INSECT SPECTRUM OF A MIXED CULTIVAR SESAME FIELD

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Abstract

A mixed cultivar (54) of sesame collected from ten Asian, three African and other regions were evaluated in the field for arthropod incidence for three consecutive years between 2005 and 2007. Insects were recorded from as early as 6 days after transplanting to as late as the harvesting day (24 weeks). Arthropods recorded on the plants were from the orders Orthoptera (Pyrgomorphidae), Lepidoptera (Noctuidae and Sphingidae), and Hemiptera (Aphididae, Miridae and Pentatomidae). Predators (Mantodea and Araneae) and pollinating Hymenoptera (bees and wasps) were recorded as well. In a small plot experiment the sesame cultivars were ranked based on the relative incidence frequency and the mean population of insect pests. Eight cultivars including a comparatively susceptible cultivar were selected and sampled for a further season to confirm the insect spectrum after the first two years. Early maturing cultivars like 11Pusan are suspected to employ also evasive mechanisms in avoiding insect pests. In the third season when selected cultivars were kept at the vegetative stage in tandem by debudding the early maturing cultivars during the entire sampling period, 11Pusan became a preferred host amongst the selected cultivars for Myzus persicae and Psilogramma sp. The cultivar 56S. radiatum hosted only Atractomorpha lata in each of the three years irrespective of the number of available cultivars. These results indicate that insect pests of field sesame select their hosts amongst available cultivars based on relative repellent attributes. Although all the cultivars were susceptible to at least one insect, the incidence intensities were graded. Insect population counts on the sesame cultivars over time enabled us to select the high insect aversion cultivars for further insect physiology tests.

Key words: *Sesamum* sp., field arthropods, insect aversion

INTRODUCTION

In spite of the use of all available means of plant protection, about one-third of the world's yearly harvest is destroyed by pests (Raghavendra et al., 2006). Insects have evolved systems that can excrete, sequester, metabolize the xenobiotic or even behaviourally avoid plants (Mello and Silva-Filho, 2002). Plants can also develop an evasive mechanism where maturity period is either shortened or elongated to avoid a pest (Niks and Parlevliet, 1993). Plants employ both physical structures (hairs, spines, wax) and chemical volatiles (antixenosis or antifeedants) to ward off pests or, can re-direct photosynthates to damaged portions to compensate for pest damage in tolerance mechanisms. Plants also sometimes emit volatiles that invite predators as a security, thus bringing to play a tritrophic interaction.

Sesame (*Sesamum indicum*) is one of the plants whose chemical constituents have been of interest recently (Morris, 2002). One of its metabolites, sesamin has been of astronomical interest in plant protection due to its reported synergistic properties with pyrethroids (Gunning, 2005). It is a broadleaf summer crop that belongs to the Pedaliaceae plant family which has bell-shaped flowers and opposite leaves. It is an erect annual plant that can reach two metres in height. Sesame cultivars grown commercially require 90 to 110 days from planting to reach physiological maturity (Oplinger et al., 1990). There is great diversity within the several thousand cultivated sesame cultivars (IPGRI & NBPGR, 2004). It is one plant that thrives in all the continents, and does best especially from 40°N to 40°S latitude. In 2003 there were 16 034 088 acres of sesame that produced 3 048 321 tons (FAOSTAT-Sesame, 2000). Asia produced 73% of the sesame with the three largest producers being China, India, and Myanmar. The sesame cultivars are usually divided into two types: shattering and non-shattering (Weiss, 1983). The cultivars may also be identified with the matured pericarp colour as dark or white (FAOSTAT-Sesame, 2000). Although sesame is touted to be a panacea to resistance slowing due to its sesamin content, (Gunning, 2005), its wide spectrum of cultivars, are each associated with a diverse array of insects, which have been successful using the plant as food. Comparisons between authors working on common plants are often difficult due to normal biological variations relating to cultivar, seasonal, environmental and agronomic practices hence the need to mass up diverse cultivars when one attempts to attribute an insect as a pest of a plant genera.

A key variant to non-morphological characters of sesame includes resistance to pests and diseases including insects (IPGRI & NBPGR, 2004). Insects that have been successful using sesame include the whitefly in Texas and Venezuela (Laurentin et. al., 2003), the green peach aphid and the cabbage looper in India and, thrips, grasshoppers, stink bugs and cutworms in Texas (Oplinger et al., 1990). In Australia and Pakistan the sesame leaf webber and green vegetable bug have been recorded associated with sesame (Bennet, 2004; Talpur et al., 2002). Reported cases of insect incidence on sesame has been suspected to be correlated with varying plant metabolites from different cultivars of which foliar acidity was said to be the determining factor in whiteflies (Laurentin et al., 2003; Berlinger et al., 1983).

