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Pre-Harvest Assessment of *Sitophilus Zeamais* Motshulsky and *Sitotroga Cerealella* (Olivier) in Major Maize Producing Areas: Evidence from Southern Ethiopia

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Abstract
An assessment of the levels of field infestation of maize to major primary maize stored pests, namely *Sitophilus zeamais* Motshulsky and *Sitotroga cerealella* (Olivier) was carried out in major maize growing district of 'Sidama Zone', Southern Ethiopia in 2002 cropping season. During survey time questionnaries were parepared to know farmers' peception about these two pests and to get information on whether infestation starts at field or at storage and there exist alternative host for *S. zeamais* and *S. cerealella***.** At the same time the distance of maize field from farmer's house and/or storage structure was measured to know the impact of nearness of house and/or storage structure on field infestation. Moreover, cropping pattern together with the history of the field was recorded to know their impact on field infestation of maize by these insect pests. Both *S. zeamais* Motschulsky and *S. cerealella* (Olivier) were recorded from standing maize in the field. Field population of both pests was not significantly different among Peasant Associations (PAs). However, population of the pests varied among farmers' fields within PAs and plots within farmers' fields. More number of *S. zeamais* adults than S. cerealella were recorded both at sampling time and after keeping the sampled cobs in the laboratory for four weeks. Field population of the pests was governed by characteristics of the sheath cover of the cobs. Bare tipped cobs appear to attract more *S. zeamais* than *S. cerealella*. The higher the initial infestation the higher the subsequent damage in the store was observed. This indicates that to reduce damage to the grain in the store management practices shouldn't concentrate only in the store, but should start from the field.The distance of maize field from farmer's residence was negetively coorelated, which indicates that the higher the maize field from the residence of the farmer the lower the pests population. Almost all farmers in the surveyed area considered *S. zeamais* and *S. cerealela* as one species and all know that infestation starts in the field.
Keywords: *Sitophilus zeamais***,** *Sitotroga cerealella*, field infestation, distance of maize

1. INTRODUCTION

Maize (*Zea mays* L.) is the most important food crop grown in Africa and is capable of giving high yield (Assefa, 1981). It is grown on over a million hectares of land, which is 16 per cent of the total cultivated land in Ethiopia. Currently, it ranks first in total production and productivity among all cereals grown in southern Ethiopia. It covers 55.27 per cent of the total area covered by the crops and 74.29 per cent of the crop production of the region (CSA, 2002).

Numerous coleopterous and lepidopterous pests attack maize in storage in Ethiopia (Emana, 1993; Firdissa and Abraham, 1999). Emana (1993) recorded eight insect species belonging to four orders and seven families on stored maize grain in Sidama administrative region. Those include *Sitotroga cerealella* (Olivier), *Sitophilus zeamais* Motschulsky, *Ephestia cautella* (Walker*), Tribolium castaneum (*Herbst*), Tribolium confusum* Jaluelin de val*, Plodia interpunctella (*Hubner*)*, *Rhizopertha dominica* (F.) and *Liposcelis* sp.*, o*f which *S. cerealella* and *S. zeamais* are the most important primary pests.

In the store, insect pests cause losses ranging from 20 to 30 per cent in Ethiopia (Abraham, 1991; Emana, 1993). In Bako area, farmers reported 25 to 33 per cent maize grain losses within six months of storage period. In Sidama administrative region, 30 to 90 per cent crop losses could occur to maize grain stored for five to seven months (Emana, 1993)

Some storage pests like, *S. zeamais* and *S. cerealela* are field to storage pests (Nyiira, 1970; Williams and Floyd, 1971). The adults lay their eggs on mature grains in the field. This field infestation serves as initial inoculum for infestation in the store. The level of infestation in the field determines the level of infestation in the store such that higher field infestation leading to higher infestation in the store (Floyd, 1970; Emana, 1993). The degree of field infestation largely depends on the completeness of the husk cover of the cobs (Gwinner *et al*., 1996). Recently developed high yielding maize hybrids of Ethiopia such as BH140 and BH540 have bare ears at the tip, which expose them to high field infestation of the storage pests such as *S. zeamais* and *S. cerealella* (Emana, 1999). Floyd (1970) reported that maize grain that has 1 - 6 per cent kernel damage at harvest by *S. zeamais* was

severely damaged at 2 - 3 months of storage. Grain stored at zero per cent infestation at harvest was approximately in the same condition after 9 months of storage as was infested grain by *S. zeamais* in 1.5 months of storage. A number of experiments have been done on the management of storage pests at the farm storage level (Emana, 1999). However, little attention was given to control storage pests at the field level, this may be due to the fact that field infestation of maize by *S. zeamais* and *S. cerealella* was not given due emphasis. Therefore, the objective of this paper was to investigate the extent of field infestation of *S. zeamais* and *S. cerealella* in maize.

