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Maize-Cowpea Mixed Crop System Response to Insect Control  
and Maize Population Variation<sup>1/</sup>

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## ABSTRACT

Alterations of function produced by variations of insect control and maize planting density were studied in a cropping system of maize (*Zea mays* L.) associated simultaneously with cowpea (*Vigna unguiculata* Walp.). Maize yields were reduced significantly and cowpea yields increased significantly in treatments without insect control. Insect damage to maize allowed more sunlight penetration to the lower strata, thus increasing cowpea yields. Maize planting density and insect control levels interacted to condition yields of both crops. This was considered potentially significant for agroecosystem management with reduced agrochemical use.



In recent years, agricultural scientists concerned with pest management have designed alternatives that reduce excessive pesticide use. These alternatives are based on ecological knowledge that permits agroecosystem management to maintain pest populations and damage below economic levels.

Evidence indicates that the principal agricultural pest problems occur in areas that practice monoculture, characterized by reduced faunistic richness and floral simplicity (Altieri et al. 1977, CIAT 1974, IITA 1977). There are various theoretical explanations of why insect pests may be less numerous in mixed crop systems than in monoculture systems. Associated crops provide more diversity of food source, i.e. nectar and pollen, for predators and parasites (Risch 1979). Biological complexity affects olfactory responses, altering insect dynamics in the agroecosystem (Tahvanainen and Root 1972). Some insects avoid feeding on shaded plants and taller plants may provide a physical barrier for insect pests of crops in lower strata (Risch 1979). Taxonomic and climatic diversity in diversified communities tends to reduce the probabilities of phytophagous pest population explosions (Litsinger 1975, Tahvanainen and Root 1972).

Crop planting density also affects insect population dynamics. Pimentel (1961) reported that widely spaced plants attracted few insects and were less damaged than the same species at greater plant population densities. To the contrary, Way and Heathcote (1966) cite examples where less damage occurred when planting densities were increased.

Although there is considerable literature on these themes, there are few opportunities to relate the information to crop yield. The fundamental

objective of this work was to obtain information about alterations of function in a maize-cowpea (*Zea mays* L. -*Vigna unguiculata* Walp.) system caused by variation in management of naturally occurring pests and variation of maize planting density.

### Materials and Methods

The study was conducted at the experimental farm of the Centro Agronómico Tropical de Investigación y Enseñanza at Turrialba, Costa Rica (Lat. 9°53' N, Long. 83°39' W, elevation 602 m) during the November 1979 to April 1980 cropping cycle.

Holdridge (1979) classified the zone in the ecological formation "very humid Premontane Tropical Forest". The area is characterized by: 2674 mm mean annual precipitation, 251 days with rainfall, 1265 mm mean annual pan A evaporation, 83% mean daily relative humidity, 4.5 mean daily hours sunshine, 413 mean daily  $\text{cal cm}^{-2}$  radiation, and 22.3°C mean annual temperature with variation between 17°C and 27.1°C (CATIE 1977).

The experiment was located on a clay soil, derived from auguite-andesite parent rock, classified as Typic Dystropept of the USA soil taxonomy (Aguirre 1971).

Two levels of pest control, (with and without) two levels of weed control (one and two manual weedings), and six structural modifications of the system (combinations of three maize planting densities with two growth habit types of cowpea) were combined in different factor levels resulting in 24 treatments. These were randomly distributed in a split-split plot

experimental design. The smallest plot units were 5 m wide and 9.5 m long.

The maize cultivar 'Tico V-1' was planted at densities of 20, 40 and 60 thousand plants per ha with 1 m between rows and 0.5 m between hills. The cowpea cultivars, 'Vita-3' of climbing habit and 'Vigna-44' of semi-climbing habit, were planted at densities of 80 thousand plants per ha. Two rows of cowpea, spaced 0.5 m apart and 0.5 m between hills, were planted between maize rows. Both maize and cowpea were planted simultaneously.

Insect damage, plant population, plant growth and grain yield components data were analyzed by the causal models method using structural equations of cause and effect, and estimations obtained by the generalized least square method (Van de Geer, 1971). Analysis of variance for the crop variables was used to test hypotheses on main effects and interactions.

### Results and Discussion

Maize and cowpea yields were highly significantly different for pest control levels and for structural changes in the system caused by varying the maize population. No differences were observed for levels of weed control.