The present study was conducted to determine the field arthropod spectrum of sesame, time of incidence and narrow to a few cultivars amongst the multiple cultivar collections.

MATERIALS AND METHODS

The experiment started in April 2005 at the Matsudo campus of Chiba University using a plot with a plant capacity of up to 400 at a planting distance of 45 × 10 cm. A few cultivars with relatively higher insect aversion were needed amongst fifty-four sesame cultivars available at the Crop Science Department, Chiba University. These cultivars had been collected from Asia, Africa and the Americas. The distinguishable features amongst these cultivars are pericarp colour, plant orientation and days to maturity. At the seedling stage, all the cultivars have a spherical leaf shape that changes to variable shapes (from linear to palmate) later in the plants life. The experiment was repeated for three consecutive years at different plant stand densities. The only agronomic practice done after transplanting was weed control using perforated plastic sheets and also seed-sample collection at maturity. In the first season (2005), all the fifty-four cultivars were randomly grown and replicated thrice, with a plant stand of two plants (six plants per cultivar). In the second season (2006) all the 54 cultivars were tested again but the plant density was reduced to four plants per cultivar and in the third season (2007) eight selected cultivars from the earlier two seasons were compared where there were 18 plants per cultivar. In the 2005 and 2006 seasons, cultivars displayed their characteristic life cycle durations between 10 and 24 weeks to maturity but in the last season (2007) all the eight tested cultivars were kept at the vegetative stage. Unlike the first two seasons, inflorescences of the early maturing cultivars amongst these eight were constantly removed to keep them at the vegetative stage in tandem.

Throughout the experiments, there was no plant stand discrimination as all plants were assessed. Insect presence and on which cultivar were recorded from one week after transplanting. In the 2005 and 2006 experiments, sampling was made at weekly intervals initially for four consecutive times (vegetative period), one sampling within the next three weeks (flowering period), two samplings in the next two consecutive weeks (podding period) and the last sampling at maturity (harvesting period). In all there were eight sampling periods between June and November each year. Plants were thoroughly inspected for insects and their numbers were counted. Insects were identified at the Faculty of Horticulture, Chiba University by comparing them to photographic samples or conferring. Six of these species were also kept and used as wild samples and or were mated with our laboratory samples (to prevent inbreeding) that were used in subsequent biochemical experiments (Sintim et al., 2009). Sampling in 2007 was done continuously at weekly intervals for 12 weeks between May and August and unlike preceding years; the insects identified were destroyed after recording.

At the vegetative stage, leaves were collected, and a modified method of Pethkar et. al. (2001) was used in sample preparation prior to pH measurement. Briefly the plant parts were crushed in a mortar with distilled water at a ratio of 1:3 w/v, to smoothness. The supernatant was decanted and this served as the slurry for pH determination. Foliar acidity was measured with a TOA DKK digital pH meter, model WM 22EP.

The insect incidence data collected in the first season, 2005, was used in ranking the cultivars. A ranking method was a sum up of a cultivar's performance against all the insect pests using incidence frequency and population ranks. The frequency rank was based on the number of times an insect species was recorded on a cultivar. Insect population and fluctuation over time was based on the data collected during the 2005 and 2006 seasons which was $\log_{10}$ transformed. The arthropod spectrum was based on observations during the first two years. The cumulative (destructive sampling) insect pests incidence on the eight selected cultivars is based on data collected between May and August 2007.