2. Materials and methods

2.1 Site Description

The field assessment for *S. zeamais* and *S. cerealella* was done in Awassa zuria *woreda* of Sidama zone, Southern Ethiopia. The altitude of areas surveyed ranges from 1510 to 2000 meters above sea level. Awassa Research Center, where laboratory assessment was done, located in southern part of Ethiopia, 275 km from Addis Ababa and the center lies 7^0 04' N Latitude and 38^0 31' E Longitude and at an altitude of 1700 meters above sea level. The type of soil is volcanic origin and is classified in the fluvisol and/or Andosol order. The average annual rainfall of the center for the last 15 years was 1100 mm.

2.2 Field assessment

Fifteen maize fields were assessed for field infestation of maize by *S. zeamais* and *S. cerealella* in 2002 cropping season. In the *woreda,* three Peasant associations (PAs) were selected and from each PA five farmers' fields were randomly assessed two weeks prior to harvest (Russell, 1962). In each field, five ears were selected randomly from 2 m x 2 m plot in eight replications (Russell, 1962). During field assessment similar variety and sowing date were considered. Other alternative host around maize field was also assessed for the occurrence of the pests. Zone, *Woreda* and PAs were selected based on their potential for maize production, while farmers within PA were selected randomly. The experiment was designed in a mixed model nested design.

The ears were inspected for *S. zeamais* and *S. cerealella* adults emergence holes and the presence of all stages of the insects and simultaneously the condition of cobs were described as either bare tipped or complete husk cover. Then each cob was labeled and put in a polythen bag and brought to Awassa Research Center laboratory for further investigation for one month under ambient room temperature (Russell, 1962). The number of new emergence holes of the pests and adult insects were counted 1^{st}, 2^{nd}, 3^{rd} and 4^{th} weeks after keeping the samples in the laboratory.

During field assessment, distance of maize field from the farmers house and/or storage structure was measured to know the impact of nearness of house and/or storage structure on field infestation. Cropping patterns (maize monocropping or intercropping) together with the history of the field (type of crop grown on the field previously) was also recorded.

Questionnaires were prepared to know farmers perceptions about storage pests to get information on, whether infestation starts at field or at storage and whether there exist alternative host for *S. zeamais* and *S. cerealella* or not. *S. zeamais* and *S. cerealella* were kept in vials and farmers were asked whether they observed any of these storage pests before they harvest maize.

2.3 Laboratory assessment

Emergence was also assessed after keeping sampled cobs for four weeks to see the latent infestation, i.e., revealing infestations that were not apparent in some cases at sampling time in the field

3. RESULTS AND DISCUSSION

3.1 Field assessment

There was no significant variation among PAs in terms of number of *S. zeamais* recorded during field assessment (Table 1). However, there were variations among farmers' fields within PAs and among plots within farmers' fields regarding number of *S. zeamais* recorded. The number of *S. zeamais* adults recorded per infested cob ranged from 1 to 35 with a mean value of 7.82.

S. zeamais was recorded from 93.33 per cent of surveyed fields, with 0 - 40 per cent of cob infestation (Table 4). In Tulo PA, field infestation was 100 per cent with the rate of infestation ranging from 2.50 - 22.50 per cent. The total number of *S. zeamais* adults recorded from farmers' fields in Tulo PA ranged from 6 - 58 per 40 cobs. In Gara Rikata PA 80 per cent field infestation by *S. zeamais* was recorded, with the rate of infestation ranging from 0 - 40 per cent. The total number of *S. zeamais* adults recorded from farmers' field in Gara Rikata PA was ranging from 0 - 178 per 40 cobs. In Gamato Galle PA field infestation was 100 per cent with 12.50 - 37.50 per cent infestation. The total number of *S. zeamais* adult recorded from farmers' fields in the PA ranged from 29 - 114 per 40 cobs. In the field *S. cerealella* was recorded from 6.67 per cent of sampled fields with 2.50 per cent of infestation. The result of the present study agrees with reports of previous workers in terms of differential infestation levels. Floyd (1970) reported that the degree of field infestation by *S. zeamais* varies from 0 to 100

per cent in Louisiana. He further indicated that the pest infested about 35 per cent of the ears produced at the time of harvest. Brown and Lee (2002) reported that 15.60 per cent field infestation by *S. zeamais* in Georgia. Weston (1993) explained variations in field infestation by *S. zeamais* and *S. cerealella* on the same variety planted at the same time might be attributed to differences in local population of *S. cerealella*, the direction of fields from the grain storage, the presumed source of the infesting moths, and the local topography.

