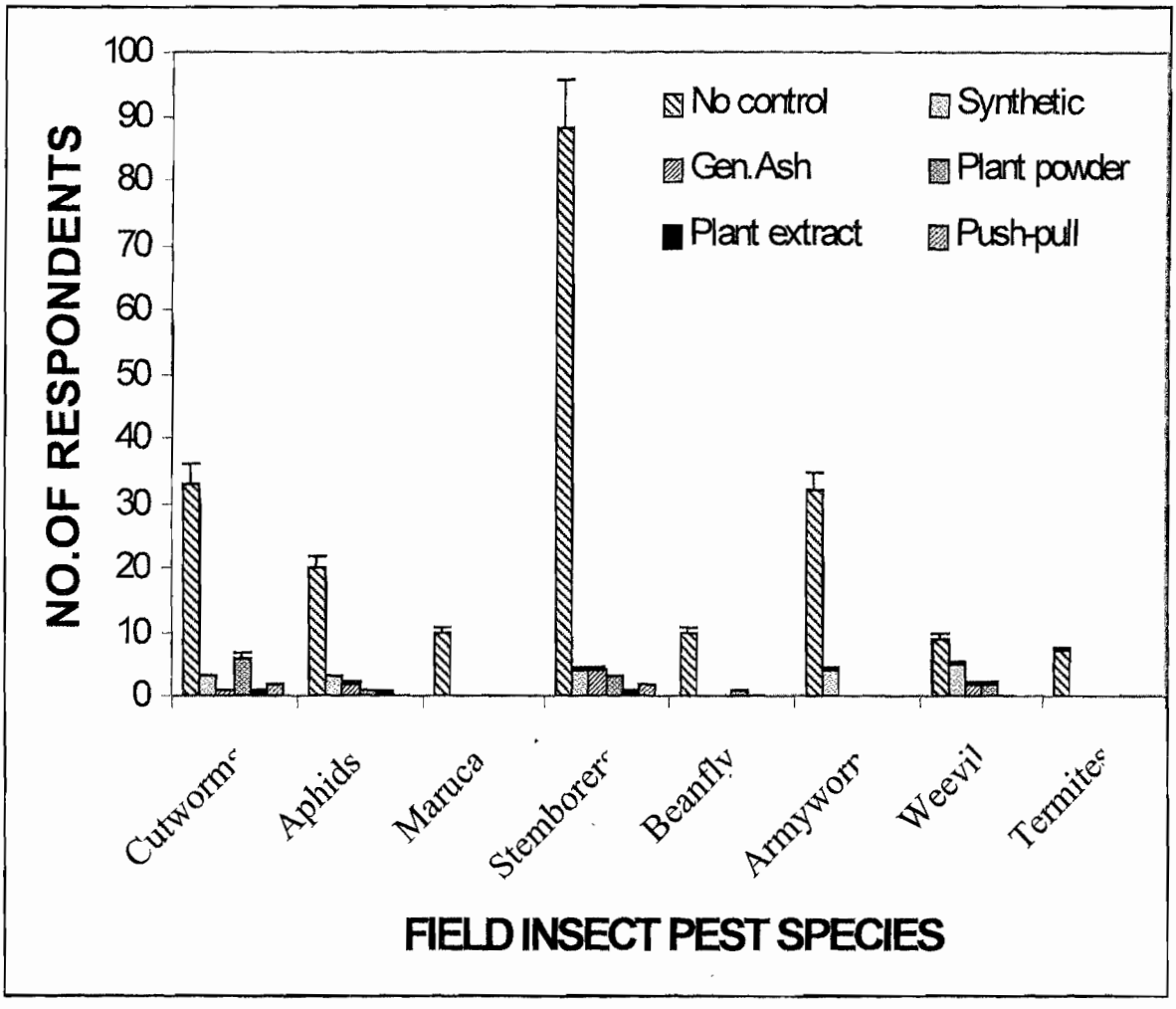

Figure 3: Farmers' pest control methods against major field insect pests

Table 1(a): Major crops, acreage, yield and perceived crop yield losses due to field insect pests

Crop	*Mean Acreage (ha*) (± SE)*	*Mean Yield (t/ha) (± SE)*	*Mean Percent yield loss due to field insect pests (± SE)*
1. Maize	1.168 ± 0.098	0.668 ± 0.070	25.4 ± 1.465
2. Sorghum	0.514 ± 0.109	0.754 ± 0.078	25.1 ±1.626
3. Beans	0.735 ± 0.116	0.243 ± 0.083	25.5 ±1.924
4. Cowpea	0.409 ± 0.288	0.129 ± 0.207	25.7 ±5.441
5. Finger millet	0.439 ± 0.332	0.537 ± 0.238	28.3 ±4.967
6. Groundnut	0.288 ± 0.226	0.689 ± 0.162	23.1 ±6.084
7. Green gram	0.236 ± 0.332	0.045 ± 0.023	35.0 ±8.168