RESULTS AND DISCUSSION

Sesame is one plant that can host a wide array of insects in different regions. In this study, insects recorded were from the orders Hemiptera, Lepidoptera and Orthoptera. Predators, such as Mantodea and Araneae and also pollinating Hymenoptera were recorded as well as shown in Table 1, and it conforms to reports available on monocrops, by Oplinger et al. (1990). The maturity periods of the cultivars used was from 10 to 24 weeks after transplanting (Table 2). Plants that stay longer on the field are certainly at risk of long exposure to a plethora of insects arriving at different times, unlike short maturing ones that can evade generations of pests in a season. Insect population on the cultivars as presented in Figure 1 is an indication of insect incidence on the cultivars in a perfect polyculture field with multiple cultivars exhibiting diverse plant phenologies and morphologies. Throughout the experimental period, the Orthopterans (Pyrgomorphidae) were recorded on 98.1% (53 cultivars), the Hemipterans (Aphididae) on 83.3% (45 cultivars) and (Pentatomidae) on 33.3% (18 cultivars). The predating Miridae were present on only the cultivar 31Red sesame for three consecutive weeks. The other predators, Araneae (Agelenidae) and Mantodea (Mantidae)) were found on 25.9% (14 cultivars), and the Hymenopterans on 3.3% (2 cultivars). The Hymenoptera was recorded on 11Pusan, an early maturing (11 weeks) cultivar and 51Acc. 8724, a medium maturing (17 weeks) cultivar. The periods of incidence of all the insects were variable but there was an overlap between the 3rd and 6th plant growth stage (Figure 3). *Atractomorpha lata* (grasshoppers) and *Myzus persicae* (aphids) were the first insect pests to colonize a cultivar at the first plant growth stage and their incidence was terminated by the 7th stage. The early observance of the grasshoppers was attributed to the fact that the experimental plot was bordered by a grass field, which is reminiscent of sesame fields bordered by range land in Texas (Dudley et al., 2000). The presence of predators was out of phase especially with the aphids and grasshoppers, (Figure 3). Whilst these two insect pests were recorded between the 1st and 6th growth stages, the predators were present during the 3rd growth stage, peaked at the 6th stage and terminated at plant maturity. These periods of predator incidence were however in consonance with that of the caterpillars and true bugs. The insect-predator numbers had a negligible correlation over time hence the establishment of a tritrophic interaction among the arthropods in this sesame field was ruled out.

When the experiment was repeated in 2007 with eight selected cultivars from the previous experiments, two cultivars 29Bode-5 and 11Pusan that have short phenologies displayed classical insect evasion mechanisms as reported by Niks and Parlevliet (1993). In the 2007 experiment, the cultivars were prevented from fruiting

Tab. 1: Arthropod spectrum of a mixed cultivar sesame field during the growing seasons (2005–2006)

Species	Order	Family	Year present[a] 2005 2006	Incidence[b] (growth stage)
PESTS				
Psilogramma sp.	LEPIDOPTERA	SPHINGIDAE	+ +	3–8
Spodoptera litura		NOCTUIDAE	+ +	2–8
Spodoptera frugiperda				
Trichoplusia ni			– +	6–8
Atractomorpha lata	ORTHOPTERA	PYRGOMORPHIDAE	+ +	1–7
Myzus persicae	HEMIPTERA	APHIDIDAE	+ +	1–7
Halyomorpha halys		PENTATOMIDAE	+ +	3–8
Nezara viridula			+ +	
PREDATORS				
Campylomma chinensis		MIRIDAE	+ +	5–6
Tenodera aridifolia	MANTODEA	MANTIDAE	+ +	3–8
Agelena opulenta	ARANEAE	AGELENIDAE	+ +	4–7
POLLINATORS				
Apis sp.	HYMENOPTERA	APIDAE	+ +	5–8

[a]present +, absent –
[b]The plant growth stages were classified into eight. From week one to four (1 to 4) was vegetative stage, followed by flowering (5) and up to maturity (6 to 8), which were variable and characteristic of the cultivars. Insects were collected on 324 plants (2005: 54 cultivars) and 216 plants (2006: 54 cultivars)

Tab. 2: Characteristics of some fifty-four sesame cultivars and their relative insect aversion levels in a mixed cultivar field

