EFFECTS OF VEGETABLE SOYBEAN AND BABY CORN INTERCROPPING ON THE ABUNDANCE OF SOYBEAN INSECT PESTS

MR. WUTIKIAT MONGKOLPORNRUGEE

A Thesis Submitted in Partial
Fulfillment of the Requirements
for the Degree of
Master of Science
(Agronomy)

Department of Agronomy
Graduate School
Maejo University

1996

GRADUATE SCHOOL MAEJO UNIVERSITY

Master of Science (Agronomy)

(Degree)

Agronomy Agronomy

(Field) **(Department)**

Thesis Title : Effects of Vegetable Soybean and Baby Corn Intercropping on the Abundance of Soybean Insect Pests

By : Mr. Wutikiat Mongkolpornrugee

Approved by :

Charnnarong Doungsa-ard
(Asst. Prof. Dr. Charnnarong Doungsa-ard)
Chairman
Jan. / 10 / 1997

Anan Pintarak
(Mr. Anan Pintarak)
Committee
10 / Jan / 97

R. Juttum
(Mr. Ruangchai Juwattanasomran)
Committee
Jan / 10 / 1997

Apichart Suankamgong
(Mr. Apichart Suankamgong)
Head, Department of Agronomy
Jan / 10 / 1997

(Assoc. Prof. Dr. Ahnon Tiangtrong)
Dean, Graduate School
Maejo University
13 / 1 / 97

ABSTRACT

Title : Effects of Vegetable Soybean and Baby Corn Intercropping on the Abundance of Soybean Insect Pests

By : Mr. Wutikiat Mongkolpornrugee

Degree : Master of Science (Agronomy)

Major Field : Agronomy

Chairman, Thesis Advisory Board : Charnnarong Doungsa-ard

(Asst. Prof. Dr. Charnnarong Doungsa-ard)

Jan / 10 / 1997

The abundance of soybean insect pests were monitored at three different cropping patterns which consisted of soybean monocrop (S), one-row soybean : two-rows corn intercrop (SCC) and two-rows soybean : one-row corn intercrop (SSC). The important insect pest of soybean including bean pod borer, *Etiella zinckenella* (Treitschke); soybean aphid, *Aphis glycines* (Matsumura) and bean leaf folder, *Hedylepta indicata* (F.) were observed.

Relative abundance of insect pest populations was greater in SSC than in S and SCC, respectively. The population densities of entomophagous species were simultaneously monitored and found that there was no significance in all cropping patterns. Differences in the mean number of insect pests in relation to growth stages of soybean plants in each cropping patterns were significant. Relatively high density of insect pests occured during the third and fifth weeks after seedling emergence.

Monocropped soybean showed the highest yield as compared with other cropping patterns. The efficiency of land used in the cropping patterns in terms of the land equivalent ratio (LER) were not significantly different.

บทคัดย่อ

ชื่อเรื่อง : ผลของการปลูกพืชสลับระหว่างถั่วเหลืองฝักสดและข้าวโพดฝักอ่อนต่อปริมาณความหนาแน่นของแมลงศัตรูถั่วเหลือง

โดย : นายวุฒิเกียรติ มงคลพรรุจี

ชื่อปริญญา : วิทยาศาสตรมหาบัณฑิต (พืชไร่)

สาขาวิชาเอก : พืชไร่

ประธานกรรมการที่ปรึกษาวิทยานิพนธ์ : ชาญณรงค์ ดวงสอาด

(ผู้ช่วยศาสตราจารย์ ดร. ชาญณรงค์ ดวงสอาด)

10 / มค. / 2540

การติดตามปริมาณความหนาแน่นของประชากรแมลงศัตรูถั่วเหลือง ได้ดำเนินการในรูปแบบของการปลูกพืช 3 รูปแบบ ซึ่งประกอบด้วย ถั่วเหลืองพืชเดี่ยว (S), ถั่วเหลือง 1 แถว : ข้าวโพด 2 แถว (SCC) และ ถั่วเหลือง 2 แถว : ข้าวโพด 1 แถว (SSC) แมลงศัตรูที่สำคัญของถั่วเหลืองที่ตรวจพบได้แก่ หนอนเจาะฝักถั่ว , *Etiella zinckenella* (Trietschke); เพลี้ยอ่อนถั่วเหลือง , *Aphis glycines* (Matsumura) และหนอนห่อใบ , *Hedylepta indicata* (F.)

ปริมาณความหนาแน่นสัมพันธ์ของประชากรแมลงศัตรูพบมากที่สุดในรูปแบบของ SSC รองลงมาคือ S และ SCC ตามลำดับ ส่วนปริมาณความหนาแน่นประชากรของศัตรูธรรมชาติสามารถตรวจพบตลอดระยะเวลาที่ทำการสำรวจและไม่มีความแตกต่างกันทางสถิติในทุกรูปแบบของการปลูก ปริมาณของแมลงศัตรูในแต่ละระยะการเจริญเติบโตของถั่วเหลืองมีความแตกต่างกันทางสถิติ โดยพบปริมาณความหนาแน่นสูงในระหว่างสัปดาห์ที่ 3 ถึง 5 หลังจากการงอกของเมล็ด

ผลผลิตของถั่วเหลืองฝักสด พบว่ารูปแบบของการปลูกถั่วเหลืองเดี่ยว (S) ให้ผลผลิตสูงสุดเมื่อเปรียบเทียบกับรูปแบบการปลูกแบบอื่น ส่วนประสิทธิภาพในการใช้ที่ดิน ซึ่งวัดจากค่าสัดส่วนการใช้พื้นที่สมมูลย์ (Land Equivalent Ratio, LER) พบว่าไม่มีความแตกต่างกันทางสถิติในทุกรูปแบบของการปลูก

ACKNOWLEDGMENTS

The National Biological Control Research Center, Northern Regional Center, the Department of Agronomy, Maejo University and Sikhiu"Sawadpadungwittaya" School are greatly acknowledged for their support to this study.

Sincere thanks and appreciation are due to the following :

Dr. Charnnarong Doungsa-ard, Adviser and Chairman of the Advisory Committee for all his valuable suggestions; Lecturer Anan Pintarak and Lecturer Ruangchai Juwattanasomran, members of the Advisory Committee for their suggestions and criticisms for the improvement of the study;

Professor Saran Permpool for his valuable suggestions during the study;

My brother, Mr. Kittipong Sriket-ngam for the financial support;

Mr. Songkram Arkarawittayatorn and Mr. Sanan Maneejunteuk for maintaining the experimental plots;

The staff members of Sikhiu"Sawadpadungwittaya" School, Division of Agriculture, for attending to my obligations during my absence from the school;

All my friends and colleagues who helped me directly and indirectly in the completion of the study;

And to my dearest father and mother to whom this work is dedicated.

Wutikiat Mongkolpornrugee

December 1996

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Appendix Page

INTRODUCTION

Intercropping is one type of cropping system which can be defined as growing two or more crops simultaneously on the same field (Andrews and Kassam, 1976). Intercropping has long been practiced in the tropical countries for centuries (Pookpakdi, 1982). The possibility in which two or more crops are grown in the intercropping system, including mixed intercropping (no distinct row arrangement), row intercropping (one or more crops are planted in rows), strip intercropping (crop grown in diferrent strips wide enough to permit independent cultivation but narrow enough for the crops to interact agronomically), relay intercropping (two or more crops grown simultaneously during part of life cycle of each, a second crop being planted before the harvest of the first) (Andrew and Kassam, 1976) and alley intercropping (annual crops are grown in strips between trees) (ICRISAT, 1989).

There are many benefits to be derived from intercropping, including the provision of a greater total land productivity as well as insurance against failure or unstable market value of single crop (Dent, 1991). In addition, crops in intercropping system may improve soil fertility and availability of alternative source of nutritious products. Aside from such benefits, intercropping can also be effective in the reduction of insect pest abundance on crop plant (Risch *et al.*, 1983 and Tingey and Lamont, 1988). The studies on relative abundance of insect pest in intercropping systems have been conducted and have provided more enough evidence to show that it can be used to reduce the incidence of insect pest attack (Dent, 1991). Several studies on the effects of corn and soybean intercropping on the incidence of insect pest, have been carried out but concentrated only on the major pests of corn (Suryatna and Harwood, 1976; Capinera *et al.*, 1985; Martin *et al.*, 1989 and Cayme, 1991). Few studies have been conducted on the abundance of soybean insect pests in soybean and corn intercropping system. Thus, to gain more basic information on the abundance of insect pests of soybean as well as their natural enemies, this study was conducted to investigate within the following objectives : 1) to compare the relative abundance of insect pests of soybean and their natural enemies in relation to plant growth and different cropping patterns; and, 2) to assess the best cropping pattern in terms of yield and yield components.

REVIEW OF LITERATURE

Insect Pests of Soybean

Thirty seven species of insects were found associated with soybean in Thailand (Wongsiri, 1991). They consisted of a species of rose beetle, *Adoretus compressus* (Weber); black cutworm, *Agrotis ipsilon* (Hufnagel); common black aphid, *Aphis craccivora* (Koch); soybean aphid, *Aphis glycines* (Matsumura); cotton aphid, *Aphis gossypii* (Glover); leaf miner, *Aproaerema modicella* (Deventer); leaf-roller, *Archips micaceana* (Walker), *Hedylepta diamenalis* (Guenee), *Hedylepta indicata* (Fabricius); tobacco whitefly, *Bemisia tabaci* (Gennadius); thrips, *Caliothrips indicus* (Bagnall), *Frankliniella williamsi* (Hood), *Megalurothrips usitatus* (Bagnall), *Scirtothrips dorsalis* (Hood), *Thrips palmi* (Karny), *Thrips tabacci* (Lindeman); cowpea weevil, *Callosobruchus chinensis* (Linnaeus); rice moth, *Corcyra cephalonica* (Stainton); leafhopper, *Empoasca spp*.; pod borer, *Etiella zinckenella* (Treitschke), *Maruca testulalis* (Geyer); blister beetle, *Epicauta maklini* (Haag), *Epicauta waterhousei* (Haag), *Mylabris phalerata* (Pall.); cotton bollworm, *Heliothis armigera* (Hubner); caster leafhopper, *Jacobiasca formosana* (Paoli); rice stink bug, *Leptocorisa acuta* (Thunberg); bean stem miner, *Melanagromyza sojae* (Zehntner); green stink bug, *Nezara viridula* (Linnaeus); termite, *Odontotermes sp*.; bean fly, *Ophiomyia centrosematis* (de Meijere), *Ophiomyia phaseoli* (Tryon); leaf-eating caterpillar, *Orgia turbata* (Butler); stink bug, *Piezodorus hybneri* (Gmelin); bean bug, *Riptortus sp*.; beet armyworm, *Spodoptera exigua* (Hubner) and common cutworm, *Spodoptera litura* (Fabricius). Among these insects, *M. sojae, O. phaseoli, A. glycines, H. diamenalis, H. indicata, A. micaceana, Empoasca spp., S. litura, H. armigera, N. viridula, P. hybneri, Riptortus sp., E. zinckenella, M. testulalis* and *B. tabaci* are considered as major insect pests of soybean (Napompeth *et al*., 1983; isitpanich, 1985; Duangsa-ard, 1986 and Anonymous, 1986).