Attempts were made to know the impact of husk completeness in the field population of *S. zeamais* and *S. cerealella*. In all cases, bare tipped cobs were highly infested by *S. zeamais* than complete husk covered cobs. In bare tipped cobs, the mean per cent infestation by *S. zeamais* was 74, while the mean per cent infestation was 11.78 in complete husk covered cobs. The result of the present study agrees with report of previous worker. Dobie (1977) reported that when *S. zeamais* infested maize ears the major barrier that the pest has to penetrate was the sheath of leaves, which covers the maize ear.

In the case of *S. cerealella* complete husk covered cobs were highly infested than bare tipped cobs. In complete husk covered cobs, the mean per cent infestation by *S. cerealella* was 11.64, while the mean per cent infestation was 9.10 in bare tipped cobs. From the above it can be concluded that in the field *S. cerealella* prefers complete husk covered cobs than bare tipped ones. In the case of *S. zeamais* the vice versa is true. However, to confirm the result repeated assessment of maize field is required.

When we compare population of *S. zeamais* and *S. cerealella* that were recorded from sampled fields, higher population of *S. zeamais* was recorded from field than *S. cerealella* (Tables 4 and 5). Cotton (1956) reported that initial infestation of maize in the field involves only a small percentage of grain by *S. cerealella.* Small amount of infestation in the field, which carried to storage, causes severe damage and loss in the store (Dakshinamurthy and Regupuathy, 1988). Floyd (1970) indicated that in Louisiana an average of 10.60 per cent kernel damage recorded at harvest of which most was caused by *S. zeamais*.

Efforts were made to know per cent of damaged kernels during field assessment. The mean per cent of damaged kernels from field infested cobs was 8.09. However, the over all mean per cent kernel damage was 0.08.

The correlation matrix of field population of *S. zeamais* and *S. cerealella* and the distance of maize field from residence are presented in (Table 6). *S. zeamais* adults emerged from sampled cobs after keeping in the laboratory for four weeks positively correlated with the initial population counted in all PAs during field assessment. In Tulo PA subsequently emerged *S. zeamais* adults population was strongly correlated (r = 0.888) followed by Gara Rikata PA (r = 0.826) and Gamato Galle PA (r = 0.287). The positive correlation indicates that the higher the field population the higher the subsequent poulation, which causes heavey damage in the store. This agrees wth the result reported by Floyd (1970) who reported that subsequent damage to storage was directly related to the amount of infestation in the grain at the time the grain was placed in the store.

Distance of maize field was negatively correlated with *S. zeamais* and *S. cerealella* populations recorded at assessment and one-month incubation in the laboratory. The initial field population of *S. zeamais* was strongly correlated with maize field distance in Gara Rikata PA (r = -0.906) followed by Tulo PA (r = -0.878) and Gamata Galle PA (r = -0.315). Subsquently emerged *S. zeamais* population was correlated most in the Tulo PA (r = -0.835) followed by Gamato Galle PA (r = -0.667) and Gara Rikata PA (r = -0.649). *S. cerealella* population later emerged from laboratory was correlated moderately in Tulo PA (r = -0.719) and Gara Rikata PA (r = -0.348). The negative correlation values between the parameters indicate that the higher the distance of the maize field from residence, the lower the *S. zeamais* and *S. cerealella* population recorded. This agrees with the result reported by Arbogast and Mullen (1988) and Emana (1993) who reported that maize field near to the storage structure or residence encountered higher infestation of *S. cerealella*. High infestation of *S. cerealella* was recorded from rice and maize samples collected in the nearest distance to the farm storage (Singh *et al*., 1979).

3.2 Laboratory assessment

Emergence was also assessed after keeping sampled cobs for four weeks to see the latent infestation, i.e., revealing infestations that were not apparent in some cases at sampling time in the field. There was no significant variation among PAs in terms of number of *S. zeamais* adults emerged (Table 5). *S. zeamais* adults emerged from 100 per cent of sampled fields with the rate of infestation ranging from 32.50 to 80 per cent. The number of *S. zeamais* adults emerged per infested cob ranged between 1 to 264. However, there were variations among farmers' fields within PAs and among plots within farmers' fields (Table 2).

