

Evaluation of cacao hybrids under two shade systems at CATIE, Costa Rica

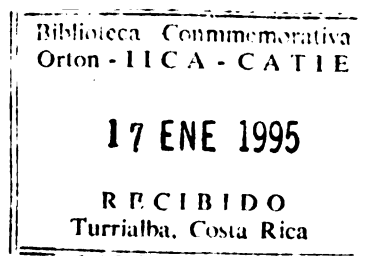
J. A. Morera and A. Mora

Tropical Agricultural Research and Training Center, CATIE, Costa Rica

ABSTRACT

The cacao crop in Central America and the Caribbean Islands has been traditionally managed by farmers in different ways, using diverse sustainable ecological systems.

Two shade systems: "poró" (*Erythrina poeppigiana*) and "laurel" (*Cordia alliodora*) were compared to measure yield and other characteristics of a cacao hybrid. After 15 years of collecting data on each shade system, one hybrid of cacao was evaluated for certain characteristics. There were significant differences between treatments for the 15 year average. Although no significant differences between the studied shade systems were observed, "poró" system presented an increase of 49.5 Kg ha⁻¹ on cacao yield when compared with the laurel system. These and other previously presented results suggest that the cacao-poró shade system is slightly more effective for increasing yield in cacao than the cacao-laurel system.



Introduction

The cacao crop in Central América and the Caribbean Islands has been traditionally managed by farmers in different ways, using diverse sustainable ecological systems.

The natural habitat of cacao are the zones of predominant low land in tropical forest. Under these circumstances, it lives biologically associated with other species such as palms, small trees and bushes. For this reason, cacao cropping has been traditionally established under shade, and it is considered as being typically umbrophyllus (3,9).

Growing cacao without shade may cause some problems. Depending on the soil's natural fertility, an increase extraction of nutrients leads, through time, to a decrease in production and the early senescence of the tree.(2).

Complete elimination of shade in productive cacao plantations leads to a rapid yield increase, but it also leads to early deterioration of the plantation due to regressive death caused by diseases and insect attacks, finally causing the trees death (13). Rarely does a single arboreal species have all the desirable characteristics of an ideal shade tree for cacao. However, the species with the best qualities should be selected (8, 10, 11).

The use of some shade species varies widely among regions and countries (9). Vinha and Mattos (12) provide a list of 131 native trees recommended for permanent shade for cacao in Bahía State and Northern Espírito Santo State, Brazil. Some recommended species for permanent shade are fruit trees such as *Citrus* spp, *Annona* spp., *Anacardium occidentale*, *Calocarpum mammosum*, etc. Legume trees, mainly the genus *Gliricidia*, *Inga* and *Erythrina*; timber trees; *Cedrela toona* (red cedar) and *Cordia alliodora* (laurel); *Bactris gasipaes* and other species; *Cocos nucifera* and *Hevea brasiliensis* (5, 8, 9).

Legume trees have the advantage of incorporating nitrogen into the soil, and some of them also produce firewood (5, 12). The species *Erythrina poeppigiana* incorporates an approximate amount of 224 Kg ha⁻¹ of ammonium sulfate per year; and it is easily propagated through cuttings and seeds (9). *C. alliodora* (laurel) is considered a promising shade tree due to its capacity for fast growth, straight bole and an apparently deep radical system. The crown, which requires little space, presents high leaf production and self pruning. In addition, its wood is widely used for construction: for floors, ceilings, doors, windows and cabinets (9).

Alpizar *et al* (1) studied in CATIE, Costa Rica, two agroforestry systems: cacao under laurel (*C. alliodora*) and cacao under mountain inmortelle (*E. poeppigiana*). There were no differences in regards to nitrogen, phosphorus and calcium accumulation in the cacao; however, potassium and magnesium production were higher under laurel shade. Total biomass was higher under *C. alliodora* system, and there was almost no difference in cacao aerial biomass production under both shade systems.

