

Sweet Corn Insect Pests and their Control

แมลงศัตรูข้าวโพดและการป้องกันกำจัด

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ABSTRACT

A study was undertaken at the agricultural farm of Khon Kaen University. Seven treatments were compared as follows: T1 control (no management of pests), T2 carbofuran 3%G, T3 one release of brown earwig *Proreus simulans*, T4 two releases of brown earwig *P. simulans*, T5 two releases of black earwig *Euborellia annulipes*, T6 two releases of *P. simulans* with two releases of *Trichogramma* sp. and T7 two releases of common brown earwig *Labidura riparia*. A total of 22 insect pest species (both seasons), 16 (dry season), and 14 (wet season) species of natural enemies were recorded. Pests that were noted as causing severe injuries to sweet corn were corn borer (*Ostrinia furnacalis*), corn earworm (*Helicoverpa armigera*), and aphid (*Rhopalosiphum maidis*). Natural enemies were spiders, brown earwig (*P. simulans*), coccinellids (*Menochilus sexmaculatus*, *Micraspis discolor*). In the dry season, the percent plant damage at day 49 of T1 and T5 were highly significant difference to T2, T4 and T6 at $P \leq 0.01$ ($P=0.0001$). The percent plant damage at day 56 of T5 and T7 were highly significant difference to T1, T2, T3, T4 and T6 at $P \leq 0.01$ ($P=0.0001$). The percent plant damage at day 63 of T5 was highly significant difference to T1, T2, T3, T4, T6 and T7 at $P \leq 0.01$ ($P=0.0001$). Benefits of T2, T3, T4, T5 and T6 were highly significant difference to T1 and T7 at $P \leq 0.01$ ($P=0.006$). In wet season, percent plant damage at day 56 of T1 was highest (27.5%) and highly significant difference to T2, T3, T4, T5, T6 and T7 at $P \leq 0.01$ ($P=0.0001$), respectively. Ear damage was highest (12.34%) at the control (T1) and was highly significant difference at $P \leq 0.01$ ($P=0.002$) to T5, T6 and T7.

บทคัดย่อ

การศึกษานี้ได้ปฏิบัติ ณ ฟาร์มมหาวิทยาลัยขอนแก่น มี 7 วิธีการประกอบด้วย แปลงควบคุม (T1) การใช้สารคาร์โบฟูราน (T2) การปล่อยแมลงหางหนีบน้ำตาล (*Proreus simulans*) 1 ครั้ง (T3) การปล่อยแมลงหางหนีบน้ำตาล 2 ครั้ง (T4) การปล่อยแมลงหางหนีบสีดำ (*Euborellia annulipes*) 2 ครั้ง (T5) การปล่อยแมลงหางหนีบน้ำตาล 2 ครั้ง ร่วมกับการใช้แตนเบียนไข่ *Trichogramma* sp. (T6) และ การปล่อยแมลงหางหนีบ

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Labidura riparia 2 ครั้ง (T7) ผลการศึกษาในสองฤดูกาล พบแมลงศัตรู 22 ชนิด ศัตรูธรรมชาติพบ 16 ชนิด ในฤดูแล้ง และ 14 ชนิด ในฤดูฝน แมลงศัตรูที่สำคัญได้แก่ หนอนเจาะลำต้นข้าวโพด หนอนเจาะสมอฝ้าย เพลี้ยอ่อน ศัตรูธรรมชาติที่พบมากได้แก่ แมงมุม แมลงหางหนีบ ตัวเต่าลาย การประเมินความเสียหายของลำต้นที่เกิดจากหนอนเจาะลำต้นข้าวโพด ในฤดูแล้งพบว่าต้นข้าวโพดถูกทำลายเมื่ออายุ 49 วัน ที่แปลง T1 และ T5 มีความแตกต่างอย่างมีนัยสำคัญยิ่งทางสถิติกับ T2 T4 และ T6 $P \leq 0.01$ ($P=0.0001$) ข้าวโพดถูกทำลายเมื่ออายุ 56 วัน ที่แปลง T5 และ T7 มีความแตกต่างอย่างมีนัยสำคัญยิ่งทางสถิติ กับ T1 T2 T3 T4 และ T6 $P \leq 0.01$ ($P=0.0001$) ข้าวโพดถูกทำลายเมื่ออายุ 63 วันแปลง T5 มีความแตกต่างอย่างมีนัยสำคัญยิ่งทางสถิติกับ T1 T2 T3 T4 T6 และ T7 $P \leq 0.01$ ($P=0.0001$) รายได้ T2 T3 T4 T5 และ T6 มีความแตกต่างอย่างมีนัยสำคัญยิ่งทางสถิติกับ T1 และ T7 $P \leq 0.01$ ($P=0.006$) ในฤดูฝนพบว่าเมื่อข้าวโพดอายุ 56 วัน แปลงควบคุม (T1) เสียหายสูงสุด 27.5% ต่างจาก T2, T3, T4, T5, T6 and T7 อย่างมีนัยสำคัญยิ่งทางสถิติ $P \leq 0.01$ ($P=0.0001$) ฝักข้าวโพดถูกทำลายสูงสุด 12.34% ในแปลงควบคุม (T1) แตกต่างกันอย่างมีนัยสำคัญยิ่งทางสถิติกับแปลง T5, T6 และ T7