In Tulo PA *S. zeamais* adults emerged from 100 per cent of sampled fields with the rate of infestation ranging from 32.50 to 67.50 per cent. Total number of *S. zeamais* adults emerged from farmers' field in the PA ranged from 67 to 520 per 40 cobs. In Gara Rikata PA also from 100 per cent sampled fields *S. zeamais* adults emerged with the rate of infestation ranging from 32.50 to 77.50 per cent. Total number of *S. zeamais* adults emerged ranged from 86 to 1618. In Gamata Galle PA field infestation was 100 per cent with the rate of infestation ranging from 57.50 to 80 per cent. The total number of *S. zeamais* adults emerged ranged between 149 to 839 per 40 cobs.

There was no variation among PAs interms of *S. cerealella* adults emerged (Figure 1 and Table 3). *S. cerealella* adults emerged from 86.67 per cent of sampled fields, with the rate of infestation ranging from 0 to 30 per cent (Table 5). The number of *S. cerealella* adults emerged per infested cob ranged from 1 to 22. However, there were variations among farmers' fields within PAs and among plots within farmers' fields.

In Tulo PA, *S. cerealella* adults emerged from 80 per cent of the sampled fields with the rate of infestation ranging from 0 to 30 per cent. Total number of *S. cerealella* adults emerged from farmers' field ranged between 0 to 37 per 40 cobs. In Gara Rikata PA field infestation was 100 per cent with the rate of infestation ranging between 5 to 20 per cent. Total number of *S. cerealella* adults emerged from farmers' fields ranged between 5 to 20 per 40 cobs. In Gamata Galle PA from 80 per cent fields *S. cerealella* adults emerged, with the rate of infestation ranging from 0 to 15 per cent. Total number of *S. cerealella* adults emerged from farmers' field ranged between 0 to 40 per 40 cobs.

The degree of subsequent damage to kernels was examined after further keeping shelled kernels in the laboratory for two months. The per cent kernel damage was 20.60 in Tulo PA and 22.20 in Gara Rikata PA, while it was 21.30 in Gamata Galle PA. From this study, it can be concluded that the higher the initial infestation the higher the subsequent damage in the store (Tables 2 and 4). This result agrees with report of previous worker. The level of infestation in the field determines the level of infestation in the store such that higher field infestation leads to higher infestation in the store (Floyd, 1970; Emana, 1993).

4. CONCLUSION

Both *Sitopilus zeamais* Motschulsky and *Sitotroga cerealella* (Olivier) were recorded from standing maize in the field. Field population of both pests was not significantly different among PAs. However, population of the pests varied among farmers' fields within PAs and plots within farmers' fields. In general, more number of *S. zeamais* adults than *S. cerealella* were recorded both at sampling time and after keeping the sampled cobs in the laboratory for four weeks. Field population of the pests was governed by characteristics of the sheath, which cover of the cobs. Bare tipped cobs appear to attract more *S. zeamais* than *S. cerealella*. To have good estimation of field population of *S. zeamais* and *S. cerealella* prior to harvest, it needs a number of surveys and the surveys should cover all maize producing areas of southern region.

The higher the initial infestation the higher the subsequent damage in the store was observed. This indicates that to reduce damage to the grain in the store management practices shouldn't concentrate only in the store, but should start from the field. Cultural control practices such as sowing date adjustment and distance of maize field from potential source of the pests, which showed promising result elsewhere should be practiced under our condition. Some effective botanicals, which have been screened in the laboratory against these two pests, should be tried under field condition before harvest. Many botanical field trials were conducted to reduce field population of storage pests around the world on other crops. In addition to this, there is a need to study the ecology of both pests in order to develop a sound management strategy.