Heuvelodop *et al* (6), showed by comparing the above systems that cacao almond and bark production was slightly higher under *Erythrina* shade system. Natural production of vegetative residues under *E. poeppigiana* was 8.91 t.ha⁻¹. a⁻¹ higher than under *C. alliodora* (7.07 t ha⁻¹.a⁻¹). Models of the cycles of organic matter and

nutrients (N, P, K, Ca, Mg) for this agroforestry systems were studied by Fassbender et al (4).

The purpose of this study was to compare two shade systems for a cacao hybrid, evaluate the response on yield and some other factors inherent to the crop under the Turrialba, Costa Rica conditions.

Materials and Methods

The experiment was planted or sown in 1977 and is located in the Tropical Agronomical Center for Research and Training (CATIE), at 602 meters above sea level, 83°38' West longitude and 9°53' North latitude. Annual average temperature is 21.5°C, with a maximum average of 26.5°C. Annual rainfall average was 2629 mm, with a relative moisture of 88% (Appendix 1,2,3 and 4). The soil is of loam texture and very deep, the pH oscillates between 5 and 6. The treatments to be compared included poro (*E. poeppigiana*) and laurel (*C. alliodora*) shade and the cacao hybrid. (Catongo x Pound 12). The two shade systems were sown at 6 X 6 m between plants, and they were analyzed as an irrestrictive model at random, with two replicates. Cacao was grown at 3X3 m.

The experimental unit (CATONGO X POUND 12) was made up of 32 plants of cacao for a total of 64 per plot. Two crossbreedings were cultivated as a border for the net plot and as pollen donors. Plot management in the two shade systems has been uniform. Poró has been pruned twice a year. The first pruning of almost a 100% is in may, at the beginning of the wet season, and the second one of 50% in november.

Once the plantation was sown, 100 g of 10-30-10 per plant or the equivalent of 111.1 Kg ha⁻¹, was applied. Later, a fertilization of 666.6 Kg ha⁻¹ of 18-10-6-5 formula was used, at a rate of 600 g per plant in four applications per year. From the fourth year on, fertilization was unequally distributed in regards to number of applications and kind of fórmula available in the market.

For weed control, Glyphosato was applied at the beginning of sowing, with the crop maintained afterwards by manual cleanings. After 10 months of planting, formation pruning began, and it was extended for a year until the appropriate architecture for the cacao plants was achieved. When the first pods appeared, a biweekly record on production for 15 years of continuous yields began.

In 1985, the data collection was interrupted for 6 months and only the number of pods per tree was counted, from which production for that period was estimated. The variables evaluated were average yield of dry cacao in Kg ha⁻¹, average number of pods per tree, number of infected pods with cherelle wilt and number of shoots per tree. Additionally, pods index for the hybrid and year in particular were calculated. Once the information was analyzed, mean difference was determined through the Duncan test.

Results and Discussion

The analysis of the 15 year average does not present differences between the evaluated shade treatments (Table 1). However, the statistical analysis for each year indicates that there were significant differences between treatments for some particular years. Data on Moniliasis and Black pod were not studied because the experiment was not affected by these diseases. The experiment was located in an area relatively isolated from cacao plantations, thus there were no inoculum sources near by that could infect the hybrid.

Production and data recording started in 1979, two years after planting. During this year, yield for the hybrid CATONGO X POUND 12 was low since under laurel system 97 Kg ha⁻¹ of dry cacao was obtained, and 71.2 Kg ha⁻¹ under poró system (Figure 1). In 1980, production increased up to 421.3 Kg ha⁻¹ under laurel shade and up to 477.4 Kg ha⁻¹ under the poró system. During 1985, yield was 469.4 and 422.2 Kg ha⁻¹ under laurel and poró respectively, but this average is only for the first half of the year, since collection of data was interrupted during the second one, due to lack of labor hand. It was expected that for this year production would be between 700 and 900 Kg ha⁻¹ according to the observation from the previous years.