Cause and effect relations of the variables, in time and space, (Figs. 1 and 3) were determined by multiple regression analysis. The size and sign of the standard coefficient indicates the importance and type of relation between variables. Quantified entomological variables are related to the most affected yield variable for both crops in Fig. 1. Magnitudes

and signs of the standard coefficients indicate that maize yields decreased and cowpea yields increased in treatments without insect control.

Maize yield reduction caused by insect damage is indicated by the standard coefficients (-0.55) for early attack of adult Chrysomelidae, mostly *Diabrotica balteata* Leconte, and percent whorl infestation by *Spodoptera frugiperda* (J.E. Smith). Concurrently, control of pests in the soil maintained maize plant populations and increased plant height, and indicator of vigor (Table 1). Maize grain yield was 59% more in treatments with pest control than in those without control (Fig. 2).

Mean yields for both cowpea cultivars were 145% more in treatments without pest control (Fig. 2). Apparently this is a consequence of pest damage to roots and foliage of maize, thus favoring better cowpea development because of reduced competition. Number of pods for both cowpea cultivars increased with intensification of maize defoliation by *S. frugiperda*, indicated by the standard coefficient (0.54) in Fig. 1. Insect pests also reduced the number of maize plants harvested and height of maize (Table 1). These alterations favorably modified the microclimate where cowpea develops by allowing more light penetration and probably reduced competition for nutrients.

Relations between final maize plant population and yield variables are presented in Table 3. Standard coefficients for maize yield (0.62) and cowpea yield for both cultivars (-.51) denote strong relationship between final maize plant population and yield of both crops. An increase in maize population increased maize yield but decreased yields of both cowpea cultivars

(Fig. 2). This indicates that maize has more competitive capacity, increasing with plant density. Shade was possibly the strongest influence of maize on cowpea (Willey and Osiru 1972).

As reported by Fisher (1975), the primary competitive effects of high maize plant densities on cowpea was manifested principally as pod abscission (Table 2). This effect has been explained partially as a defense mechanism to compensate for reduced photosynthesis under reduced light. The number of maize ears per plant and number of grains per ear varied in inverse proportion to maize planting density (Table 3) but this did not significantly affect yield. The reduction was compensated for by the greater number of harvested plants per unit area.

Cowpea growth habit did not significantly affect other components of the system but yields were different for the two cultivars, especially in treatments with insect control. Ability of each cultivar to capture light or genetic potential possible explain these differences.

The joint effect of maize planting density and insect control level as yield modifiers of both species was established. Yield differences between the two insect control levels diminished as maize planting density increased (Fig. 2). This response is potentially significant for agroecosystem management with reduced agrochemical use.



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**Footnotes**

- 1/ Part of dissertation presented by the senior author to the graduate school of the University of Costa Rica/Centro Agronómico Tropical de Investigación y Enseñanza in partial fulfillment of requirements for the Master of Science degree.
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Table 1.— Effect of insect control and maize planting density on final population and height of maize grown in association with cowpea.

Planting density	Plants harvested per ha		Plant height (m)	
	Control	No control	Control	No control
20000	19445	16144	2.18 b*	1.63 d
40000	39151	34441	2.30 a	1.78 c
60000	58595	52974	2.36 a	1.95 c

\* Means not followed by same letter are significantly different at P=0.05.

Table 2.— Effect of insect control and maize planting density on cowpea yield components in a maize-cowpea cropping system.

Maize planting density	Pods per plant		Grains per pod		Weight per grain (g)	
	Control	No control	Control	No control	Control	No control
20000	5.9 a*	2.9 c	14.3 a	13.4 b	0.12 a	0.12 a
40000	3.8 b	1.6 e	13.7 b	13.6 b	0.12 a	0.12 a
60000	2.6 d	0.7 f	13.7 b	12.7 c	0.12 a	0.12 a

\* Means not followed by same letter are significantly different at P=0.05

Table 3.— Effect of insect control and maize planting densities on maize yield components in a maize-cowpea cropping system.

Maize planting density	Ears per plant		Grains per ear		Weight per grain (g)	
	Control	No control	Control	No control	Control	No control
20000	1.2 b*	1.3 a	500.0 b	540.6 a	0.22 b	0.27 a
40000	1.0 c	1.0 c	455.3 c	491.4 bc	0.22 b	0.26 a
60000	0.8 d	0.9 d	431.2 c	478.9 bc	0.22 b	0.22 b

\* Means not followed by same letter are significantly different at P=0.05

**Running head:**

**Juarez et al: Maize-Cowpea System Response to Insect Control.**