Key Words : Sweet corn, insect pest, pest control

คำสำคัญ : ข้าวโพดหวาน แมลงศัตรูพืช การควบคุม

Introduction

Sweet corn production is rapidly increasing in Asian region, especially in Eastern and Southeast Asia. Production has increased from 87 million tons in 1980 to 167 million tons in 1999. In Thailand, sweet corn is economically important crop and its importance is projected to increase in the future (Kongkanjana and Choonhawong, 1997). It popularly grows in several parts of the country. Many varieties have been being grown. Sweet and waxy corn are popular and suitable to grow for the farmers in the remote areas of Thailand. They also are the alternation of consumers. Especially, the first supper sweet bicolor was released in 1994 and widespread throughout the country (Lertrat and Bussarakul, 1999). In 2001, sweet corn was grown on approximately 56,000 ha with 437,000 tons produced. In tropical

and subtropical regions, insects generally cause more damage to sweet corn than diseases; over half of the area under sweet corn is seriously affected by insect problems (Granados et. al. 2000). However, of the large number of insect species that feed on the corn plant, only a few cause damage of economic importance. (Kongkanjana and Choonhawong (1997) reported that 76 insect species have been reported in Thailand, but only 8–9 species are common. Jamjanya et al. (2000) reported that the major pests of sweet corn in Northeastern Thailand are corn stem borer (*Ostrinia furnacalis*) and corn earworm (*Helicoverpa armigera*) with damage of 10–65%. The status of existing natural enemies is assessed from surveys. If a priority objective is to conserve, augment and use natural enemies then surveys and evaluation need to be undertaken regularly

(Napompeth, 2001). Furthermore such objectives will provide a better understanding of the diversity of natural enemies, which provides a solid basis for making decisions on the likely efficacy of biological control and integrated pest management. In the past three decades, entomologists have developed several new control methods that have become part of the integrated pest management concept, since they are effective and have minimal disruptive effects in ecosystem.

Biological control of *O. furnacalis* is an attractive alternative to insecticidal control because of environmental and health issues associated with insecticide use. A number of egg parasitoids (largely Trichogrammatidae, Hymenoptera) have been considered for biological control of *O. nubilalis* (Smith, 1996). However, he reported only one case where biological control of *Ostrinia* spp. in corn using *Trichogramma* sp. was considered to be economically feasible. Siri et al. (2003) reported that *Proreus simulans* is predator which can control populations of many insect pest species such as corn armyworm, corn earworm, corn aphid. They have been found to be a particularly effective predator in sweet corn field. The optimum rate is 100 insects /rai (625 per ha). In Thailand, there are total of 62 species of helpful lady beetles (Chunram, 2002). These potential are encouraging and strategies to promote their effectiveness need to be developed, leading to environment friendly and sustainable production of sweet corn. My study of current pests and natural enemies of sweet corn was conducted to strengthen integrated pest management through releasing natural enemies against corn borer *O. furnacalis* and other pests.

This study aims to: (i) identify the abundance of insect pest species and their natural enemies in sweet corn crops; (ii) determine the relative potential of different species of natural enemies as biological control agents; (iii) assess crop losses from the economic important pest species; (iv) determine an appropriate strategy for integrated pest management of insect pests of sweet corn.