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Table 1. Analysis of variance (Nested ANOVA) for field population of *S. zeamais,* 2002

Source of variation	df	SS	MS	F-value
Between PAs	2.00	239.50	119.7500	2.004^{NS}
Between farmers' fields within PAs	12.00	715.39	59.6158	2.497*, **
Between plots with in farmers' fields	105.00	2507.00	23.8762	1.77*, **
Error	480.00	6456.00	13.4500	-
Total	599.00	9917.89		

Key: NS, not significant; *, ** Significant at P≤ 0.05 and 0.01, respectively

Table 2. Analysis of variance (Nested ANOVA) for *S. zeamais* population emerged in laboratory, 2002

Source of variation	df	SS	MS	F-value
Between PAs	2.00	6662.88	3331.4400	0.790^{NS}
Between farmers' fields within PAs	12.00	50601.28	4216.7733	4.779*, **
Between plots within farmers' fields	105.00	92649.30	882.3742	1.342*
Error	480.00	315630.00	657.5625	-
Total	599.00	465,593.46		

Key: NS, not significant; *, **, Significant at P ≤ 0.05 and 0.01, respectively

Table 3. Analysis of variance (Nested ANOVA) for *S. cerealella* emerged in the Laboratory, 2002

Source of variation	df	SS	MS	F-value
Between PAs	2.00	5.56	2.7800	0.594^{NS}
Between farmers' fields within PAs	12.00	51.17	4.6808	2.104*
Between plots with in farmers' fields	105.00	233.60	2.2248	1.290*
Error	480.00	828.00	1.7250	-
Total	599.00	1123.33		

Key: NS, not significant; *, Significant at $P \leq 0.05$

Table 4. Distance of maize fields from residence, number of *S. zeamais* adults and per cent infestation in Awassa zuria *woreda* during assessment period, 2002

PAs	Field number	Distance of field from residence (m)	*S. zeamais* per 40 cobs	% Cob infested
Tulo	1	21.00	35.00	12.50
	2	20.00	58.00	22.50
	3	40.00	40.00	17.50
	4	65.00	9.00	2.50
	5	100.00	6.00	2.50
Mean	-	49.20	29.60	11.50
Gara Rikata	1	200.00	0.00	0.00
	2	65.00	70.00	20.00
	3	40.00	178.00	37.50
	4	4.00	156.00	40.00
	5	120.00	53.00	25.00
Mean	-	85.50	91.40	24.50
Gamato Galle	1	50.00	34.00	17.50
	2	15.00	29.00	12.50
	3	15.00	114.00	20.00
	4	30.00	46.00	17.50
	5	50.00	64.00	37.50
Mean	-	32.00	57.40	21.00

Table 5. Distance of field from residence, number of *S. cerealella* and *S. zeamais* emerged and per cent infestation in Awassa zuria *woreda* in laboratory assessment , 2002

PAs	Field number	Distance of maize field from residence (m)	*S. cerealella* emerged/40 cobs	% Cob infested	*S. zeamais* emerged/40 cobs	% Cob infested
Tulo						
	1	21.00	29.00	30.00	380.00	57.50
	2	20.00	37.00	22.50	421.00	60.00
	3	40.00	12.00	10.00	520.00	67.50
	4	65.00	0.00	0.00	102.00	45.00
	5	100.00	11.00	5.00	67.00	32.50
Mean		49.20	17.800	13.50	298.00	52.50
Gara Rikata						
	1	200.00	9.00	12.50	86.00	32.50
	2	65.00	3.00	12.50	683.00	60.00
	3	40.00	5.00	5.00	1618.00	62.00
	4	4.00	20.00	20.00	594.00	77.50
	5	120.00	5.00	10.00	141.00	50.00
Mean		85.80	8.40	12.00	624.40	56.50
Gamato Galle						
	1	50.00	42.00	15.00	201.00	57.50
	2	15.00	0.00	0.00	427.00	80.00
	3	15.00	16.00	10.00	654.00	60.00
	4	30.00	10.00	5.00	839.00	80.00
	5	50.00	1.00	2.50	149.00	57.50
Mean		32.00	13.80	6.50	454.00	67.00

Table 6. Correlation matrix of *S. zeamais* and *S. cerealella* population at assessment and after one month incubation in the laboratory and distance of maize field from residence in three PAs of Awassa zuria *woreda* , 2002

Character	TW1	GRW1	GGW1	TW2	GRW2	GGW2	TM2	GRM2	GGM2	TD	GRD	GGD
TW1												
GRW1	-.096											
GGW1	-.088	.653										
TW2	.888*	.089	.283									
GRW2	.391	.826	.760	.606								
GGW2	-.030	.890*	.287	.065	.648							
TM2	.819	-.639	-.476	.585	-.186	-.529						
GRM2	-.573	.319	-.221	-.518	-.162	.599	-.638					
GGM2	.109	-.364	-.079	.348	-.178	-.193	.189	.178				
TD	-.878	.147	.242	-.835	-.249	-.084	-.719	.198	-.486			
GRD	.064	-.906*	-.334	.077	-.649	-.882*	.518	-.348	.627	-.169		
GGD	-.615	-.688	-.315	-.576	-.839	-.667	-.108	.158	.402	.434	.739	

