CHAPTER III
MATERIALS AND METHODS

3.1. Site description

A field experiment was conducted during the dry season in 1989 (July to December) at the Manggoapi Experimental Station of the Faculty of Agriculture, Cenderawasih University in Manokwari ($134^0$05'E, $0^0$50'S). The station is 110 m above sea level, with plate topography and a red-yellow Mediterranean soil type, with a pH of 5 to 7 (Karyoto et al. 1987).

The average rainfall and rainy days per month during the field experiment were 187 mm and 16 days, respectively. Based on average monthly rainfall recorded during 40 years , the location is classified as having 5 to 6 months wet period and < 2 months of dry period, with an annual rainfall of approximately 2390 mm (Oldeman et al. 1980). Low rainfall (< 200 mm) occurs during May to October, and high rainfall (> 200 mm) occurs during November to April each year (Fig. 7); these periods are considered as dry and wet season, respectively.

According to land use history, the experimental location was previously planted with mungbean, *Phaseolus radiatus*, corn, *Zea mays*, and sweet potato, *Ipomoea batatas*, after which it was abandoned for four years, and had become weed infested. Vegetation analysis carried out prior to land clearing showed that elephant grass, *Pennisetum purpureum*, as well as *Sida rhombifolia*, and *Callopogonium mucuniodes*, were the dominant weeds.

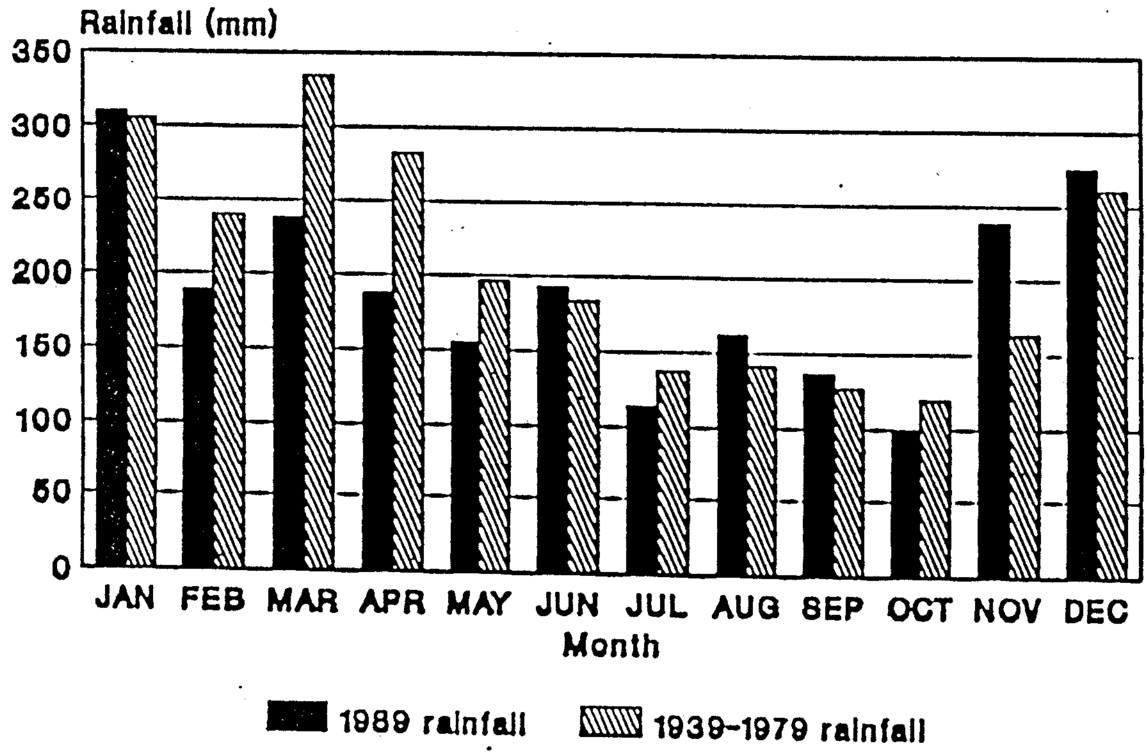

Fig. 7. Monthly rainfall recorded at Manggoapi experimental farm during 1989 and the average of monthly rainfall in Manokwari recorded during a previous 40-year period (1939 to 1979).

3.2. Experimental design

The following five treatments were tested using a randomized complete block design with three replications of 150 m^2 plots (Appendix 1).

A = sweet potato monoculture

B = sweet potato + corn

C = sweet potato + soybean

D = sweet potato + corn + soybean

E = sweet potato + tomato + cabbage

3.3. Crop arrangement and spacing within each treatment

3.3.1. Sweet potato monoculture

A sweet potato monoculture was planted with a spacing of 100 cm between ridges and 40 cm within rows, giving a density of 370 plants per 150 m^2 plot (24.668 sweet potato plants per ha).