Materials and methods

These experiments were conducted in horticulture research farm of Khon Kaen University during May to July 2004 and November 2004–January 2005. The experiment designed is a Randomized Completed Block Design (RCBD) with 7 treatments and 4 replications. Plot size is 4mx 6.5m. A non released control plot (T1) was compared with 6 other plots which were treated with carbofuran 3%G at 37.5kg/ha (T2), one release of brown earwig (*Proreus simulans*) (T3), two releases of brown earwigs (*P. simulans*) (T4), two releases of black earwigs (*Euborellia annulipes*) (T5), two releases of brown earwigs (*P. simulans*) plus two releases of *Trichogramma* sp. 30,000 wasps/rai (T6) and two releases of common brown earwig *Labidura riparia* (T7). One individual per each hill (equal to 4 earwigs per square meter) of third instar or adult earwigs (1:3) were released 30 and 40 days after planting. Carbofuran was single application per crop season at 30 days after planting (DAP) and *T. ostriniae* was released also at 30 and 40 days after planting in the pupae stage. The fresh host egg of rice grain moth was glued to paper card (1x1cm), then introduced to the UV cardboard for 15 minute and then introduces to the glass tubes harboring for 5 days under rearing standard condition 25°C.

The parasitized pupae were distributed in the field just prior to emergence of the adult wasps. The card staples closed to the corn leaf in the center of the plot. Totally 30,000 wasps per rai were released (Siri et al., 2003). Corn was planted in 11 May 2004 and 08 November 2004; 5 rows and 20 plants per row were planted with a spacing 30x80 cm. Fertilizer 15-15-15 was applied as basal with a rate of 30 kg/rai (195kg/ha). Urea 46-0-0 was applied in 30kg/rai at 21 and 57 DAP. Insects were monitored at 14, 21, 28, 35, 42, 49, 56 and 63 DAP. Twenty plants from 3 rows 3 rows inside each plot were randomly checked insect pests and natural enemies on each leaf, stem, tassel and ear. Sucking species particularly corn aphids were recorded on a scale of 0-3:0 = no insects, 1 = 1-50 individuals, 2 = 51-100 and 3 $\geq$ 100 (Jamjanya et al., 2002). Corn borer damage stalk was particularly focused by checking plant tunnel and ears for damage. Fresh ears were harvested from 3 rows in the middle of the plots when the corn reached 65DAP. Ear quality was graded in 4 categories A> 17 cm, B $\leq$ 17-15cm, C $\leq$ 15-13cm and D<13cm. All ears were measured for width and length and the characteristics from *O. furnacalis* *H. armigera* were recorded. All ears were weighed and converted to ton per hectare. Total ears damaged and undamaged were counted. Earwig population density was recorded from cut tillers during one week after harvest. Yield, plants damaged (%), marketable, unmarketable ears, and benefits were analyzed using variance (ANOVA) in RCBD (SAS, 1985). Means of all treatments were compared by DMRT.

Results and discussions

1. Insect pests, natural enemies of sweet corn and damage assessment

In the sweet corn field experiments, 22 insect pest species were recorded, and 16 and 14 species of natural enemies for dry and wet seasons, respectively, were recorded from 17 field surveys (Table 1, 2 and 3). Insects noted as causing severe or moderate injuries were as follows: corn borer (*O. furnacalis*), corn earworm (*H. armigera*), corn armyworm (*Mythimna separata*), and aphids (*Rhopalosiphum maidis*); those causing light injuries were: corn looper (*Phytometra chalytes*), corn thrip (*Frankliniella williamsi*), derbid planthopper (*Phenice moesta*), rose beetle (*Adoretus compressus*), cletus bug (*Cletus trigonus*), mirid bug, leaf eating beetle (*Monolepta signata*), leafhopper (*Bothrogonia* sp.), rice green bug (*Nizara viridula*) and hairy caterpillar (*Orgyia turbata*). Mole crickets (*Gryllotalpa africana*) were only presented in the first and second weeks after germination, with damage severe in the first week only. Corn thrips were also present at high densities from the second and third weeks after planting, but their infestation levels were lower in the fourth and fifth weeks after planting. Corn aphid infestation varied between the dry and wet seasons: there was higher infestation in the dry season during the tassel stage at 49 DAP. The average number of individuals per plant was 29.56, 22.68, 3.75, 34.14, 1.25 and 27.03 in T1, T3, T4, T5, T6 and T7, respectively; at 56 DAP in the wet season the average number of individuals per plant was 0.64, 0.13, 0.06, 0.05 and 0.1 in T1, T2, T5, T6 and T7, respectively (Figure1).