In the northeastern region, the most serious insect pests of soybean are *O. phaseoli, A. glycines, H. indicata, S. litura, E. zinckenella,* and *P. hybneri* (Anonymous, 1990; Thawatsin *et al*., 1990 and Anonymous, 1994).

Plant Diversity and Insect Outbreak

Tahvanainen and Root (1972) reported that insect outbreaks were apparently more frequent and more severe in pure stands of forest trees and especially in plantation. They also reported that insect pest populations are higher and cause greater crop losses in monoculture than in diverse stands where other crop plant species and weeds occur. Altieriand Letourneau (1984) made an extensive review on vegetation diversity and insect pest outbreaks and concluded that agricultural diversification leads to lower pest abundance. Andow (1991 b) also suggested that arthopod herbivore populations would be more likely to surge to outbreak in monoculture (sole-crop fields) than in polyculture (mixed-crop fields). To explain the lower densities of insect pests in diverse agroecosystem or in intercropping system, Root (1973) proposed two different hypotheses, so-called "resource concentration" hypothesis and the "enemies" hypothesis.

The "resource concentration" hypothesis predicts that monophagous or oligophagous herbivores (specialist feeder) are more easily found, stay in and can reproduce in monocultures of host plants than in polycultures (Root, 1973). Additionally, It has also a predicted lower pest abundance in polycultures because a specialist feeder is less likely to find its host plant due to the presence of confusing or masking chemical stimuli, physical barriers to movement or other environmental effects such as shading; it will tend to remain in the intercrop for a shorter period of time simply because the probability of landing on a non-host plant is increased; it may have a lower survivorship and/or fecundity (Dent, 1991).

The "enemies" hypothesis predicts that populations of natural enemies will be greater, and consequently, herbivore populations are lower in polycultures due to the increased availability of alternate prey or host, nectar resource and suitable microhabitat (Root, 1973). Inaddition, Letourneau (1987) stated that the "enemies" hypothesis predicts a positive correlation between plant species richness and natural enemies abundance, which results in the regulation of herbivores at lower level in polyculture than in monoculture.

Intercropping and Insect Pests Control

Several studies showed that agricultural diversification through intercropping tend to reduce the incidence of insect pest attack. Tahvanainen and Root (1972) found that the populations of flea beetle, *Phyllotetra cruciferae* were lower on collards interplanted with tomato and tobacco or grown in a weedy old field than on control grown in monoculture. Burandy and Raros (1975) reported that intercropping tomato with cabbage decreased the population of diamond back moth, *Plutella xylostella.* Yaku *et al.* (1992) reported that the fewer populations of sweet potato weevil, *Cylas formicarius* were found on intercropped sweet potato and corn (2 weevils/kg infected tubers) than in monoculture sweet potato (37 weevils/kg). The percentage of damaged tubers follow this trend ranging from 2.6 per cent in intercropped potato to 21.9 per cent under monoculture. The intercropped sweet potato had, however, lower yields from 0.8 t/ha compared to 7.0 t/ha under monoculture. Suharto (1989) reported that a significantly lower number of eggs and larvae was observed in cotton intercropped with corn and sorghum than on cotton monoculture or those with soybean or peanut intercrop at 77 days after planting. *Heliothis armigera* damages on flowers and bolls were generally lower on cotton intercropped with corn and sorghum than on those with other intercrops or monoculture.

In 1973, The International Rice Research Institute (IRRI) reported that intercropping corn with groundnut decreased the population of the Asian corn borer, *Ostrinia furnacalis*. Likewise, intercropping of corn with red clover (Lambert *et al.*, 1987) and corn with soybean (Martin *et al.*, 1989) reduces damage by European corn borer, *Ostrinia nubilalis* compared with monocrops in a two-year trail. Karel *et al.* (1980) studied on intercropping of corn and cowpea to determine the effect of plant production on insect pests and seed yield in Tanzania. They reported that the damage from insect pests was higher in pure stands than in mixtures, and that maize acted as a barrier to the dispersal and entry of many pests in mixtures (intercropping). Cayme (1991) studied the four-monoculture and four- polyculture cropping systems for comparison on the basis of plant complexity and arthropod species diversity, and reported that the population of adult stem fly, *Melanagromyza sojae* (Zehnt.) was greater in soybean monoculture kept weed-free throughout the season than in soybean monocultures and polycultures (intercropped with corn) which were left weedy for two or four weeks after planting or throughout the season. Andow (1991 a) studied five methods for measuring the effect of arthropod pest on crop yields in vegetationally diverse agroecosystem and reported that two methods measured absolute yield benefits in which polyculture yields were higher than yields in monocultures. Polycultures had lower pest populations than monocultures and pest injury is less likely to exceed economic injury levels in polycultures than in monocultures.

Capinera *et al.* (1985) studied effect of strip intercropping of pinto beans and sweet corn on insect abundance in Colorado. Insect abundance was monitored in corn and beans in alternating multiple-row patterns of 1, 2, 4, 8 and 16 rows. Insect responses to intercropping treatment were variable with positive, negative, and neutral responses, depending on species of insect and crop. Sutater (1986) found that cabbage, tomato and corn were intercropped with soybean at three row spacings, i.e., 100, 150 and 200 cm. Soybean as main crop was planted between the intercropped plant at 25 x 25 spacing, and yield as well as frequency of pest attack were compared with those of monoculture of either soybean, cabbage, tomato or corn. Results showed that the intercropping did not significantly affect percentage of leaf and pod damage. However, in a review of relevant literature, Andow (1983 a, b) showed that careful diversification of vegetational component of agriculture habitat often significantly lower insect pest populations.

MATERIALS AND METHODS

Description and Layout of the Experimental Site

The experiment was conducted at the Division of Agriculture, Sikhiu "Sawadpadungwittaya" School, Sikhiu district, Nakornrachasima province.

Sikhiu district is located between latitude 14.52° N. and longitude 101.39° E. The attitude is 235 m. The sikhiu soil texture is clay loam with a pH value of 6.7 and organic matter of 1.02 %. The chemical elements contained are as follows : 0.05 % total N, 75 % available P and 191 ppm exchangeable K. The lowest average temperature is 14.6° C in mid-January and the highest is 36.9° C in April (Department of Agriculture, 1994). The meteorological data, i.e. temperature, relative humidity and amount of rainfall during the course of field investigation from January to June 1996 is presented in Appendix 8.

Randomized complete block design was used with three replications for each cropping pattern. The cropping patterns evaluated were soybean monocrop (S), corn monocrop (C), one-row soybean : two-rows corn intercrop (SCC) and two-rows soybean : one-row corn intercrop (SSC) (Appendix 9 and 10).

The prepared field was divided into twelve 128 square meters-plots, each plot consisted of 16 rows representing three replications for each cropping pattern. The experiment was conducted during the early rainy season starting from March to June 1996.

Cultural Management and Yield Assessment of Each Crop at Different Cropping Patterns

1. Soybean Monocrop (S)

Chiangmai # 1 variety of soybean was sown at a spacing (row x plant) of 50 x 25 cm. Seedlings were thinned with two seedlings left per hill.

Fertilizer (15-15-15 and 12-24-12) was applied 15 and 30 days after emergence at the rate of 50 kg per rai.

2. Corn Monocrop (C)

Pacific 421 variety of corn was sown at a spacing (row x plant) of 50 x 25 cm with one plant left per hill.

Fertilizer (15-15-15 and 12-24-12) was applied 15 and 30 days after emergence at the rate of 50 kg per rai.

3. One-row soybean : Two-rows corn Intercrop (SCC)

One row of soybean was sown alternately with two rows of corn in the same spacing as in both sole crops. Seedlings were thinned and two soybean and one corn seedlings left per hill, respectively.

Fertilizer (15-15-15 and 12-24-12) was applied 15 and 30 days after emergence at the rate of 50 kg per rai.

4. Two-rows soybean : One-row corn Intercrop (SSC)

Soybean seeds were sown alternately in two rows with one row of corn in the same spacing as that in both sole crops. Two soybean plants and one corn plant were left per hill.

Fertilizer (15-15-15 and 12-24-12) was applied 15 and 30 days after emergence at the rate of 50 kg per rai.

In all experimental plots, sprinkler irrigation system were applied every week. No chemical pesticide was applied to both crops throughout the period of study. Hand weeding was done at least twice throughout the experiment.

Sampling Techniques for the Soybean Insect Pests and Entomophagous Species

Soybean insect pests and the entomophagous species associated with vegetable soybean canopy was sampled at weekly interval from fourteen days after planting until harvesting. Various sampling methods were used depending on the behavior of insects. Sampling was started early in the morning until all samples were taken. Sampling methods used are as follows :

1. Direct count

Twenty-four plants per plot designated as one sample were selected at random. The insects observe on the canopy was recorded. For soybean aphids, trifoliate leaves terminal of vegetable soybean were collected and placed in plastic bag and brought to the laboratory. The trifoliate leaves were placed in a screwcapped plastic vial 6 cm in diameter and 12 cm in length, filled with water and shaken vigorously for 2 minutes to dislodge the aphid. Aphids dislodged from the leaves were counted under microscope. For bean leaf folder, direct counting was made and recorded.

2. Sweep net sampling

The insect sweep net (38 cm diameter 60 cm length) was used to sample the more mobile insects such as bean leafhoppers, bean bugs, stink bugs, the coccinellid predators and hymenopterous parasites. A total of 10 strokes designated as "one sample" per plot was taken. The net contents were shaken into plastic bags. A cotton ball with chloroform was placed immediately into the bag to kill the insects. Insects were brought to and counted in the laboratory.

3. Sampling for stems and pods damage

During the second and third week after seedling emergence, suspected seedlings were collected in each plot and brought to the laboratory for dissecting and examining for the stem borer damaged. At harvest, all pods from twenty-four plants per plot were collected at random and examined for pod damage.

Yield of Soybean, Corn and Land Equivalent Ratio (LER)

Yield and yield components of soybean were measured as the weight of fresh pods within 6 x 8 square meters. The component parameters of yield such as plant height (cm), branches per plant, nodes per plant, pods per plant, pods weight (gm per plant), empty pods per plant, full pods per plant, number of pods per kg and 100-seed fresh weight (gm) were sampled from 24 plants in all plots. Harvesting was done during 75 and 80 days after planting.