3.3.2. Sweet potato and corn

Two ridges of sweet potato were planted between two double rows of corn plants. The corn spacing between rows was 50 cm, so that the populations obtained were 240 corn plants and 222 sweet potato plants per plot (16.000 corn plants and 14.800 sweet potato plants per ha).

3.3.3. Sweet potato and soybean

Three rows of soybean were planted, followed by two rows of sweet potato. The soybean spacing was 25 x 25 cm. The sweet potato spacing was the same as in the monoculture treatment. The populations of soybean and sweet potato in this treatment were 720 and 222 plants per plot, respectively (48.002 soybean plants and 14.800 sweet potato plants per ha).

3.3.4. Sweet potato, corn and soybean

One row of corn was planted between two rows of soybean, to be followed by two rows of sweet potato. The same arrangement was repeated for the rest of the plot, so that the populations of soybean, corn and sweet potato were 720, 90 and 148 plants per plot, respectively (48.002 soybean plants, 6.000 corn plants, and 9.867 sweet potato plants per ha).

3.3.5. Sweet potato, tomato and cabbage

Two rows of cabbage were planted between two rows of tomato, followed by two rows of sweet potato. This arrangement was repeated for the rest of the plot. The populations of tomato, cabbage and sweet potato were 180, 222 and 148 plants per plot, respectively (12.000 tomato plants, 14.800 cabbage plants, and 9.867 sweet potato plants per ha).

3.4. Field preparation and management

3.4.1. Land preparation

The experimental site was cleared of grasses and shrubs, and then plowed. The land was then divided into 15 plots of 150 m^2 each, and ridges for sweet potato were formed in each plot.

3.4.2. Preparation of planting materials

Terminal cuttings of sweet potato vines, about 25 to 35 cm in length with a few leaves at the tip, were prepared three days before planting. The cuttings were tied in groups of 10; wet jute sack was wrapped around the cut end and the bundles were stored in a cold and shady place to accelerate root growth.

Local varieties of corn, soybean, tomato and cabbage were selected. The seeds of cabbage (cv. K-K Cross) and a local variety of tomato were sown in the nursery four weeks prior to planting out. After one week the seedlings were transfered to Pandanus-leaf containers.

3.4.3. Planting and fertilizing

All crops were planted simultaneously; the sweet potato cuttings, one per hole, on the ridge tops, and corn and soybean, 3 or 4 seeds per hole, according to planting design.

Transplanting of tomato and cabbage was carried out by opening the containers and planting the seedlings in holes that had been filled with 250 gram chicken manure, as a basic fertilizer, three days before planting.

All crops received one or two applications of inorganic sources of nitrogen, phosphorous and potassium. Total amounts applied are given in Table 6.

Table 6. Total amount of nitrogen, phosphorous and potassium (kg/ha) applied to sweet potato, corn, soybean, tomato and cabbage.

	Fertilizer (kg/ha)		
Crop	Nitrogen (N)	Phosphorous (P_2O_5)	Potassium (K_2O)
Sweet potato	90	50	240
Corn	120	45	25
Soybean	45	90	50
Tomato	100	150	50
Cabbage	90	60	0

The first application took place immediately after planting, and, for most crop, the second application occured 30 days after planting (DAP).

For sweet potato, half of the fertilizer was applied as a spot application at planting time, and the other half at 30 DAP. For corn, two-third of the nitrogen was applied at planting, the remaining one third at 30 DAP. The complete dose of phosphorous and potassium was applied at the time of planting.

Soybean fertilizer was applied once at planting time as a continuous band 7 to 10 cm to one side of the row. Tomato and cabbage were fertilized once by means of spot and ring applications, respectively, at 21 DAP.

3.5. Crop maintenance

Crops maintenance included watering, replanting, weeding and hilling up of the soil, staking of tomato plants, lifting of vines, and pruning of the old leaves.

Watering was provided, especially for cabbage and tomato, during the first two weeks before the plants were well established. Sweet potato was also watered early in the growing season, when the weather was dry. All dead and missing plants were replaced within 7 to 10 DAP.

Hand weeding, especially of nutsedge, *Cyperus rotondus*, which dominated the experimental area, was undertaken twice. Weeding was done 14 and 28 DAP. Hilling up of the soil was done immediately after weeding to support the crops.

Tomato plants were staked with 75 cm long sticks, 21 DAP. Lifting of sweet potato vines to prevent the growth of adventious roots took place twice, at 28 and 56 DAP. Pruning of old sweet potato leaves was carried out as necessary.