* Significant at P $\leq$0.05

Key: TW1 = Tulo *S. zeamais* population at sampling, GRW1= Gara Rikata *S. zeamais* population at sampling, GGW1 = Gamato Galle *S. zeamais* population at sampling, W2 = *S. zeamais* population emerged from laboratory, M2 = *S. cerealella* population emerged from laboratory, D = distance of maize field from residence

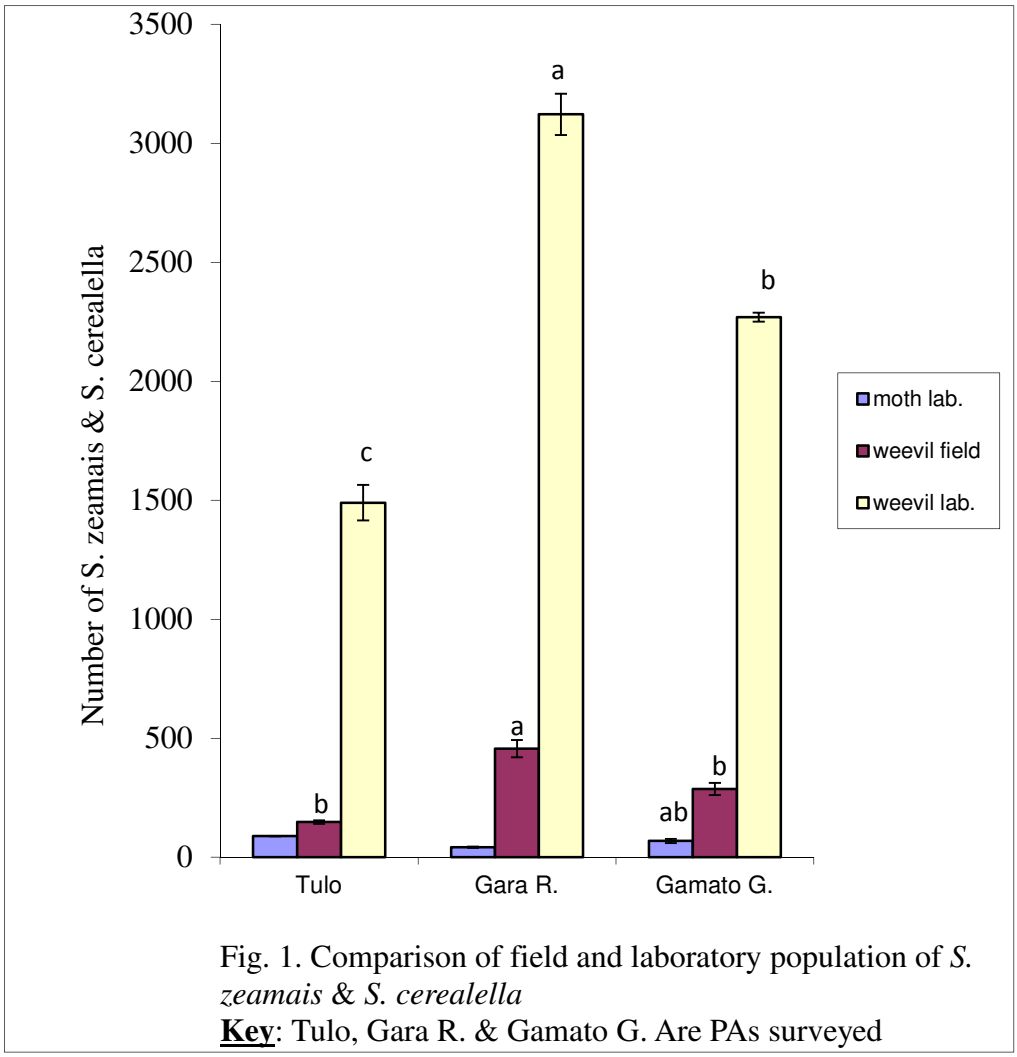

Fig. 1. Comparison of field and laboratory population of *S. zeamais* & *S. cerealella*
Key: Tulo, Gara R. & Gamato G. Are PAs surveyed