Yield and yield components of corn were measured as the weight of young corn ears without husk within 6 x 8 square meters. The component parameters of yield such as plant height (cm), ear with husk weight (kg per rai), ear without husk weight (kg per rai), ears per plant, ear length (cm), ear diameter (cm) and standard ears (%) were sampled from 24 plants in all plots. Harvesting was done during 55 and 65 days after planting.

The yield of vegetable soybean and baby corn in cropping systems were used to calculate the Land Equivalent Ratio (LER) values using the following formula (Baker, 1979 and Pookpakdi, 1985) :

$$LER = (Yij/Yii) + (Yji/Yjj)$$

where :

Yij = Yield of crop i grown with crop j

Yii = Yield of crop i grown sole

Yji = Yield of crop j grown with crop i

Yjj = Yield of crop j grown sole

crop i = Vegetable soybean

crop j = Baby corn

RESULTS

Relative Abundance of the Insect Components of Different Cropping Patterns

Sampling populations of soybean insect pests and entomophagous species at different cropping patterns were conducted during March to June 1996. Insect pest species found associated with soybean plant were bean stem miner, *Melanagromyza sojae* (Zehnt.); bean leaf folder, *Hedylepta indicata* (F.); soybean aphid, *Aphis glycines* (Mat.); bean leaf hopper, *Empoasca spp.*; one-banded stink bug, *Piezodorus hybneri* (Gmel.); monolepta beetle, *Monolepta signata* (F.); bean bug, *Riptortus linearis* (F.) and bean pod borer, *Etiella zinckenella* (Treitschke). Among this group of insects, *E. zinckenella, H. indicata* and *A. glycines* were considered as major pests of soybean whereas the others were considered as minor ones. Entomophagous species found associated with soybean plants were the coccinellid predators, hymenopterous parasites, ants, dragonflies and the tettigonid predators. Various species of spiders were also observed at the sampling site. The total number of soybean insect pests and entomophagous species collected from different cropping patterns are summarized in Table 1.

There were no significant differences in the total number of insects and entomophagous species among the different cropping patterns. However, significant differences between the total number of insect components in the different cropping patterns were obtained (Table 1).

Among the different cropping patterns, the total number of insect pest was highest in SSC followed by S and SCC, respectively. The population of entomophagous species including spiders, was highest in SCC followed by SSC and S, in decreasing order (Table 1). The total number of insect pests and entomophagous species in different cropping patterns is illustrated in Figure 1.

Table 1 Total number of soybean insect pests and entomophagous species collected in each cropping pattern, from March to June 1996.

CROPPING PATTERN	INSECT COMPONENTS		TOTAL
	Insect Pests	Entomophagous Species	
S	285.00 a	108.00 a	393.00 b
SCC	268.00 a	114.00 a	382.00 b
SSC	832.00 a	111.00 a	943.00 a

Mean in a column of insect components with the same letter are not significantly different (P>0.05;DMRT).

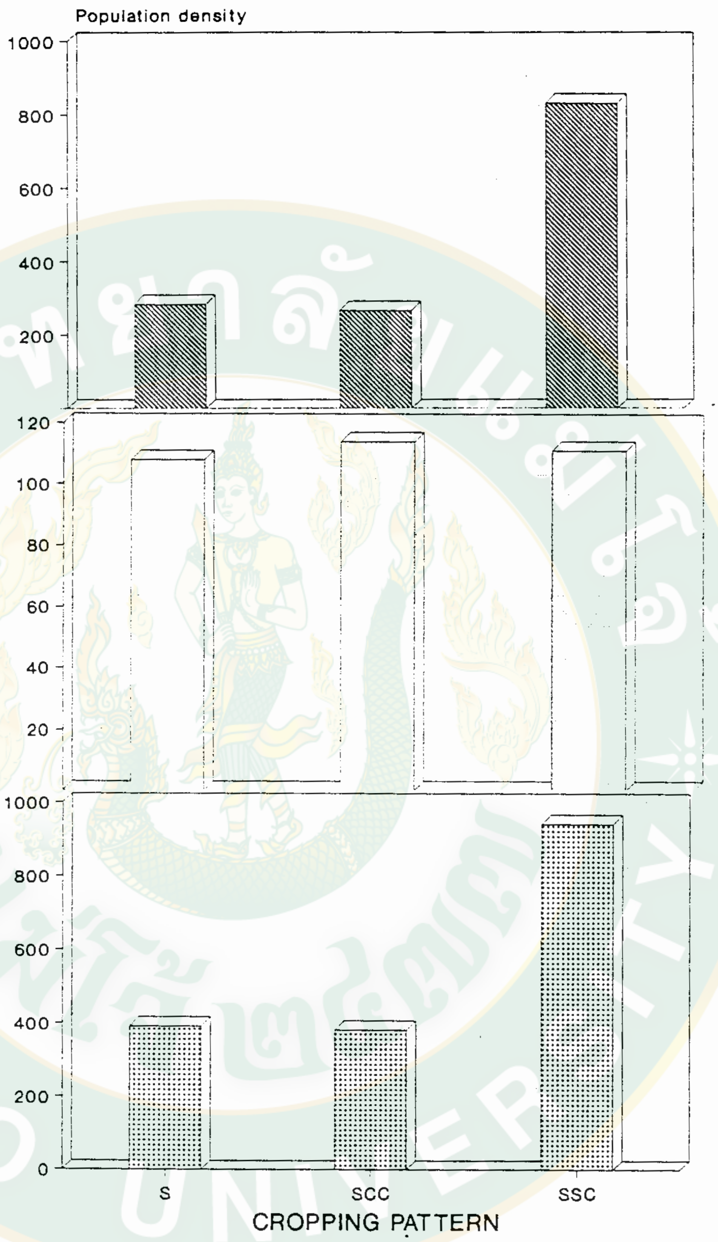
INSECT COMPONENTS	CROPPING PATTERN
Soybean insect pests	
Entomophagous species	
Total insect component	

Figure 1 Total number of soybean insect pests and entomophagous species in each cropping pattern.

Relative Abundance of the Insect Components in Relation to Plant Growth

The total mean number of insect pests and entomophagous species collected in all cropping patterns at different growth stages of soybean plants were significantly different. The relatively high population levels of insect pests was observed during the third and fifth weeks and reached the peak at the fifth week after seedling emergence. Thereafter, the population densities decreased drastically in the following weeks. As for entomophagous species, the population at their peak at the second week and decreased slightly from the third week after seedling emergence (Table 2 and Figure 2).

Significant differences in the total number of insect components among the different cropping patterns at different growth stages of soybean plants were also obtained. The relatively high population densities were observed during the third and fifth weeks and reached the peak at the fifth week after seedling emergence. The population densities slightly decreased in the following weeks.

As shown in Table 3 and illustrated in Figure 3, there were no significant differences in the total number of insect components in S but there were significant differences in SCC and SSC at different growth stages of soybean plants. The total populations were at their peak at the ninth, fifth and third weeks for S, SCC and SSC, respectively. The total populations of insect pests and entomophagous species were more abundant in SSC than S and SSC, respectively.

Table 2 Total mean number of soybean insect pests and entomophagous species collected from different cropping patterns at different weeks after seedling emergence, from March to June 1996.

WEEKS AFTER SEEDLING EMERGENCE	INSECT COMPONENTS		TOTAL
	Insect Pests	Entomophagous Species	
2	4.00 b	18.33 a	22.33 b
3	116.33 ab	16.99 ab	133.32 ab
4	99.34 ab	9.34 c	108.68 ab
5	143.34 a	14.32 abc	157.66 a
6	33.67 ab	11.32 bc	44.99 ab
7	16.33 b	16.35 ab	32.68 ab
8	11.67 b	12.99 abc	24.66 b
9	36.98 ab	11.33 bc	48.31 ab
Total	461.66	110.97	572.63

Mean in a column of insect components with the same letter are not significantly different (P>0.05;DMRT).

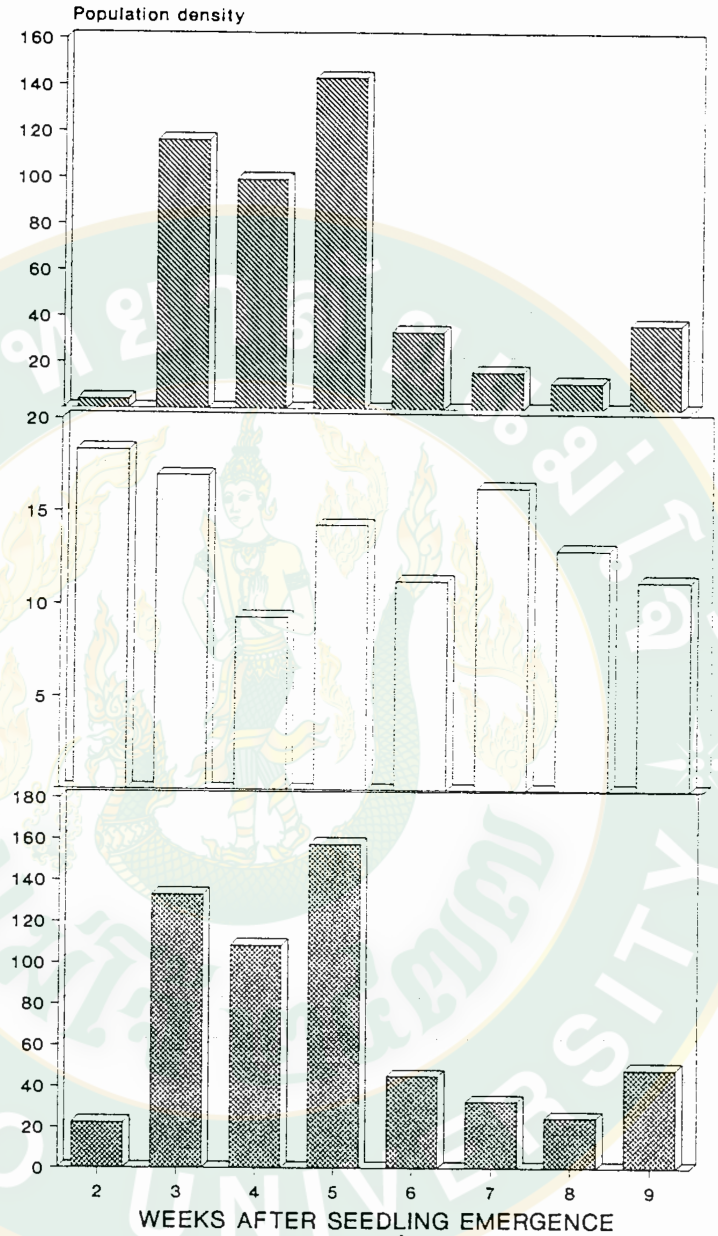
INSECT COMPONENTS	WEEKS AFTER SEEDLING EMERGENCE
Soybean insect pests	
Entomophagous species	
Total insect component	

Figure 2 Total mean number of soybean insect pests and entomophagous species at different weeks after seedling emergence.