The corn borer (*O. furnacalis*) first appeared in the sweet corn plantation in the third week after planting; they fed on the leaf blade and leaf-sheath. However, stem tunnel incidence considerable increased from the fifth week after planting up to harvest. Corn thrip appeared in the second week after planting and its occurrence appeared to be associated with weather condition. The population density increased when it was dry and warm but numbers drastically fell when there was frequent rain and high humidity. Other pests such as corn aphids were relatively low in number. This may be due to frequent rain, an encounter of effective predators such as coccinellids, spiders and others. There was high mortality of insect pests and predators in treatment of carbofuran 3% from two days after application. Low percent plant damage was observed during one week application and damage was moderate three weeks later. Ear damage quickly increased from 42 DAP until harvest. Low percent stalk damage for all treatments was observed if compared with December 2003; the mean damage was greatest in the reproductive stage at 75.56%, with some fields having incidences as high as 100 % (Douangboupha et al., 2004). In the group of natural enemies, predators were more common than parasitoids. These included wolf spider (*Lycosa pseudoannulata*), long-jawed spider (*Tetragnatha mandibulata*), brown earwigs (*P. simulans*), coccinellids (*Menochilus sexmaculatus*, *Micraspis discolor*), and long horned-grasshoppers (*Conocephalus maculatus*). Black ants (*Componotus* sp.) occurred commonly, while the big eyed bug (*Geocoris* sp.), green lacewing (*Chrysopa* sp.) and the rove beetle (*Paederus fuscipes*) were less prevalent. Crop damage was assessed for plant tunnel (mainly from corn borer) and ear damage (from both corn borer and corn

earworm) and is summarized in Tables 4 and 5. There was no plant damage from *O. furnacalis* during the early three surveys at 14, 21, 28 DAP. In the dry season, plant damage at 35 and 42 DAP was higher than in the wet season and occurred in almost all treatments. Percent plants with tunnels were more consistent at 49 DAP with 15.00, 1.25, 8.79, 1.25, 22.50, 2.50 and 10.00; at 56 DAP with 8.75, 7.50, 5.00, 5.00, 30.00, 2.50 and 21.25; at 63 DAP with 18.75, 6.25, 2.50, 4.00, 56.00, 0.00 and 22.5 in T1, T2, T3, T4, T5, T6 and T7, respectively (Table4). In the wet season, it was more consistent at 49 DAP with 28.7, 22.5, 15.0, 16.2, 17.5, 18.7 and 27.5; at 56 DAP with 27.5, 20.0, 16.2, 13.7, 18.7 and 17.5 in T1, T2, T3, T4, T5, T6 and T7, respectively (Table5). Plants with tunnels (%) were often high in the control (T1) and carbofuran (T2) plots.

2. Feature of control methods

In dry season, the percent plant damage at day 49 in T1 and T5 were highly significant difference to T2, T4 and T6 at $P \leq 0.01$. The percent plant damage at day 56 in T5 and T7 were highly significant difference to T1, T2, T3, T4 and T6 at $P \leq 0.01$. The percent plant damage at day 63 in T5 was highly significant difference to T1, T2, T3, T4, T6 and T7 at $P \leq 0.01$. Percent ear damage, yield, marketable and unmarketable ears between treatments were not significantly different. Benefit cost was highest (54,112 Baht/ha) in T4 and was highly significant difference ($P \leq 0.01$) with T1 and T7 but not with T2, T3, T5 and T6 (Table 4). In the wet season, the plant damage at 49 DAP was not significantly different. However, it was highest at 56 DAP (27.5%) in T1 and was highly significant