Sesame cultivar	Origin[a]	Pericarp colour	Weeks to maturity	Foliar pH [b]	Ranked insect aversion[c]
29Bode-5	Myanmar	Cream	11	6.0	1
28Bode-4	Myanmar	Reddish	14	6.1	2
37Yasei shu	India	Black	11	5.7	3
24Nanbu-twasaki	Japan	Black	11	5.7	4
8Acc. 761	(others)	Cream	12	6.0	5
36Sciense black	Myanmar	Black	17	6.0	5
46Myanmar	Myanmar	Black	21	5.8	5
47Myanmar	Myanmar	Black	24	5.8	5
2KW 6	(others)	White	10	5.8	6
11Pusan	Korea	White	10	5.9	6
17Acc. 646	(others)	White	11	5.9	6
33Sinyadanar-3	Myanmar	Khaki	11	5.8	6
35Yellow sesame	Myanmar	Yellow	14	6.0	6
27Bode-3	Myanmar	Khaki	14	6.0	7
30Sinyadanar-5	Myanmar	Khaki	17	5.9	7
25Bode-1	Myanmar	Khaki	17	5.9	8
56*S. radiatum*	Cameroon	Khaki	17	5.8	8
26Bode-2	Myanmar	Khaki	20	6.1	9
31Red Sesame	Myanmar	Khaki	10	5.9	9
40Unnan	Japan	Black	21	5.9	9
55Kenya 868	Kenya	Brown	17	5.8	10
12Acc. 201	(others)	Greenish	11	6.2	11
53Sudan 534	Sudan	Cream	17	6.0	11
4White sesame	Myanmar	White	12	6.0	12
10Nanyo	Japan	White	12	5.9	12
14Acc. 227	(others)	Greenish	14	5.9	12
3KW 50	(others)	White	10	6.0	13
16Acc. 630	(others)	White	10	5.9	13
21Chinese-41	China	White	17	5.9	13
22Chinese 41A	China	Khaki	17	6.1	13
6Acc 403	(others)	White	10	5.9	14
9Acc. 778	(others)	Brown	14	6.0	15
18Acc. 773	(others)	Khaki	11	5.9	15
23Afghan 52	Afghanistan	Khaki	17	5.9	16
7Acc. 695	(others)	White	11	5.9	17
19Chinese-35	China	Greenish	11	5.9	17
41Laos	Laos	White	21	5.9	17
5Acc 383	(others)	Cream	10	6.1	18
15Acc. 256	(others)	Whitish	11	6.1	19
20Chinese-36	China	Khaki	14	6.0	20
38Sabah shu	Malaysia	Black	21	5.7	21
44Laos	Laos	White	24	5.7	21
51Acc. 8724	(others)	Golden	17	5.9	21
49Acc. 01751	(others)	Golden	11	5.9	22
50Acc. 017511	(others)	Golden	11	6.1	22
48Laos	Laos	Black	21	5.7	23
39Unnan	Japan	Black	21	5.7	24
13Acc. 201A	(others)	Green	11	6.0	25
34Sinyadanar-3A	Myanmar	Cream	17	5.9	26
45Laos	Laos	White	21	5.9	27
32Land Common	Thailand	Black	11	5.9	28
43Loc Ninh	Vietnam	Black	21	5.9	28
42Laos	Laos	Black	21	5.7	29
1Miedainoujyoshu	Japan	White	11	5.7	30

[a]Others include either above countries or Eritrea, Ethiopia, Guatemala and Bolivia
[b]pH of crushed aqueous leaves (1:3 w/v)
[c]Sum up of a cultivar's performance against all the insect pests using frequency ranks and mean population ranks full stop. The frequency rank was based on the number of times an insect was recorded on a cultivar

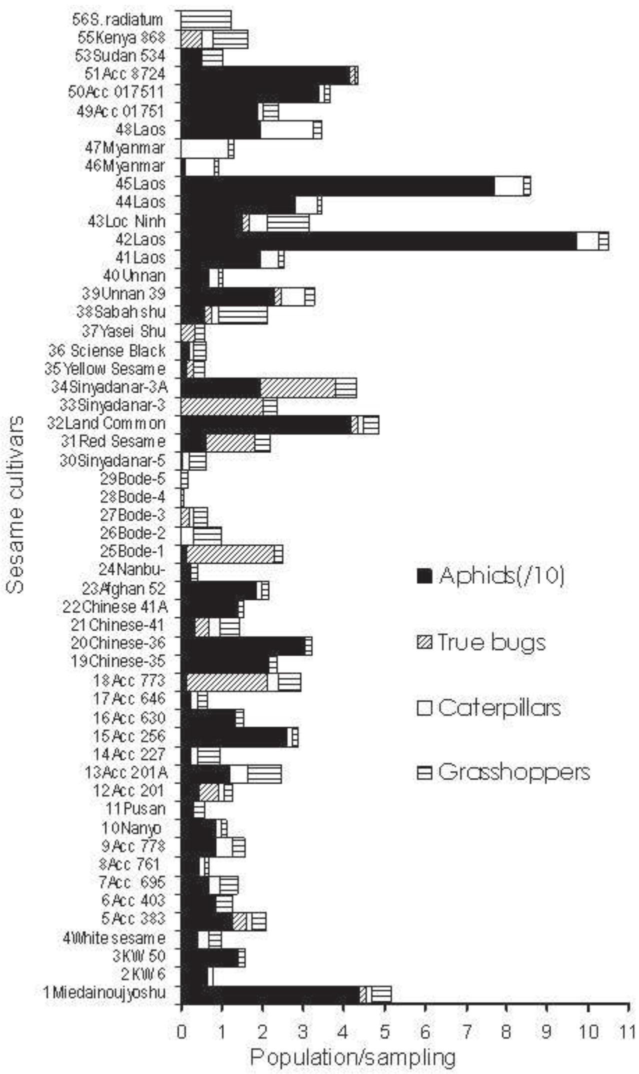


Figure 1: Mean incidence of four major field pests of sesame on fifty four cultivars