Non-significant differences were obtained in the mean number of soybean insect pests collected in S but were significantly different in SCC and SSC at different growth stages of soybean plants (Table 4). The population densities reached the peak at the third week with 101.00 individuals per sample in SSC, at the fifth week with 38.00 individuals per sample in SCC and at the ninth week with 27.33 individuals per sample in S (Table 4 and Figure 4).

Mean number of entomophagous species collected in each cropping patterns at different growth stages of soybean plants were significantly different. The populations of entomophagous species were at their peak at the second week with 7.00 and 6.33 individuals per sample in SSC and SCC. In S, the populations were at their peak at the seventh week with 6.34 individuals per sample (Table 4 and Figure 4).

Table 3 Total mean number of soybean insect pests and entomophagous species collected in each cropping pattern at different weeks after seedling emergence, from March to June 1996.

WEEKS AFTER SEEDLING EMERGENCE	CROPPING PATTERN		
	S	SCC	SSC
2	6.33 a	8.00 b	8.00 b
3	13.33 a	13.33 ab	106.66 a
4	23.01 a	20.00 ab	65.67 ab
5	18.68 a	43.99 a	94.99 ab
6	16.99 a	11.33 b	16.67 ab
7	11.00 a	10.68 b	11.00 b
8	10.00 a	9.33 b	5.33 b
9	31.65 a	10.67 b	5.99 b
Total	130.99	127.33	314.31

Mean in a column of insect components with the same letter are not significantly different (P>0.05;DMRT).

CROPPING PATTERN	WEEKS AFTER SEEDLING EMERGENCE
Soybean Monocrop (S)	
One-row soybean: Two-rows corn (SCC)	
Two-rows soybean: One-row corn (SSC)	

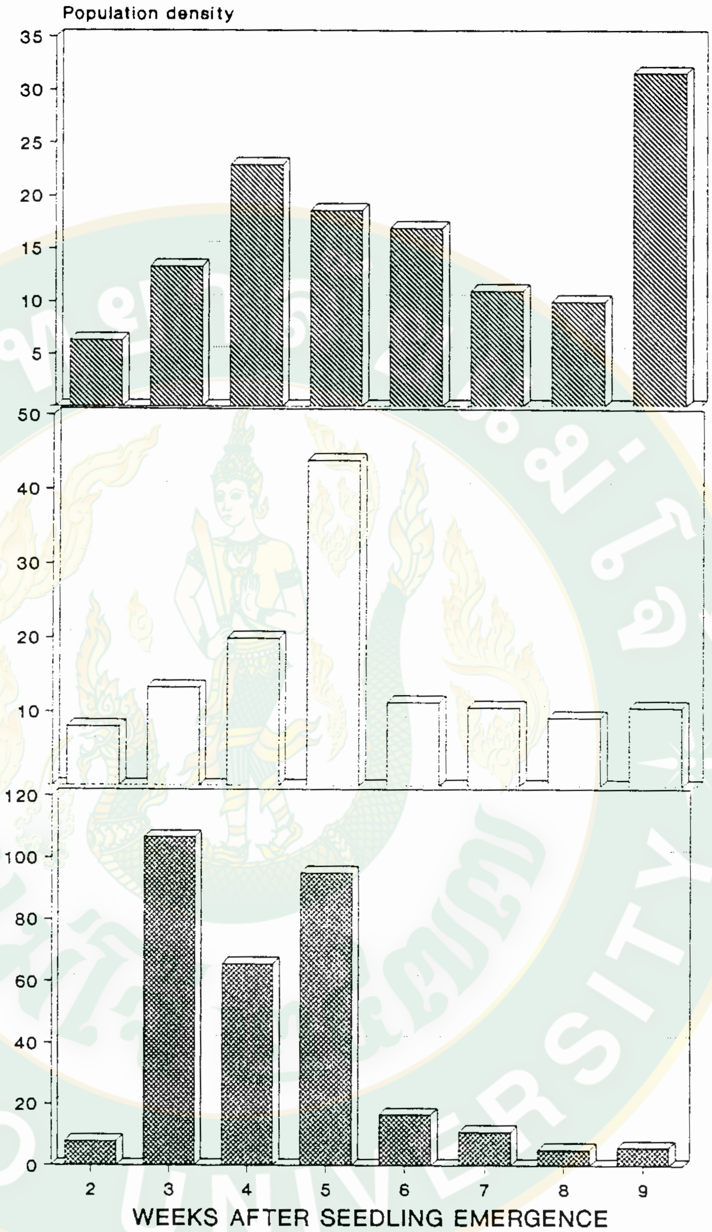


Figure 3 Total mean number of insect components in each cropping pattern at different weeks after seedling emergence.

Table 4 Mean number of soybean insect pests and entomophagous species collected in different cropping patterns at different weeks after seedling emergence, from March to June 1996.

WEEKS AFTER SEEDLING EMERGENCE	CROPPING PATTERN					
	S		SCC		SSC	
	Insect Pests	Entomoph. Species	Insect Pests	Entomoph. Species	Insect Pests	Entomoph. Species
2	1.33 a	5.00 ab	1.67 b	6.33 a	1.00 b	7.00 a
3	8.00 a	5.33 ab	7.33 ab	6.00 ab	101.00 a	5.66 ab
4	21.34 a	1.67 b	16.00 ab	4.00 ab	62.00 ab	3.67 ab
5	16.01 a	2.67 ab	38.00 a	5.99 ab	89.33 ab	5.66 ab
6	12.00 a	4.99 ab	8.00 ab	3.33 b	13.67 ab	3.00 b
7	4.66 a	6.34 a	6.34 ab	4.34 ab	5.33 b	5.67 ab
8	4.33 a	5.67 ab	4.67 b	4.66 ab	2.67 b	2.66 b
9	27.33 a	4.32 ab	7.33 ab	3.34 b	2.32 b	3.67 ab
Total	95.00	35.99	89.34	37.99	277.32	36.99

Mean in a column of insect components with the same letter are not significantly different (P>0.05;DMRT).

INSECT COMPONENTS	WEEKS AFTER SEEDLING EMERGENCE
Soybean insect pests	
Entomophagous species	
Total insect component	

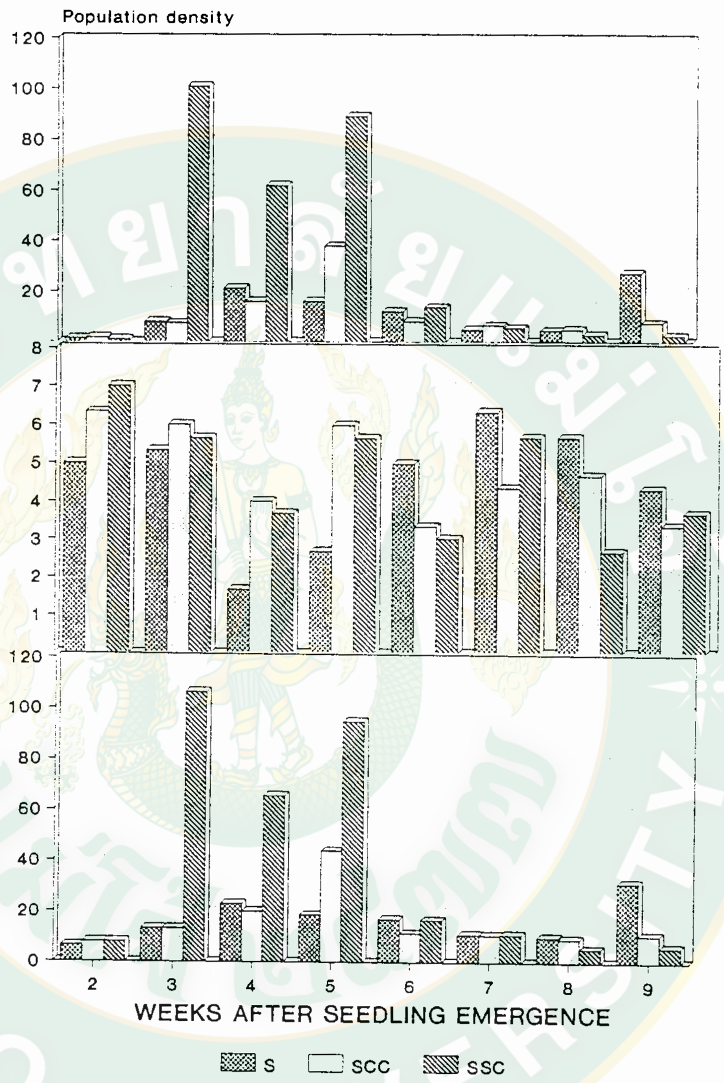


Figure 4 Mean number of soybean insect pests and entomophagous species in each cropping pattern at different weeks after seedling emergence.

Incidence of Insect Pests and Entomophagous Species in Relation to Different Cropping Patterns and Plant Growth

Major insect pests

Soybean aphid, *Aphis glycines* (Matsumura)

A. glycines was first collected in the third week in SSC and the population remained in the field up to the fifth week after seedling emergence. *A. glycines* appeared in the fourth, sixth and ninth weeks in S while in SCC, *A. glycines* could be found in the fourth, fifth and ninth weeks after seedling emergence. The total mean number of *A. glycines* among the different cropping patterns were significantly different. SSC had the highest density followed by S and SCC with an averages of 235.00, 42.34 and 40.67 individuals, respectively (Table 5 and Figure 5, 6).

Bean leaf folder, *Hedylepta indicata* (F.)

It was observed that *H. indicata* began to move into the field plots in the second week after seedling emergence and persisted in the field throughout the investigation periods. In all cropping patterns, *H. indicata* population increased gradually from the second week and reached the peak at the fifth week with 5.00, 8.33 and 12.33 individuals per sample in S, SSC and SCC, respectively. The densities of *H. indicata* among different cropping patterns were significantly different. The highest densities were in SCC, SSC and S with the total of 34.01, 30.32 and 17.99 individuals, respectively (Table 6 and Figure 5, 6).

Table 5 Mean number of soybean aphids, *Aphis glycines* (Mat.) collected in each cropping pattern at different growth stages of soybean plants, from March to June 1996.

CROPPING	WEEKS AFTER SEEDLING EMERGENCE								TOTAL
PATTERN	2	3	4	5	6	7	8	9	
S	0.00	0.00	9.67	0.00	7.67	0.00	0.00	25.00	42.34 ab
SCC	0.00	0.00	6.67	29.00	0.00	0.00	0.00	5.00	40.67 b
SSC	0.00	95.00	49.00	81.33	9.67	0.00	0.00	0.00	235.00 a

Total with the same letter are not significantly different (P>0.05;DMRT).

Table 6 Mean number of bean leaf folders, *Hedylepta indicata* (F.) collected in each cropping pattern at different growth stages of soybean plants, from March to June 1996.