difference ($P \leq 0.01$) with all treatments. Ear damage was found highest (12.34%) at control (T1) and was highly significant difference ($P \leq 0.01$) with T5, T6 and T7 but there was no difference with T1, T2, T3 and T4. However, yield, marketable, unmarketable ears and benefit cost between treatments were not significantly different (Table 5). The distribution of brown earwig before and after releases between seven treatments in wet and dry seasons is shown in Figures 2 and 3. After harvest the brown earwig was found in all released and non released plots in T1, T2, T3, T4, T5, T6 and T7 with 0.38, 0.54, 1.85, 1.36, 0.46, 1.35 and 0.15 individuals per tiller, respectively, in the wet season. Except for T5, they were also higher in T1, T2, T3, T4, T6 and T7 by 0.16, 0.09, 1.11, 1.86, 2.95 and 0.03 individuals per tiller, respectively. IPM in sweet corn through a mean release of 4.37 individuals of *P. simulans* per tiller was effective because it maintained many pests under their economic threshold. This impact was equivalent to that obtained from 2 chemical applications (Choonhawong et al., 1999). The percentage of unmarketable ears in the treatment *P. simulans* with *Trichogramma* sp. reached 6.4–7.4% which is a little higher than the threshold level (5%) of damage that is accepted by growers (Riggs et al., 1998). Yield and ear damage in carbofuran treatment were not different from others, it may be because of high mortality of predators after the application. We also observed that there was high mortality of adult *P. simulans* in the two–three weeks after their release, apparently from fungus during the wet season. Although yields in all treatments where we released three species of earwigs; these yields were higher than both the control and carbofuran treatment.

Conclusions

Sweet corn sucking insects are more abundance than chewing insects but they are opposite in condition of crop damage. Total 22 insect pest species were recorded in both dry and wet season 2004 in vegetable farm of Khon Kaen University. Insect pests were causing severe damage to sweet corn are corn borer (*O. furnacalis*), corn earworm (*H. armigera*), corn armyworm (*M. separata*), and aphids (*R. maidis*); causing light injury were corn thrip (*F. williamsi*) derbid planthopper (*P. moesta*), rose beetle (*A. compressus*) and mole crickets (*G. africana*). Total 16 and 14 species of natural enemies were found in dry and wet seasons. Among them, predators are the most number than parasitoids. Coccinellids (*M. sexmaculatus*, *M. discolor*), common natural enemies such as spiders were found at most survey fields. This study was demonstrated positive results of combination releases of 2 releases of *P. simulans* per tiller with *Trichogramma* sp. in dry season (October–February) but it inadequate to control pest in wet season (April–September) because of higher damage than economic threshold and high mortality of *P. simulans* from fungus. Further work is required in the appropriated handle technique while insect released to be avoided insect pain, particularly *P. simulans*. An appropriated rate when damage situation is high level. Third instar of brown earwig is better to be released, because it can be survived longer than adult. If adults, male and female should be released together in the same tiller to support their reproduction.

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Table 1 Insect pests of sweet corn in Khon Kaen University research farm in wet and dry seasons May-July 2004 and November 2004-January 2005

No.	Common name	Scientific name	Day after planting						Insect stage	Crop damage
			21	28	35	42	49	56		
1	Corn thrip	<i>Frankliniella williamsi</i> Hood	0.68	0.01	0.00 ^{1/}	0.00	0.00	0.00	Nymph&adult	Leaf
2	Corn aphid	<i>Rhopalosiphum maidis</i> (Fitch)	0.26	0.03	0.00	0.00	0.49	0.13	Nymph&adult	Leaf, tassel
3	Corn earworm	<i>Helicoverpa armigera</i> (Hubner)	0.00	0.00	0.00	0.00	0.00	0.03	Larvae	Leaf, ear
4	Corn borer	<i>Ostrinia furnacalis</i> Guenee	0.00	0.01	0.01	0.13	0.07	0.25	Larvae	Tip, ear, stem
5	Corn looper	<i>Phytometra chalybeis</i> Esp.	0.17	0.04	0.27	0.23	0.99	0.94	Larvae	Leaf
6	Corn armyworm	<i>Mythimna separata</i> Walker	0.02	0.03	0.02	0.01	0.01	0.01	Larvae	Leaf
7	Cletus bug	<i>Cletus trigonus</i> Thumb	0.05	0.04	0.01	0.08	0.02	0.05	Adult	Leaf
8	Miriid bug	<i>unidentified.</i>	0.00	0.16	0.11	0.03	0.03	0.05	Adult	Leaf
9	Leaf eating beetle	<i>Monolepta signata</i>	0.00	0.04	0.08	0.05	0.13	0.08	Adult	Leaf
10	Rice grasshopper	<i>Hieroglyphus banian</i> Fabricius	0.00	0.00	0.00	0.01	0.02	0.02	Adult	Leaf
11	Common black cricket	<i>Gryllus bimaculatus</i> DeGeer	0.05	0.04	0.03	0.00	0.00	0.00	Adult	Leaf
12	Common red cricket	<i>Gryllus testaceus</i> Walker	0.02	0.02	0.02	0.00	0.00	0.00	Adult	Leaf
13	Mole cricket	<i>Gryllotalpa africana</i>	0.13	0.05	0.00	0.00	0.00	0.00	Adult	Root
14	Bombay locust	<i>Patanga succincta</i>	0.00	0.00	0.00	0.00	0.08	0.03	Adult	leaf
15	Leaf eating weevil	<i>unidentified</i>	0.01	0.00	0.00	0.00	0.00	0.01	Adult	Leaf
16	Detribid planthopper	<i>Phenice moesta</i>	0.00	0.00	0.00	0.84	0.55	0.25	Adult	Leaf
17	Leafhopper	<i>Bothrogonia</i> sp.	0.16	0.17	0.1	0.07	0.13	0.02	Adult	Leaf
18	Rose beetle	<i>Adoretus compressus</i> (Weber)	0.00	0.00	0.00	0.02	0.00	0.02	Adult	Leaf
19	Sap beetle	<i>Carpophilus dimidiatus</i> Fabricius	0.00	0.01	0.01	0.02	0.02	0.00	Adult	Grain
20	Pink stem borer	<i>Sesamia inferens</i>	0.00	0.00	0.00	0.04	0.07	0.00	Larvae	Stalk
21	Rice green bug	<i>Nazara viridula</i>	0.00	0.00	0.00	0.00	0.09	0.01	Adult	Tassel
22	Leaf eating Caterpilliar	<i>Orgyia turbata</i> Butler	0.00	0.00	0.03	0.02	0.00	0.00	Larvae	Leaf