Insect population represents eight sampling periods on each cultivar with six plants during the 2005 growing season. Each bar represents the various population means per sampling of the four insect pests

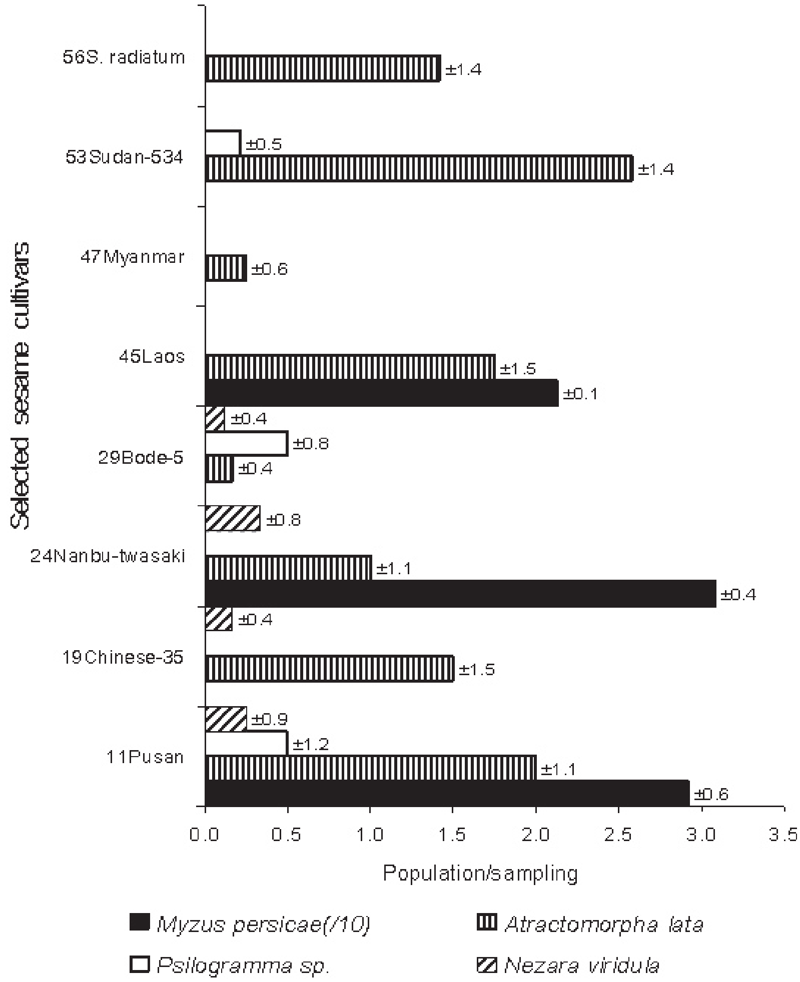
by removing the reproductive parts as they emerge, thus keeping all the eight cultivars in tandem at the vegetative stage. Figure 2 shows the heavy insect attack on 11Pusan and 29Bode-5, which hitherto had been ranked as having a high insect aversion when other cultivars were present in 2005 and 2006. In the 2007 season 11Pusan, 29Bode-5 and 53Sundan-534 hosted *Psilogramma* sp., which was the most voracious insect pest based on population thresholds. *Psilogramma* sp., "furisuzume" is recorded in Japan as an insect whose presence can prevent sesame culture (Hill, 1987). The cultivar 56S. radiatum and 47Mayanmar hosted or attracted only the generalist *Atractomorpha lata* during the 2007 season, thus confirming their high insect aversion abilities in the earlier two seasons. Insect populations on sesame in Japan increases from the 5th plant growth stage (Figure 3) hence early maturing cultivars are able to escape attacks. The incidence of *Psilogramma* sp. for example was sporadic until the 6th plant growth stage. For three years running the populations of *Psilogramma* sp. predictably started from the second week of August irrespective of the plant growth stage.