In 1989, yields of the hybrid CATONGO X POUND 12 decreased under both systems, especially under poro shade where 571.5 Kg ha⁻¹ of dry cacao were obtained. This was probably due to low fertilization during the last two year and to under management of poró shade. During 1986 and 1988, yields remained over 900 Kg ha⁻¹ of dry cacao. Although annual average for dry weight per hectare was not significant, 1981, 1986 and 1989 presented significant statistical differences between shades. In 1991, 1992 and 1993 cacao production under poró shade was higher (Figure 1).

In general, irregular shade management of poró, climate differences, and inappropriate fertilization probably increased production under laurel shade in some years. During nine of the fifteen years, yields under poró system (769,9 Kg ha⁻¹) were slightly higher than under laurel shade system (720.4 Kg ha⁻¹). This is reflected in the annual average where the difference was 49,5 Kg ha⁻¹ higher with poró. There is a possibility that this difference may be higher, since in some years poró shade management has been appropriated, reducing excessive shade. Variation in number of healthy pods over the fifteen years was similar to the variation presented by the variable dry cacao (Figure 2).

The variable infected pods with cherelle wilt only showed significant statistical difference in 1987. The higher number of pods was observed in the poró system; however, the values were relatively low in both systems in relation to other years (Figure 3). Cherelle wilt variable showed greater difference between years compared with the above. In the cacao (CATONGO X POUND 12) and laurel system, it varied from 13 pods infected with cherelle wilt per tree in 1980 up to 0,2 pods in 1987. The highest values were observed in the cacao-poró system which was reflected in the averages. These variations can be explained based on the physiological condition of cacao trees which was greatly influenced by environmental conditions. Climate differences and non-uniform fertilization from one year to another may have caused the variation observed.

Values of infected pods with cherelle wilt were high during the first five years of productivity, and lower in the following ones. This occurs because during the first years, the trees had not developed completely and did not have an adequate physiological condition to support a great number of pods to maturity. In regards to

number of shoots, the highest average was presented under the laurel shade system with significant differences in 1984 and 1985. (Figure 4). The kind of shade of poró trees and excessive shade caused by low management during some years, may have caused a decrease in light quantity; as a result, stimulus to shoot production was lower under the poró system.

Fourteen shoots were observed under the cacao-laurel shade system and eleven shoots under the cacao-poró system. A possible explanation for this situation may be that the cacao-laurel shade system had less competition for light than the cacao-poró system.

The pod index was not statistically analyzed; nevertheless, little difference between systems for the same year was observed, and annual average was similar in both systems (Figure 5). Cacao-laurel system presented the lowest pods index of 18.4, in 1979, and the highest, 31.2, in 1985. The above information means that for the last year, 12.8 additional pods were required to obtain a kg of dry cacao. From a selection viewpoint, low values in pod index are appropriate. Variation from one year to another in the pod index was observed, which may imply some environmental and nutritional influence on pod size and other factors related to the index. This variation can also be caused by segregation observed between trees of the same hybrid. It would be convenient to evaluate this system with cacao genotypes vegetatively propagated to obtain greater uniformity in the population.

These and other previously presented results suggest that the cacao-poró shade system is slightly more effective for increasing yield in cacao than the cacao-laurel system.



Table 1. Annual average of the variables analyzed for the cacao hybrid "CATONGO X POUND 12" under two shade systems. Turrialba, Costa Rica, 1994.