^{1/}-.Average insect per 80 tillers

Table 2 Natural enemies of sweet corn insect pests at Khon Kaen University research farm in dry season November 2004–January 2005

No.	Common name	Scientific name	Day after planting								Insect stage
			14	22	28	35	42	49	56	63	
1	Lady bird beetle	<i>Micraspis discolor</i>	0.02	0.02	0.00	0.01	0.00 ^{1/}	0.00	0.03	1.6	Larvae, adult
2	Lady bird beetle	<i>Menochilus sexmaculatus</i>	0.00	0.00	0.04	0.00	0.00	0.07	0.02	0.12	Larvae, adult
3	Green lacewing	<i>Chrysopa</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.02	Egg, larvae, adult
4	Lady bird beetle	<i>Coccinella transversalis</i>	0.00	0.00	0.00	0.01	0.02	0.02	0.06	0.27	Larvae, adult
5	Predatory bug	<i>Eocanthecona furcellata</i>	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	Nymph, adult
6	Black ant	<i>Componotus</i> sp.	0.00	0.00	0.02	0.00	0.03	0.02	0.02	0.07	Adult
7	Egg parasite	<i>Trichogramma</i> sp.	0.01	0.03	0.01	0.02	0.08	0.03	0.07	0.07	Adult
8	Black earwig	<i>Euborellia annulipes</i>	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	Nymph, adult
9	Brown earwig	<i>Proreus simulans</i>	0.00	0.00	0.25	0.2	0.17	0.05	0.01	0.02	Egg, nymph, adult
11	Big-eyed bug	<i>Geocoris</i> sp.	0.01	0.01	0.01	0.01	0.02	0.03	0.01	0.00	Nymph, adult
12	Spiders	<i>Lycosa</i> sp., <i>Tetragnatha</i> sp.	0.21	0.27	0.3	0.35	0.32	0.27	0.33	0.69	Nymph, adult
13	Mantid	<i>unidentified</i>	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	Adult
14	Long-horned grasshopper	<i>Conocephalus maculatus</i>	0.14	0.01	0.00	0.00	0.02	0.00	0.00	0.00	Adult
15	Syrphid fly larvae	<i>unidentified</i>	0.00	0.01	0.01	0.04	0.00	0.05	0.09	0.43	Larvae, adult
16	Rove beetle	<i>Paederus fuscipes</i>	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.00	Adult

^{1/}–Average insect per 80 tillers

Table 3 Natural enemies of sweet corn insect pest at Khon Kaen University research farm in wet season May-July 2004