3.6. Observations

3.6.1. Colonization by SPW

Observation of colonization of the sweet potato crop by SPW was carried out at 56 DAP on 10 randomly selected plants from each plot. A plant was considered to have been colonized if a SPW was present or if damage by SPW was evident. Percentage colonization data was calculated as follows:

$$C = \frac{N}{T} \times 100\ \%$$

where: C = percentage colonization of the sweet potato plant in a plot
N = number of samples colonized
T = total number of samples per plot

Percentage of colonization data were tabulated and transformed with an arcsin transformation prior to analysis of variance, as recommended by Gomez & Gomez (1976, 1984), when data are in proportions.

3.6.2. Population density of SPW and percentage of damaged tuber

Ten sampling units (plants) were taken randomly from each experimental unit to determine the size of the SPW population. The tubers and vines (15 cm above the crown) of each plant were dissected directly at harvest; and the number of weevil larvae, pupae and adults were totaled for each sampling units (plant) per experimental unit.

The percentage of infested (damaged) tubers was calculated as follows.

$$I = \frac{a}{a + b} \times 100\ \%$$

where: I = percentage of infected tubers
a = infected tubers
b = healthy tubers

Data for the number of insects, and the percentage of infected tubers, were tabulated and transformed with a square root + 0.5, and arcsin transformation, respectively, prior to analysis. The square root + 0.5 and arcsin transformation are used when data record rare events and relate to proportions, respectively (Gomez & Gomez 1976, 1984).

3.6.3. Number and fresh weight of tubers

Number of tubers from ten plants from each plot were counted and their fresh weight was recorded.

3.6.4. Marketable yield

Marketable yield of sweet potato, corn and soybean were weighed from each plot prior to being marketed. Profit obtained from marketing the yield of a particular cropping system, without taking into account the cost of production, was recorded as its economic value. The value of each of the crops was based on the market prices in the Manokwari market in December 1989.

3.6.5. Monetary index

Monetary index (Gomez & Gomez 1983) was used to evaluate the yield advantage of each treatment. This was obtained by substracting the total cost of production from total economic value of the produce from each cropping system.

Total cost of production included operational cost and materials. Operational cost consisted of land preparation, planting, fertilizing, maintaning, harvesting, washing of the tubers, drying and seeding of corn and soybean; while materials included cost of sweet potato cuttings, corn and soybean seeds, and fertilizers (Urea, TPS, and KCl).

3.6.6. Insect diversity

Insects from the monoculture and the intercropped sweet potato were sampled using a sweep net and pitfall traps as described below.

a. Sweep net sampling

Sweep net sampling was done as described by Risch (1979) in Costa Rica. One sampling unit (30 sweeps) was replicated four times in each experimental unit (plot). Thus, 120 sweeps were taken from each experimental unit and a total of 360 sweeps were taken from each treatment. Sweeping was done in straight lines and the vegetation was never swept twice during a sampling date. Sweeping was carried out on four sampling dates, 35 DAP, 42 DAP, 49 DAP and 56 DAP, always between 08.00 a.m and 11.00 a.m.

Insects collected from each sampling unit (30 sweeps) were placed in a small plastic bag, killed with chloroform, separated from the vegetation, and stored in vials in 75 % methyl alcohol. The insects were then separated into families under a stereoscopic microscope, according to the classification scheme in Borror et al. (1989).

b. Pitfall traps

Five pitfall traps per plot were used to capture ground inhabiting arthropods. The traps (12 cm diam. x 15 cm high plastic containers), were placed diagonally at five points in each plot 35 DAP (Fig. 8). They were buried in the soil so that the edge of the container was flush with the soil surface.

To prevent escape, the traps were half filled with a near saturated solution of water, salt and detergent.