Foliar pH which Laurentin et. al. (2003) reported (3.53 to 5.99) to be the principal component to whitefly repellency in sesame fields in Venezuela was between 5.66 and 6.16 in the cultivars tested in this experiment and had no influence on the insects sampled perhaps due to the near neutral pH. In an effort to select a few cultivars for further tests, a scoring procedure was devised. The scoring took into consideration cultivar attraction for each insect (number of times that a particular insect was sampled on a cultivar) and then the actual insect population. Cultivars that had an equal score (Table 2) were grouped as a single rank. The cultivars by the ranking procedure; were put into 30 insect pest aversion ranks.

Figure 2: Insect pest species sampled amongst eight selected sesame cultivars (April–August 2007)

Sampling of insect population was done once per week for 12 consecutive weeks. Each cultivar had 18 plants. Sampling of insects was destructive or cumulative. Bars are means with ±SD of insect counts on 114 plants of each cultivar over the experimental period.

Other sporadic insects which were identified included: *Trichoplusia ni* (one in the 6th week) and *Polistes* sp. (two at flowering)



Due to the large number of cultivars of sesame, it would be very difficult to classify sesame in totality as either an insect resistant or susceptible genus. Each of the thousands of cultivated sesame varieties or wild types comes with distinct attributes as seen in their morphological characteristics, from pericarp colour, plant height, pod shape and maturity period among others. Inheritable characters such as pubescence, hardiness or secondary metabolites would rather be a better attribute of sesame to rely on as resistance features. Already the lignans; sesaminol, sesamol, sesamolin and sesamolinol originating from sesame are making strides in the medical field due to their antioxidant properties as well as in contact dermatitis or allergy in humans. Sesamin has also been mentioned to have a synergistic effect with pyrethroids, whilst chlorosesame (a compound identified in sesame), is said to possess antifungal properties. Since sesame has an advantage of plasticity in geographical occurrence, cultivars that gave a high insect aversion like 56S. radiatum (which for three consecutive years supported only grasshoppers) and others in this study calls for further research into the mechanism of the bioactivity and the possibility of separating and identifying the phytochemicals concerned. The physiological and biochemical burdens that these cultivars pose as insect diet are a subject being considered. Although the aerial parts of sesame are the

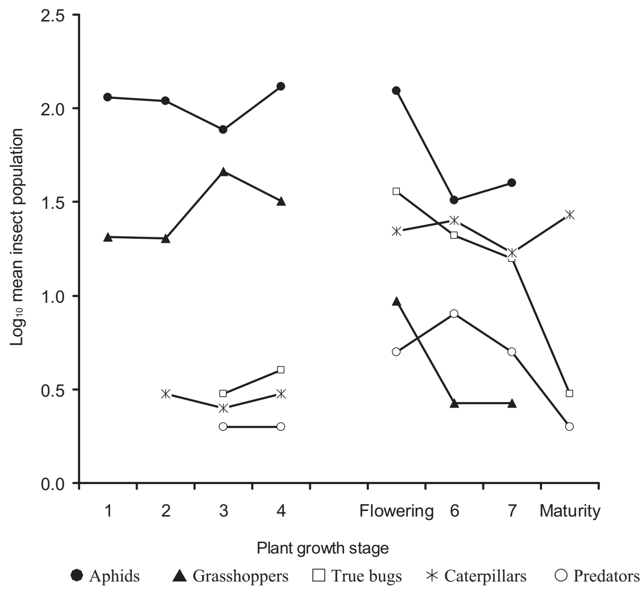


Figure 3: A Log_{10} (mean+1) plot of the insect pest incidence in a mixed plant micro-plot over time pooled for two sesame growing seasons (2005–2006)

The plant growth stages were classified into eight. From week one to four (1 to 4) was vegetative stage, followed by flowering (5) and up to maturity (6 to 8) which were variable and characteristic of the cultivars. Insects were collected on 324 plants (2005: 54 cultivars) and 216 plants (2006: 54 cultivars).

organs in contact with field insects, it must be said that all the reports available on the bioactivity of sesame phytochemicals have dwelt on the oil or seed and especially its phyto-estrogen effects on mammals (Fuss, 2003). The closest that authors came in revealing an ecological interaction between sesame leaves and insects, is that of Laurentin et al. (2003) who related the foliar pH of six sesame genotypes to whitefly resistance.

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Received for publication on November 18, 2009
Accepted for publication on October 18, 2010

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