No.	Common name	Scientific name	Day after planting							Insect stage
			14	21	28	25	42	49	56	
1	Lady bird beetle	<i>Micraspis discolor</i>	0.05	0.03	0.02	0.03	0.02	0.00 ^{1/}	0.02	Larvae, adult
2	Lady bird beetle	<i>Menochilus sexmaculatus</i>	0.00	0.04	0.03	0.04	0.05	0.03	0.05	Larvae, adult
3	Green lacewing	<i>Chrysopa</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.08	Egg, larvae, adult
4	Lady bird beetle	<i>Coccinella transversalis</i>	0.00	0.00	0.00	0.03	0.04	0.04	0.06	Larvae, adult
5	Predatory bug	<i>Eocanthecona furcellata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.13	Nymph, adult
6	Black ant	<i>Componotus</i> sp.	0.00	0.04	0.03	0.07	0.04	0.04	0.03	Adult
7	Egg parasite	<i>Trichogramma</i> sp.	0.04	0.00	0.00	0.08	0.09	0.06	0.08	Adult
8	Black earwig	<i>Euborellia annulipes</i>	0.00	0.00	0.00	0.00	0.08	0.04	0.07	Nymph, adult
9	Brown earwig	<i>Proreus simulans</i>	0.00	0.08	0.00	0.08	0.07	0.03	0.06	Egg, nymph, adult
10	Big earwig	<i>Labidura riparia</i>	0.06	0.06	0.06	0.00	0.06	0.00	0.00	Nymph, adult
11	Big-eyed bug	<i>Geocoris</i> sp.	0.00	0.00	0.00	0.05	0.00	0.06	0.08	Adult
12	Spider	<i>Lycosa</i> sp., <i>Tetragnatha</i> sp.	0.03	0.02	0.04	0.05	0.05	0.04	0.05	Nymph, adult
13	Mantid	<i>unidentified</i>	0.05	0.00	0.00	0.04	0.11	0.04	0.05	Adult
14	Long-horned grasshopper	<i>Conocephalus maculatus</i>	0.05	0.04	0.03	0.02	0.03	0.03	0.03	Nymph, adult

^{1/}. Average insect per tiller from 80 tillers

Table 4 Stalk, ear damaged by corn borer, yield, marketable-unmarketable ears and return cost of sweet corn at Khon Kaen University research farm in dry season 08 November 2004-18 January 2005

Treatments	Stalk damage (%)			yield (t/ha)	Damage ear(%)	Marketable ear(%)	Unmarketable ear(%)	Benefit (Baht/ha)
	49DAP	56DAP	63DAP					
T1 Control	15.00ab ^{1/}	8.75b	18.75b	13.72a	12.46a	70.60a	8.18a	43,693b
T2 carbofuran	1.25c	7.50b	6.25c	15.19a	13.44a	75.83a	10.15a	51,550a
T3 Brown earwig (1 release)	8.75b	5.00bc	2.50d	16.06a	11.74a	71.95a	6.91a	50,312a
T4 Brown earwig (2 releases)	1.25c	5.00bc	4.00d	16.45a	13.62a	77.03a	8.10a	54,112a
T5 Black earwig (2 releases)	22.5a	30.00a	56.00a	15.51a	17.28a	76.25a	11.94a	52,080a
T6 Brown earwig+ <i>Trichogramma</i> sp. (2 releases)	2.50c	2.50c	0.00e	14.87a	12.95a	78.78a	7.49a	49,693a
T7 Big brown earwig (2 releases)	10.00b	21.25a	22.50b	14.20a	12.68a	83.69a	8.14a	43,780b
F-test	*	*	*	ns	ns	ns	ns	*
CV(%)	37.3	30.6	23.8	10.1	14.6	6.8	16.2	7.8

^{1/}Means followed by the same letter in the same column are not significantly different at $P \leq 0.05$ by DMRT

DAP-Day after planting

Table 5 Sktalk, ear damaged by corn borer,yield, marketable-unmarketable ears and return cost of sweet corn at khon Kaen University Research farm in wet season May- July 2004