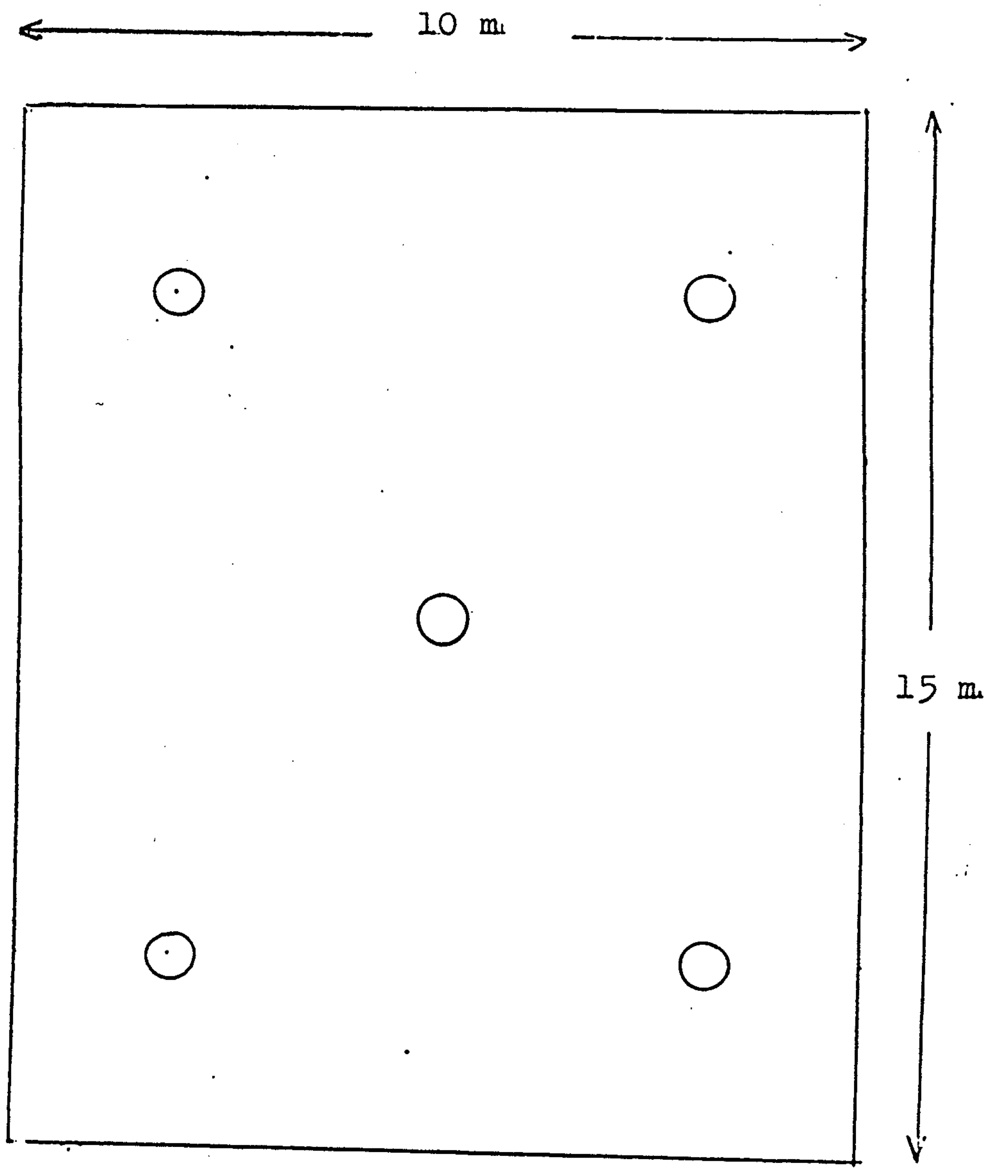

Figure 8. Arrangement of pitfall traps in each experimental unit

3.7. Analysis of data

3.7.1. Effects of intercropping on populations of SPW and on sweet potato production

For testing the significance of the effects of intercropping on the populations of SPW (number of SPW and percentage of damage) and on sweet potato production (number of tubers and fresh weight of tubers), these data were subjected to analysis of variance. Fisher's Least Significant Difference (LSD) test was used to locate differences among means.

The relationship between numbers of SPW, and percentage of damaged tubers were analyzed by means of regression analysis.

Marketable yield was tabulated to compare yield advantage. Comparison of yield advantage among treatments using Land Equivalent Ratio (LER) could not be carried out, because in the present study corn and soybean were not planted in monoculture. As a result, the yield advantage is expressed as a Monetary Index (MI). This index can be obtained by using the following formula:

$$MI = \sum_{i=1}^{n} (a_i X_i - b_i)$$ (Gomez & Gomez 1983).

where : MI = monetary index
a_i = species of crops
b_i = economic value of crops in a cropping system
X_i = yield of a species of crop

3.7.2. Insect diversity

Analysis of the diversity of insects and spiders within the four different sweet potato agroecosystems was determined by using the Kruskal-Wallis non-parametric analysis of variance (Daniel 1990). This analysis is based on Kruskal-Wallis test statistic (H).

$$H = \frac{12}{N(N+1)} \sum \frac{R_i^2}{n_i} - 3(N+1) \qquad \text{(Daniel 1990)}$$

where: N = the total number of insect and spider families within the four sweet potato cropping systems.
R_i = the sum of the ranks assigned to the number of insect and spider families within the four sweet potato cropping systems.

This analysis was used to test the following hypotheses:

1. Null hypothesis (H_0): The number of insect and spider families within each of the four sweet potato cropping systems are similar.
2. Alternative hypothesis (H_A): The number of insect and spider families within each of the four sweet potato cropping systems are not similar.

The null hypothesis is rejected if the value of **H** in Kruskal-Wallis non-parametric analysis of variance is greater than $\mathbf{X}^2_{3,0.05}$.