CROPPING	WEEKS AFTER SEEDLING EMERGENCE								TOTAL
PATTERN	2	3	4	5	6	7	8	9	
S	1.00	4.00	5.00	3.67	3.33	0.33	0.33	0.33	17.99 b
SCC	1.67	6.67	8.33	7.67	5.00	2.67	1.67	0.33	34.01 a
SSC	1.00	5.00	12.33	6.33	2.33	1.33	0.67	1.33	30.32 b

Total with the same letter are not significantly different (P>0.05;DMRT).

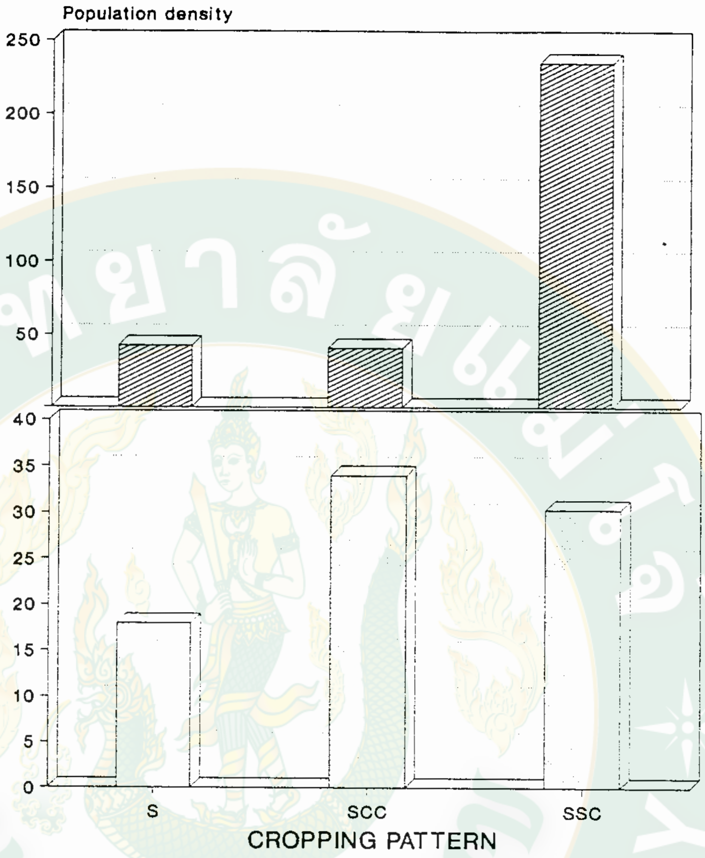
SOYBEAN INSECT PESTS	CROPPING PATTERN
Aphis glycines (Mat.)	
Hedylepta indicata (F.)	

Figure 5 Relative abundance of soybean insect pests in each cropping patterns.

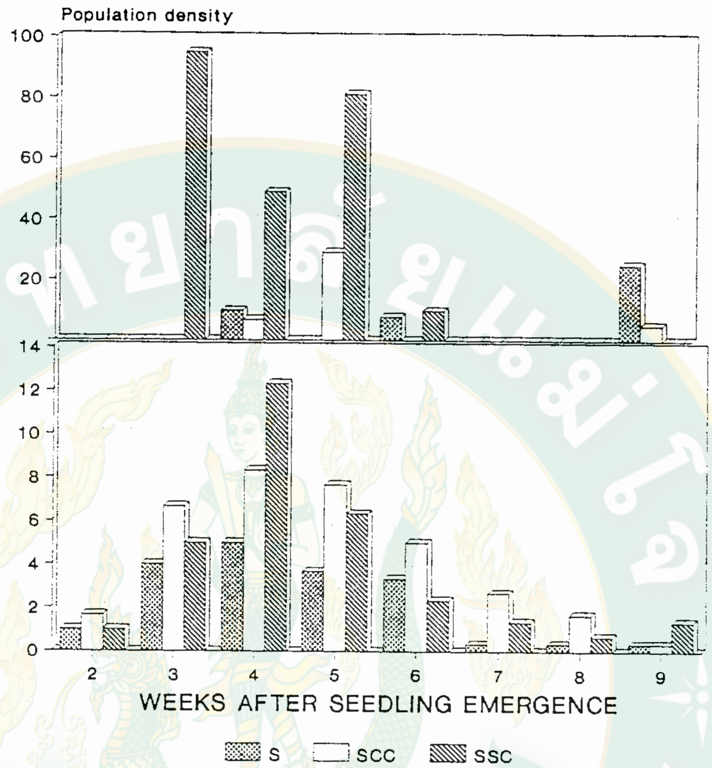
SOYBEAN INSECT PESTS	WEEKS AFTER SEEDLING EMERGENCE
Aphis glycines (Mat.) *Hedylepta indicata* (F.)	

Figure 6 Relative abundance of soybean insect pests in each cropping pattern at different weeks after seedling emergence.

Bean pod borer, *Etiella zinckenella* (Treitschke)

At harvest, all pods of soybean from twenty-four plants per plot were collected and examined for pod damage caused by *E. zinckenella*. Percent pod damage among cropping patterns were significantly different. SCC had the highest percentage, followed by SSC and S at 33.42, 22.63 and 20.32, respectively (Table 7).

Minor insect pests

During the second and third weeks after seedling emeregence, twenty-four seedlings were collected at random and examined for the percentage of infestation caused by *M. sojae*. There were no significant differences in the percentage of stem infestation among the different cropping patterns. Percent infestations were relatively low with an average of 2.59, 2.41 and 2.07 in SSC, S and SCC, respectively (Table 7).

Nymphs and adults of *Empoasca spp*. were collected from the second week until the ninth week after seedling emergence. The density was relatively low throughout the sampling period. The total number of *Empoasca spp*. among different cropping patterns were significantly different. The highest densities were in S, SCC and SSC with 32.01, 14.00 and 11.34 individuals, respectively (Appendix 1).

Table 7 Mean percentage of pod infestation by bean pod borers, *Etiella zinckenella* (Treitschke) and percentage of stem infestation by bean stem miners, *Melanagromyza sojae* (Zehnt.) in each cropping pattern, from March to June 1996.

CROPPING	BEAN POD BORERS	BEAN STEM MINERS
PATTERN	Percent pod infestation	Percent stem infestation
S	20.32 b	2.41 a
SCC	33.42 a	2.07 a
SSC	22.63 ab	2.59 a

Mean in a column of insect components with the same letter are not significantly different (P>0.05;DMRT).

M. signata was sampled only in the third week and fifth week in S and in the third week after seedling emergence in SCC while *M. signata* did not appear in SSC (Appendix 2).

Few nymphs and adults of *P. hybneri* were collected in the seventh and ninth weeks in S and only in the ninth week in SSC while *P. hybneri* was not occured in SCC (Appendix 3).

The population density of *R. linearis* was also very low in all different cropping patterns. Its could be sampled in the third and ninth weeks in S and in the ninth week after seedling emergence in SCC and SSC (Appendix 4).

Entomophagous species

As for the entomophagous species, the hymenopterous parasites were collected throughout the sampling periods while the coccinellid predators were sampled from the fourth week until the ninth week. Other entomophagous species such as ants, dragonflies, tettigonid predators and spiders were occasionally collected during the course of the investigation. The relative abundance of entomophagous species including spiders was illustrated in Figure 4.

Yield and Yield Components of Vegetable Soybean

The mean yield of vegetable soybean per rai between cropping patterns were significantly different. The highest yields were obtained in S followed by SSC and SCC with averages of 474.02, 263.36 and 53.16 Kg per rai, respectively (Table 8).

Plant height between cropping patterns were significantly. SCC showed the highest plant height followed by SSC and S with averages of 27.63, 26.89 and 23.23 cm, respectively (Table 8).

Branches per plant between cropping patterns were not significant. S had the highest branches followed by SSC and SCC with averages of 3.06, 2.89 and 2.03, respectively (Table 8).

Nodes per plant of SCC and SSC were the highest with S showing the lowest, with averages of 9.06, 9.00 and 8.84, respectively (Table 8).

Pods per plant were highest in S followed by SSC and SCC with averages of 16.51, 13.74 and 6.74, respectively (Table 8).

Weight of pods between cropping patterns were significantly different. The highest weight of pods was obtained in S followed by SSC and SCC with averages of 16.32, 13.60 and 5.68 gm, respectively (Table 8).

Means of 5.64, 4.84 and 3.11 empty pods per plant were collected from S, SSC and SCC, respectively, and the difference was not significant (Table 8).

Full pods per plant between cropping patterns were significantly different. Full pods per plant were high in S followed by SSC and SCC with averages of 10.88, 8.90 and 3.63, respectively (Table 8).

Number of pods per kilogram between cropping patterns were not significant. Number of pods were high in SCC followed by S and SSC with averages of 1189.84, 1014.44 and 1009.38, respectively (Table 8).

Table 8 Yield and yield components of vegetable soybean (Chiangmai # 1) in early rainy season (March-June 1996).

CROPPING PATTERN	YIELD AND YIELD COMPONENTS					
	Plant height (cm)	Branches / pl.	Nodes / pl.	Pods / pl.	Pod weight (gm/pl.)	Empty pods/pl.
S	23.23 b	3.06 a	8.84 a	16.51 a	16.32 a	5.64 a
SCC	27.63 a	2.03 a	9.06 a	6.74 a	5.68 b	3.11 a
SSC	26.89 a	2.89 a	9.00 a	13.74 a	13.60 ab	4.84 a

Mean in a column of yield and yield components with the same letter are not significantly different (P>0.05;DMRT).

Table 8 Continued.

CROPPING PATTERN	YIELD AND YIELD COMPONENTS			
	Full pods/pl.	No. of pods/kg	100-seed fresh wt.(gm)	Yield of fresh pods (kg/rai)
S	10.88 a	1014.44 a	39.43 a	474.02 a
SCC	3.63 b	1189.84 a	34.97 ab	53.16 b
SSC	8.90 ab	1009.38 a	34.47 b	263.36 ab

Mean in a column of yield and yield components with the same letter are not significantly different (P>0.05;DMRT).

The 100-seed fresh weight were significantly different in both patterns. S had the highest weight followed by SCC and SSC with averages of 39.43, 34.97 and 34.47 gm, respectively (Table 8).

Yield and Yield Components of Baby Corn

The mean yield of young corn ears without husk per rai of baby corn between cropping patterns were not significant. C had the highest yield followed by SCC and SSC with averages of 317.00, 234.37 and 143.86 kg per rai, respectively (Table 9).

Plant height of baby corn in cropping patterns were not significantly different. C had the highest plant height followed by SCC and SSC with averages of 146.72, 142.85 and 136.68 cm, respectively (Table 9).

The ear-with-husk weight was not significantly different in both patterns. C had the highest weight followed by SCC and SSC with averages of 954.22, 814.21 and 550.10 kg per rai, respectively (Table 9).