Treatments	Stalk damage at (%)		Yield (t/ha)	Damage ear (%)	Marketable ear(%)	unmarketable ear(%)	Benefit (Baht/ha)
	49DAP	56DAP					
T1 Control	28.7a ¹	275a	8.93a	12.34a	73.49a	12.46a	40,250a
T2 carbofuran 3%	22.5a	20b	8.97a	11.48a	78.84a	9.89a	37,250a
T3 Brown earwig (1release)	15.0a	16.2b	8.81a	11.21a	77.42a	9.45a	37,687a
T4 Brown earwig (2releases)	16.25a	13.7b	9.49a	10.04a	79.26a	11.87a	39,012a
T5 Black earwig (2releases)	17.5a	18.7b	9.17a	9.64b	77.43a	8.80a	41,780a
T6 Brown earwig+Trichogramma sp. (2release)	18.75a	17.5b	9.86a	6.93b	77.77a	6.44	43,337a
T7 Big brown earwig	27.5a	12.5b	9.05a	6.85b	74.18a	7.45a	40,862a
F-test		*	ns	*	ns	ns	ns
CV(%)		15.38	12.5	10.03	11.53	28.53	11.1

¹Means foolowed by the same leatter in the same colum are not significantly different at P≤0.05 by DMRT.

DAP-Day after planting.

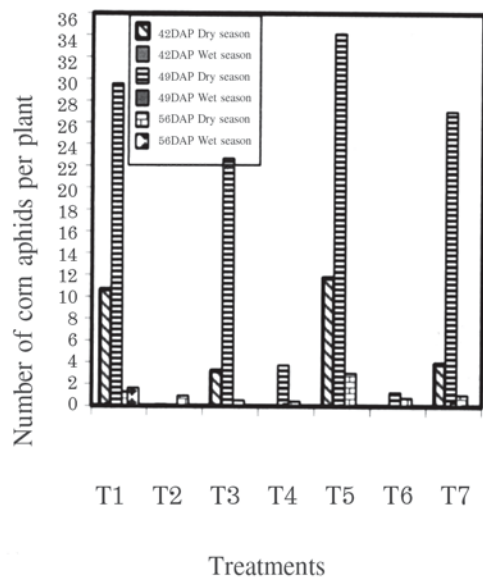


Figure1 Average corn aphids per plant at 42, 49, 56 days after planting in dry season (November 2004-January 2005 and wet season May-July 2004)

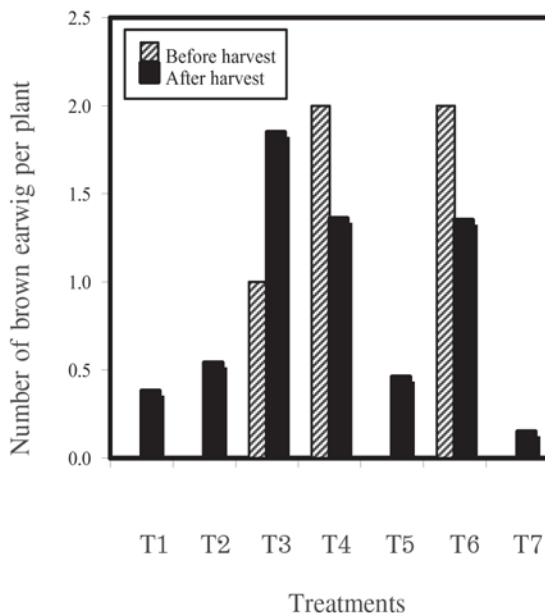


Figure3 Average of brown earwigs per sweet corn plant in each treatment at before and after harvest in May-July 2004

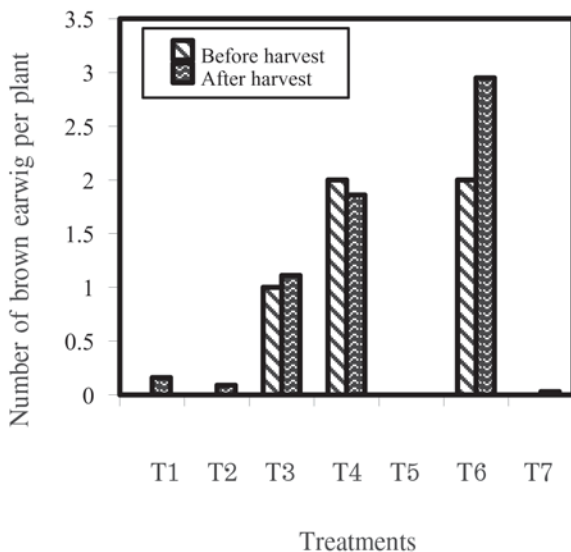


Figure2 Average of brown earwigs per sweet corn plant in each treatment at before and after harvest during November 2004-January 2005