*Ha = hectare; t/ha = tonnes per hectare

Table 1(b): Crops and their socio-economic ranking in Suba District

CROP	*PERCENTAGE OF RESPONDENTS WHO RANKED THE CROP*			
	1ST	*2ND*	*3RD*	*4TH and Below*
1. Maize	**94.3****	5.7	0.0	0.0
2. Sorghum	5.7	**75.7****	0.0	0.0
3. Beans	0.0	18.6	**38.6****	**12.9**
4. Cowpea	0.0	0.0	7.1	4.3
5. Finger millet	0.0	0.0	7.1	0.0
6. Groundnut	0.0	0.0	5.7	**12.9****
7. Green gram	0.0	0.0	1.4	8.6
8. Cotton	0.0	0.0	2.8	4.3
9. Banana	0.0	0.0	1.4	0.0
10. Sweet potato	0.0	0.0	0.0	1.4
TOTAL	100.0	100.0	64.1*	44.4*

Other important crops reported: sesame, sunflower, horticultural crops (vegetables)

*The sum total is less than 100 since not all respondents availed ranking for some crops

**These are the major staple cereal and legume crops in Suba District

Table 2: Tobit estimates of the farmer characteristics determining the pest management

	Tobit Coefficient	*Standard Error*	*t*	*P>|t|*	*95% Confidence. Interval*	
Sex	0.7984	0.8216	0.9700	0.3350	-0.8429	-2.4397
Age	0.0751	0.0390	1.9200	0.0590	-0.0029	0.1531
Fexp	-0.0958	0.0436	-2.2000	0.0320	-0.1830	-0.0087
Job	1.3634	0.9211	1.4800	0.1440	-0.4768	3.2036
Educ	0.1747	0.1036	1.6900	0.0970	-0.0322	0.3816
Constant	-6.3021	2.9976	-2.1000	0.0390	-12.2904	0.3138
SE	1.7480	0.4003				

Fexp = Farming experience, Job=main occupation of household head, Educ=Education level.

Table 3: Rotated factor patterns for crop yield losses and pest control status

Variables	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*
Crop	-0.25882	-0.17951	0.01959	**0.73840**
Area Cropped	**0.90788**	-0.01278	-0.02168	-0.09778
Actual Harvest	**0.89528**	-0.03486	-0.20714	-0.06125
Total yield loss	-0.16911	-0.00137	**0.89843**	0.06879
Yield loss (pests)	-0.04385	-0.10460	**0.92003**	-0.11546
Ranking –traditional value	-0.16317	**0.73471**	-0.15000	-0.17761
Ranking-food	0.07284	0.24435	0.10668	**-0.71486**
Ranking-Cash	0.20095	0.46079	0.06987	**0.77694**
Ranking-Overall Crop Value	0.09194	**0.97278**	0.02441	-0.02281
Variance explained by:	1.804056	1.802673	1.736745	1.723341
Eigen value	2.2405	1.7550	1.7275	1.3438
Proportion	0.2489	0.1950	0.1919	0.1493
Cumulative variance	0.2489	0.4439	0.6359	0.7852

Table 4: Perceived magnitude of field grain losses due to specific insect pest species

INSECT PEST SPECIES	*NUMBER OF RESPONDENTS*						
	PERCEIVED PERCENT GRAIN LOSSES DUE TO FIELD INSECT PESTS						
	≤10	10.5-20	20.5-30	30.5-40	40.5-50	>50	Mean % loss (± SE)
Cutworms	5	12	8	5	1	1	22.08 ± 2.106
Aphids	1	5	1	5	2	0	27.02 ±3.183
Whitefly	0	1	0	0	0	0	15.25 ±11.911
Maruca spp	0	3	1	0	0	0	17.75 ±5.956
Stem borer	9	30	30	15	6	1	23.70 ±1.249
Beanfly	1	1	3	0	1	0	24.40 ±4.863
Armyworm	2	5	10	6	2	1	26.95 ±2.336
Weevils	6	1	3	1	3	0	23.00 ±3.304
Bruchids	0	0	0	1	0	0	35.25 ±11.911
Tribolium sp	0	0	0	1	0	0	35.25 ±11.911
Pollen beetle	0	0	1	0	0	0	25.25 ±11.911
Bollworm	2	0	3	0	0	0	24.30 ±4.863

Ladybird beetle	0	0	3	0	0	0	25.25 ±6.877
Termites	1	2	2	1	0	1	21.04 ±4.863
TOTALS	27	60	65	35	15	4	206
% of Respondents	13.1	29.1	31.6	17.0	7.3	1.9	100

The overall grand mean field crop yield losses due to specific insect pests were 24.75%.

Table 5: Farmer perceived frequency of insect pest occurrence in cereal and legume crops

CROP	*Cutw* *	*Aphd*	*Mar*	*Stbor*	*Bfly*	*Awo*	*Weev*	*Podb*	*Term*	*Amsa*
	Frequency of pest occurrence among the respondent farmers									
Maize	21	3	0	60	0	23	8	0	5	0
Sorghum	13	3	0	45	0	11	6	0	2	0
Beans	5	15	6	0	10	1	0	7	0	0
Groundnut	0	0	0	0	0	0	0	0	0	1
Cowpea	1	4	2	0	0	0	0	0	0	0
Green gram	0	2	0	0	2	0	0	0	0	0
Totals[θ]	40	27	8	105	12	35	14	7	7	1

*Cutw = cutworm, Aphd = Aphids, Mar = *Maruca* sp., Stbor = Stem borers, Bfly = Beanfly, Awo = Armyworm, Weev = Weevil, Podb = Pod borers, Term = Termites, Amsa = *Amsacta moori*

[θ]Column totals represent the overall farmer perceived frequency of pest occurrence (and hence importance) in Suba district