Non-significant differences in the ears per plant of baby corn yield components among cropping patterns were obtained. SSC had the highest ears followed by SCC and C with averages of 2.94, 2.54 and 2.23, respectively (Table 9).

The ear length of baby corn was not significant in both patterns. SSC had the highest ear length followed by C and SCC, with averages of 10.19, 9.88 and 9.88 cm, respectively (Table 9).

The ear diameter of baby corn was not significant in both patterns. C had the highest ear diameter followed by SCC and SSC with averages of 1.57, 1.54 and 1.52 cm, respectively (Table 9).

The percentage of standard ears of baby corn in cropping patterns were not significantly different. SCC had the highest standard ears followed by SSC and C with an averages of 57.26, 57.17 and 53.32, respectively (Table 9).

Table 9 Yield and yield components of baby corn (Pacific 421) in early rainy season (March-June 1996).

CROPPIN GPATTER N	YIELD AND YIELD COMPONENTS						
	Plant height (cm)	Ear with husk (kg/rai)	Ears/ plant	Ear length (cm)	Ear diameter (cm)	Standard ears (%)	Ear without husk (kg/rai).
C	146.72 a	954.22 a	2.23 a	9.88 a	1.57 a	53.32 a	317.00 a
SCC	142.85 a	814.21 a	2.54 a	9.88 a	1.54 a	57.26 a	234.37 a
SSC	136.68 a	550.10 a	2.94 a	10.19 a	1.52 a	57.17 a	143.86 a

Mean in a column of yield and yield components with the same letter are not significantly different (P>0.05;DMRT).

Relations Between Cropping Patterns : Land Equivalent Ratio (LER) and Total Income

Non-significant differences were obtained in mean values of land equivalent ratio (LER) in all cropping patterns (Table 10). SSC had the highest LER value followed by SCC, S and C, with averages of 1.29, 1.11, and 1.00, respectively.

The total income (Baht per rai) in each cropping pattern was obtained from the market prices of vegetable soybean at 8.00 Baht per kg and baby corn (with husk) at 3.00 Baht per kg. S and SSC had the highest total income followed by SCC and C, with averages of 3792.16, 3757.18, 2894.91 and 2862.66 Baht per rai, respectively (Table 10).

Table 10 Relations between cropping patterns : Land Equivalent Ratio (LER) and total income in early rainy season (March-June 1996).

CROPPING PATTERN	LER	VEGETABLE SOYBEAN Yield (kg/rai)	VEGETABLE SOYBEAN Income (Baht/rai)	BABY CORN Yield (kg/rai)	BABY CORN Income (Baht/rai)	Total Income (Baht/rai)
S	1.00 a	474.02	3792.16	-	-	3792.16
C	1.00 a	-	-	954.22	2862.66	2862.66
SCC	1.11 a	53.16	452.28	814.21	2442.63	2894.91
SSC	1.29 a	263.36	2106.88	550.10	1650.30	3757.18

Remarks market prices : vegetable soybean = 8.00 Baht/kg

baby corn (with husk) = 3.00 Baht/kg

DISCUSSION

The number of soybean insect pests were relatively low during the course of investigation. This was probably due to the investigation site which was isolated from the soybean growing areas in the district. In addition, the duration of the experiment was out of the normal soybean growing season. Hence, few insects moved into the experimental fields.

The greater abundance of insect pests was observed in SSC than in S and SCC. This may be due to the more favorable microclimatic conditions in SSC as reported by Shelton and Edwards (1983).

The mean number of entomophagous species was not significantly different among the different cropping patterns. Thus, the differences in the number of insect pests were not attributed to the number of entomophagous species.

Results obtained from this study indicated that insect pests were more abundant in intercropping especially in SSC in contrast to the previous studies reported by several authors (Tavanainen and Root, 1972 ; Altieri and Letourneau, 1984 and Andow, 1991 a, b). However, insect pest populations may not respond to the intercropping system. Risch *et al.* (1983) reported that 53 % of herbivore species studies exhibited population decreases in diverse cropping patterns, while 18 % were more abundant in diversified systems and 9 % was unaffected. This findings may fall within 18 % of the more abundant insect pests in diverse cropping pattern as reported by Rich.

The population of insect pests was lower in the early weeks and reached the peak during the third and fifth week after seedling emergence, then decreased as the plant approaches to senescence. Such findings generally agreed with the previous studies reported by Peongjarern *et al.* (1977), Cervancia (1982) and Cayme and Titayawan (1991).

Among the group of insect pests, *A. glycines*, *H. indicata* and *E. zinckenella* were considered as a major pests. It was hypothesised that insect pests would be more abundant in soybean-monocrop but the results obtained in this findings were contrary. Surprisingly, more abundance of *H. indicata* and *A. glycines* was observed in intercropping, i.e. SCC and SSC. This was probably due to the characteristic of crop canopies which created a humidity and shaded microenvironment that favored the growth and development of such insects (Aganon, 1989). However, it was also observed that *A. glycines* populations disappeared during the seventh and eighth week and resurged in the ninth week after seedling emergence. Such phenomenon could be attributed to the heavily rainfall washed-out insects from the plants during such periods (Appendix 8).

The presence of taller corn plants in the mixtures provided the microclimatic conditions and favorable habitat for the pod borer. It could be observed in this studied that the higher percentage of pod damage caused by *E. zinckenella* was detected in SCC than in SSC and S, respectively.

Bean leafhoppers, *Empoasca spp*. a minor pest, was more abundant in S than SCC and SSC. Such findings was similar to the results reported by Letourneau (1990). The other minor pests including *M. sojae*, *M. signata, R. linearis* and *P. hybneri* were occasionally collected in the experimental plots. This was probably due to unfavorable climatic conditions. Additionally, corn in the mixtures may emit substances which repel the insects (Cervancia, 1982).

Land Equivalent Ratio (LER) among the different cropping patterns were not significantly different. By considering the relative abundance of insect pests as well as LER, average yield and the total income obtained from this study, it could be stated that soybean monocrop was the best system under this condition. The practical lesson to be learned from these experiments is that diversification of cropping pattern is a critical way to get the desired effect on the abundance of insect pest populations.

SUMMARY

Investigations on the abundance of insect pests of soybean and its entomophagous species in different cropping patterns were carried out at the Division of Agriculture, Sikhiu"Sawadpadungwittaya" School, Sikhiu, Nakornrachasima during March to June 1996. The different cropping patterns investigated were soybean monocrop (S), corn monocrop (C), one-row soybean : two-rows corn intercrop (SCC) and two-rows soybean : one-row corn intercrop (SSC). *M. sojae*, *H. indicata*, *A. glycines*, *Empoasca spp.*, *P. hybneri*, *M. signata*, *R. linearis* and *E. zinckenella* were found associated with soybean plant. Among entomophagous species, coccinellid predators, hymenopterous parasites, ants, dragonflies, tettigonid predators and spiders, were sampled during the course of the investigation.

Total number of soybean insect pests and entomophagous species associated with soybean plants in all cropping patterns were not significantly different. The population of insect pests was more abundant in SSC than S and SCC, respectively. Total density of entomophagous species was more or less at the same level in all cropping patterns.

Differences in the total mean number of insect components in relation to growth stage of soybean plant at different cropping patterns were significant. Total insect pest population was relatively high during the earlier week after seedling emergence and had increased gradually, reaching the peak at the fifth week then decreasing drastically in the following weeks.

Yield of soybean between cropping patterns were significantly different. Highest yields were obtained in S followed by SSC and SCC, with an averages of 474.02, 263.36 and 53.16 kg per rai, respectively.

Yield of young corn ears without husk between cropping patterns were not significantly different. Highest yield was obtained in C followed by SCC and SSC, with an averages of 317.00, 234.37 and 143.86 kg per rai, respectively.

Non-significant differences were obtained in the mean value of land equivalent ratio (LER) in all cropping patterns. SSC had a higher LER value than SCC, S and C with an averages of 1.29, 1.11 and 1.00, respectively.

Highest total income in terms of Baht per rai was obtained in S followed by SSC, SCC and C, respectively.

REFERENCES

Aganon, T.M. 1989. Cultural control against soybean insect pest. *J. Baguio University* (Philippines), pp. 1-3.

Anonymous. 1986. *Integrated Pest Control of Soybean : A Handbook.* Dept. of Agricultural Extension, Ministry of Agriculture and Cooperatives. 27 pp. (In Thai)

__________. 1990. *Summary report of soybean pest management in extension project of crop planting (dry season) 89/90.* Second Unit of KhonKaen Plant Pest Protection, Dept. of Agricultural Extension, Ministry of Agriculture and Cooperatives, 13 pp. (In Thai)

__________. 1994. *Summary of plant pest protection practice 1994.* First Unit of Nakornrachasima Plant Pest Protection, Div. Of Plant Pest Protection. Dept. of Agricultural Extension, Ministry of Agriculture and Cooperatives, 24 pp. (In Thai)

Altieri, M.A. and D.K. Letourneau. 1984. Vegetation diversity and insect pest outbreaks. *CRC Crit. Rev. Plant Sci.* 2(2) : 131-169.

Andow, D.A. 1983 a. The extent of monoculture and its effects on insect pest populations with particular reference to wheat and cotton. *Agric. Ecosys. Environ.* 9 : 25-35.

___________. 1983 b. Effect of agricultural diversity on insect populations. In : W. Lockeretz. (ed.). *Environmentally Sound Agriculture.* New York : Praeger, pp. 91-115.

___________. 1991 a. Yield loss to arthropods in vegetationally diverse agroecosystems. *Environ. Entomol.* 20(50) : 1228-1235.

___________. 1991 b. Vegetational diversity and arthropod population response. *Annu. Rev. Entomol.* 36 : 561-568.

Andrews, D.J. and A.H. Kassam. 1976. Importance of multiple cropping in increasing world food supplies. In : Papendick, R.I., P.A. Sanchez and G.B. Triplet (eds.) *Multiple Cropping*. ASA (American Society of Agronomy) Spec. Pub. 27, pp. 1-10.

Baker, E.F.I. 1979. *Population, time, and crop mixtures*. In : R.W. Wiley (ed.), *Proceedings of the International Workshop on Intercropping*. Hyderabad, India, pp. 52-60.

Burandy, R.P. and R.S. Raros. 1975. Effect of cabbage-tomato intercropping on the incidence and oviposition of the diamond back moth, *Plutella xylostella* (L.). *Philipp. Entomol.* 2 : 369-374.

Capinera, J.L., T.J. Weissling and E.E. Schweizer. 1985. Compatibility of intercropping with mechanized agriculture : Effects of strip intercropping of pinto beans and sweet corn on insect abundance in Colorado. *J. Econ. Entomol.* 78 : 354-357.

Cayme, T.L. 1991. Effects of vegetation textures on the density and herbivory of the soybean stem fly, *Melanagromyza sojae* (Zehntner) in soybean cropping systems. *Institute of Environmental Science and Management Bulletin.* 11(1 and 2) : 19.

___________. and M. Titayavan. 1991. Effects of vegetation textures on the density and herbivory of the soybean stem fly, *Melanagromyza sojae* (Zehntner) in soybean cropping systems. In : *Proceedings of 3rd Soybean Research Workshop,* pp. 478-486. February 21-23, 1990, Chiangmai Plaza Hotel, Chiangmai, Thailand.(In Thai)

Cervancia, C.R. 1982. Analysis of soybean insect diversity and pest infestation pattern in different cropping combinations. Ph.D. Thesis, University of the Philippines at Los Banos. 139 pp.

Dent, D. 1991. *Insect Pest Management*. CAB International. 604 pp.

Department of Agriculture. 1994. Annual report of Ban Mai Sam Rong Field Crops Experimental Station. In : *Annual Report for 1994*. Institute of Crop Research, Dept. of Agriculture, Ministry of Agriculture and Cooperatives, pp. 93-97. (In Thai)

Duangsa-ard, C. 1986. *Insect pests of economic crops and their control.* Office of Agriculture Research and Extension, Maejo Institute of Agricultural Technology, Chiangmai, 172 pp. (In Thai)

ICRISAT. (International Crops Research Institute for the Semi Arid Tropics).1989. *Annual Report for 1988*. Patanchery, India.

INTERNATIONAL RICE RESEARCH INSTITUTE. 1973. *Annual Report for1972*. Los Banos, Philippines. 246 pp.

Lambert, J.D.H., J.T. Arnason, A. Serratos, B.J.R. Philogene and M.A. Faris. 1987. Role of intercropped red clover (*Trifolium pratense*) in inhibiting European corn borer, *Ostrinia nubilalis* (Lepidoptera : Pyralidae) damage to corn (*Zea mays* L.) in eastern Ontario. *J. Econ. Entomol.* 80 : 1192-1196.

Letourneau, D.K. 1987. The enemies hypothesis : tritophic interaction and vegetational diversity in tropical agroecosystems. *Ecoloy.* 68 : 1616-1622.

______________. 1990. Abundance patterns of leafhopper enemies in pure and mixed stands. *Environ. Entomol.* 19(3) : 505-509.

Martin, R.C., J.T. Arnason, J.D.H. Lambert, P. Isabelle, H.D. Voldeng and D.L.Smith. 1989. Reduction of European corn borer (Lepidoptera : Pyralidae) damage by intercropping corn with soybean. *J. Econ. Entomol.* 82(5) : 1455-1459.

Napompeth, B., K. Charernsom and W. Suasa-ard 1983. Soybean insect pest management. In : *Annual Research Report for 1983,* pp. 10-11. Kasetsart University, Bangkok, Thailand. (In Thai)

Peongjarern, P., T. Satayavirut, V. Tanomtinh and A. Arunin. 1977. Population dynamics of certain insect pests of soybean. In : *Annual Research Report for 1977,* p. 144. Div. Of Entomology and Zoology, Dept. of Agriculture, Ministry of Agriculture and Cooperatives. (In Thai)

Pookpakdi, A. 1982. Multiple cropping : Principles and practices to increase crop production for subsistence farmers. *Technical Bulletin* No. 2, The Multiple Cropping Research Project, Faculty of Agriculture, Kasetsart University, 65 pp.

_________. 1985. *Cropping system.* (2nd ed.). Dept. of Agronomy, Faculty of Agriculture, Kasetsart University. 85 pp. (In Thai)

Risch, S.J., D.A. Andow and M.A. Altieri. 1983. Agroecosystem diversity and pest control : data, tentative conclusions, and new research directions. *Environ. Entomol.* 12 : 625-629.

Root, R.B. 1973. Organization of a plant-arthropod association in simple and diverse habitats : The fauna of collards (*Brassica oleracea*). *Ecol. Monogr.* 43 : 95-124.

Shelton, M.D. and C.R. Edwards. 1983. Effects of weeds on the diversity and abundance of insects in soybeans. *Environ. Entomol*. 12 : 296.

Suharto. 1989. Abundance of *Heliothis armigera* and its natural enemies in cotton intercropped with cereals or legume. College, Laguna (Philippines), June, 1989. 104 pp.

Suryatna, E.S. and R.R. Harwood. 1976. *Nutrient uptake of two traditional intercrop combinations and insect and disease incidence in three intercrop combination*. IRRI, Saturday Seminar, LosBanos, Philippines, February 20, 1976.

Sutater, T. 1986. The effects of intercropping of vegetables and corn on the yield and pest incidence in soybean. *Bulletin-Penelitian-Hortikultura* (Indonesia). 14(2) : 127-142.

Tahvanainen, J.O. and R.B. Root. 1972. The influence of vegetational diversity on the population ecology of a specialized herbivore, *Phyllotreta cruciferae* (Coleoptera : Chrysomelidae). *Oecologia* 10 : 321-346.

Thawatsin, S., P. Changcharern and S. Taramat. 1990. Soybean Pest Situation in Selected Area. In : *Proceedings of 3rd Soybean Research Workshop*, p. 431 February 21-23, 1990, Chiangmai Plaza Hotel, Chiangmai. (In Thai)

Tingey, W.M. and W.J. Jr. Lamont. 1988. Insect abundance in field beans altered by intercropping. *Bull. Entomol. Res.* 78 : 527-535.

Visitpanich, J. 1985. *Insect Pests of Soybean in Northern Thailand.* Dept. of Entomology, Faculty of Agriculture, Chiangmai University, 37 pp. (In Thai)

Wongsiri, N. 1991. *List of insect, mite and other zoological pest of economic plants in Thailand.* Entomology and Zoology Division, Department of Agriculture, Bangkok, pp. 129-131. (In Thai)

Yaku, A., S.B. Hill and H. Chiasson. 1992. Effects of intercropping on a population of sweet potato weevil, *Cylas formicarius* (F.) Coleoptera : Curculionidae. *Science-in-New-Guinea* (Papua New Guinea) 18(1):123-132.

Appendix 1 Mean number of bean leafhoppers, *Empoasca spp.* collected in each cropping pattern at different growth stages of soybean plants, from March to June 1996.

CROPPING	WEEKS AFTER SEEDLING EMERGENCE								TOTAL
PATTERN	2	3	4	5	6	7	8	9	
S	0.00	3.67	6.67	11.67	1.00	4.00	4.00	1.00	32.01 a
SCC	0.00	0.33	1.00	1.33	3.00	3.67	3.00	1.67	14.00 ab
SSC	0.00	1.00	0.67	1.67	1.67	4.00	2.00	0.33	11.34 b

Total with the same letter are not significantly different (P>0.05;DMRT).

Appendix 2 Mean number of monolepta beetles, *Monolepta signata* (F.) collected in each cropping pattern at different growth stages of soybean plants, from March to June 1996.

CROPPING	WEEKS AFTER SEEDLING EMERGENCE								TOTAL
PATTERN	2	3	4	5	6	7	8	9	
S	0.33	0.00	0.00	0.67	0.00	0.00	0.00	0.00	1.00 a
SCC	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33 a
SSC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 a

Total with the same letter are not significantly different (P>0.05;DMRT).

Appendix 3 Mean number of one-banded stink bugs, *Piezodorus hybneri* (Gmel.) collected in each cropping pattern at different growth stages of soybean plants, from March to June 1996.

CROPPING	WEEKS AFTER SEEDLING EMERGENCE								TOTAL
PATTERN	2	3	4	5	6	7	8	9	
S	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.33	0.66 a
SCC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 a
SSC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33 a

Total with the same letter are not significantly different (P>0.05;DMRT).

Appendix 4 Mean number of bean bugs, *Riptortus linearis* (F.) collected in each cropping pattern at different growth stages of soybean plants, from March to June 1996.

CROPPING	WEEKS AFTER SEEDLING EMERGENCE								TOTAL
PATTERN	2	3	4	5	6	7	8	9	
S	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.67	1.00 a
SCC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33 a
SSC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33 a

Total with the same letter are not significantly different (P>0.05;DMRT).

Appendix 5 Analysis of variance for the number of soybean insect pests within vegetable soybean canopy in early rainy season (March-June 1996).

SOURCE OF VARIATION	df.	MEAN SQUARE					
		A. glycines	*H. indicata*	*M. signata*	*Empoasca spp.*	*R. linearis*	*P. hybneri*
Replication	2	3.993 *	0.039 ns	0.090 ns	0.016 ns	0.160 **	0.030 ns
Treatment	2	0.980 ns	0.054 ns	0.030 ns	0.136 ns	0.010 ns	0.030 ns
Ex. Error	4	0.549	0.014	0.030	0.025	0.010	0.015
Total	8						

* = significant difference at 0.05 %   ** = significant difference at 0.01 %

ns = no significant difference

Appendix 6 Analysis of variance for the yield and yield components of vegetable soybean (Chiangmai # 1) in early rainy season (March-June 1996).

SOURCE OF VARIATION	df.	MEAN SQUARE					
		Plant height (cm)	Branches / pl.	Nodes / pl.	Pods / pl.	Pod weight (gm/pl.)	Empty pods/pl.
Replication	2	6.448 ns	0.756 ns	0.010 ns	0.084 ns	2.546 ns	1.175 ns
Treatment	2	16.728 *	0.904 ns	0.039 ns	76.063 ns	91.667 ns	5.006 ns
Ex. Error	4	1.239	0.531	0.090	19.898	13.424	3.701
Total	8						

* = significant difference at 0.05 % ns = no significant difference

Appendix 6 Continued.

SOURCE OF VARIATION	df.	MEAN SQUARE			
		Full pods /pl.	No. of pods/kg	100-seed fresh wt.(gm)	Yield of fresh pods (kg/rai)
Replication	2	0.695 ns	40134.747 ns	15.501 ns	3684.747 ns
Treatment	2	62.097 ns	31680.084 ns	22.434 ns	132842.413 *
Ex. Error	4	8.229	27956.687	4.399	9309.574
Total	8				

* = significant difference at 0.05 % ns = no significant difference

Appendix 7 Analysis of variance for the yield and yield components of baby corn (Pacific 421) in early rainy season (Mar.-Jun. 1996).

SOURCE OF VARIATION	df.	MEAN SQUARE			
		Plant height (cm)	Ear with husk (kg/rai)	Ears/ plant	Ear length (cm)
Replication	2	260.577 *	218001.396 ns	0.145 ns	2.299 ns
Treatment	2	76.916 ns	126336.764 ns	0.380 ns	0.098 ns
Ex. Error	4	32.116	95650.668	0.077	0.338
Total	8				

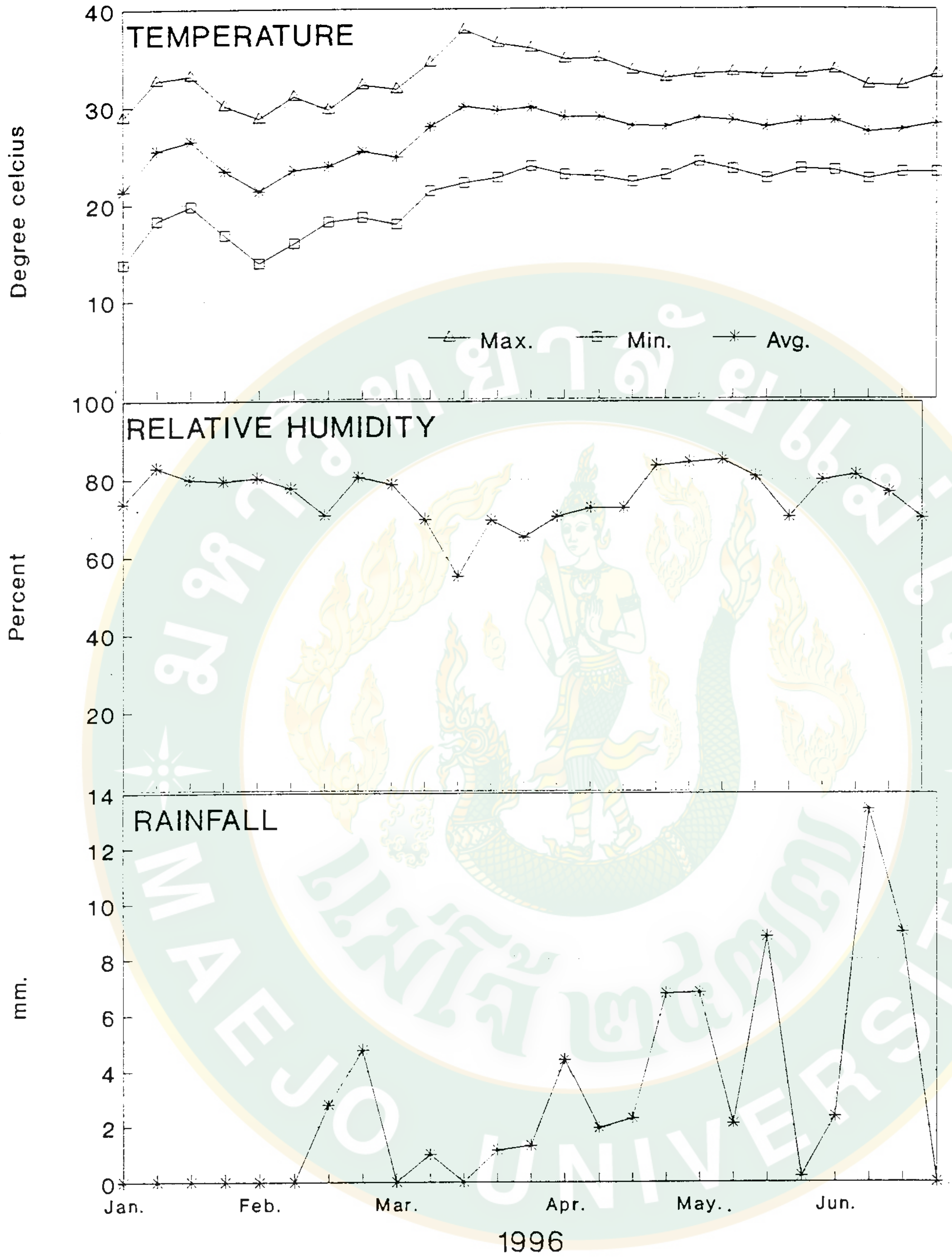
* = significant difference at 0.05 % ns = no significant difference

Appendix 7 Continued.

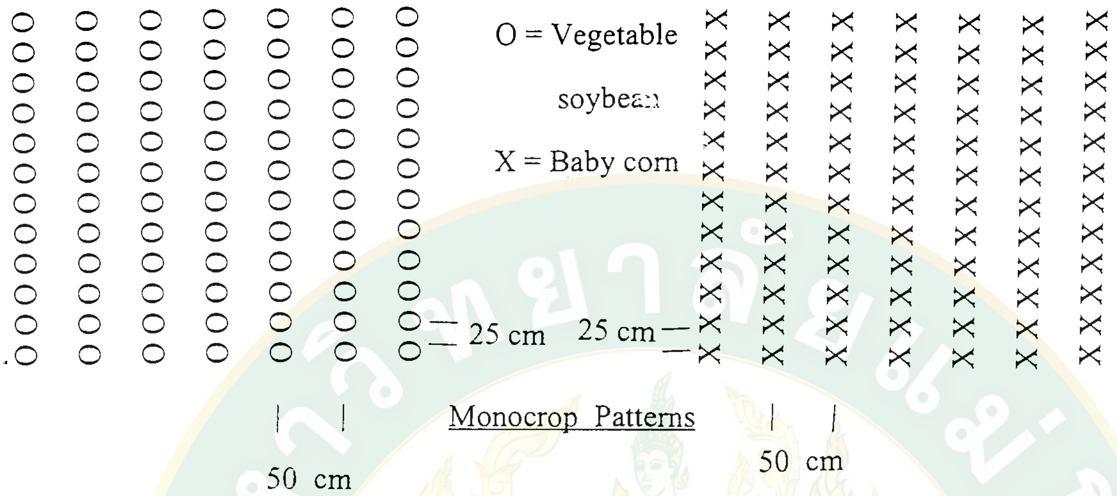
SOURCE OF VARIATION	df.	MEAN SQUARE		
		Ear diameter (cm)	Standard ears (%)	Ear without husk (kg/rai)
Replication	2	0.047 **	439.876 **	12942.104 ns
Treatment	2	0.002 ns	15.177 ns	22499.471 ns
Ex. Error	4	0.001	12.627	15521.968
Total	8			

** = significant difference at 0.01 %

ns = no significant difference

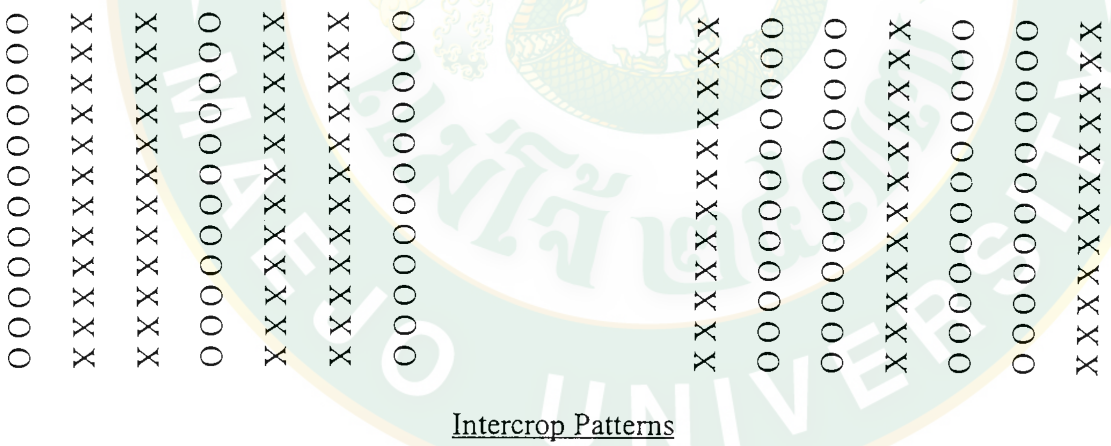


Appendix 8 Temperature, relative humidity and amount of rainfall during January to June 1996 at Ban Mai Sam Rong Field Crops Experimental Station, Sikhiu district, Nakornrachasima province.



Soybean Monocrop (S)

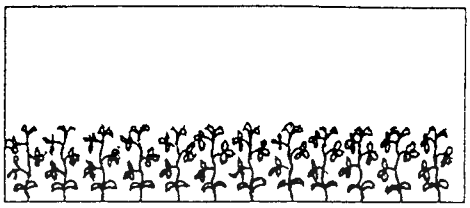
Corn Monocrop (C)



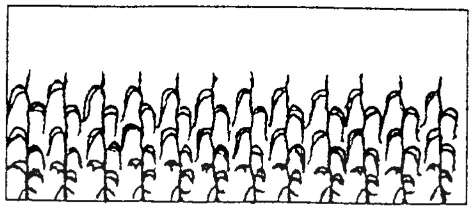
One-row soybean : Two-rows corn Intercrop (SCC)

Two-rows soybean : One-row corn Intercrop (SSC)

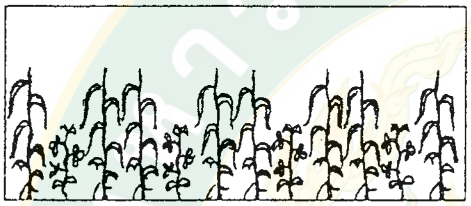
Appendix 9 The different cropping patterns (top view).



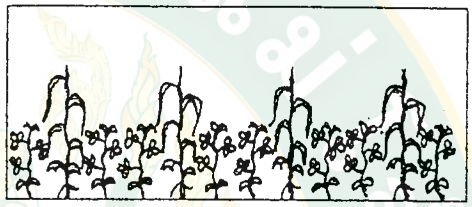
Soybean Monocrop (S)



Corn Monocrop (C)



One-row soybean : Two-rows corn Intercrop (SCC)



Two-rows soybean : One-row corn Intercrop (SSC)

 = vegetable soybean plant

 = baby corn plant

Appendix 10 The different cropping patterns (side view).

Appendix 11 Soybean Monocrop (S)

Appendix 12 Corn Monocrop (C)

Appendix 13 One-row soybean : Two-rows corn Intercrop (SCC)

Appendix 14 Two-rows soybean : One-row corn Intercrop (SSC)

BIOGRAPHICAL SKETCH

The author was born on November 9, 1959 at Khoksamrong, Lopburi, Thailand. He finished his elementary and secondary education from Jareuk-lomwittaya School and Khoksamrongwittaya School, respectively.

In 1980, he obtained a Diploma in Farm Mechanics degree at the Institute of Technology and Vocational Education at Nakornrachasima Campus, Nakornrachasima, Thailand. He then joined the Office of Nonsung District Agriculture, Nakornrachasima, as an Agricultural Officer (level 2). After one year, he continued further study in Crop Technology at Maejo Institute of Agricultural Technology, Chiangmai, Thailand. He finished his Bachelor of Agricultural Technology in 1983.

In 1984, he was appointed as a teacher at the Sikhiu"Sawadpadung- wittaya" School, Division of Agriculture, Sikhiu district, Nakornrachasima province, Thailand and holds this position to date.

WUTIKIAT MONGKOLPORNRUGEE