Treatment (shade)	Dry weight (Kg ha ⁻¹)	Healthy pod/tree	Infected pod/tree	Pod index	Shoots/tree
<i>Cordia</i>	720.4 ^a	16.8 ^a	5.6 ^a	26.5	14.3
<i>Erythrina</i>	769.9 ^a	17.8 ^a	6.7 ^a	26.2	11.3

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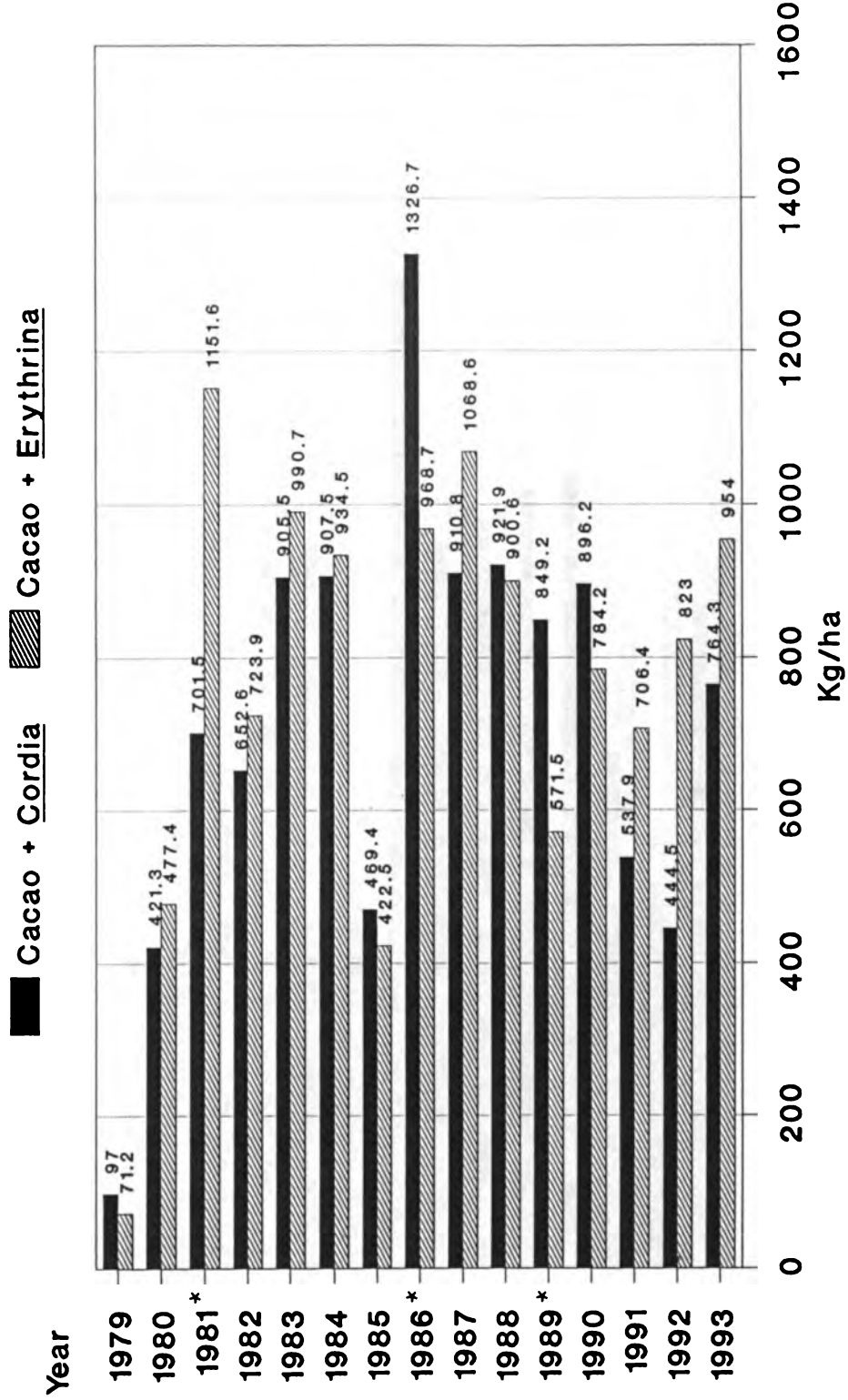


Figure 1. Kilograms of dry cacao per hectare of the hybrid CATONGO X POUND 12 evaluated under two shade systems. Turrialba, Costa Rica. 1979 - 1993.
 * = significant statistical difference at 5%

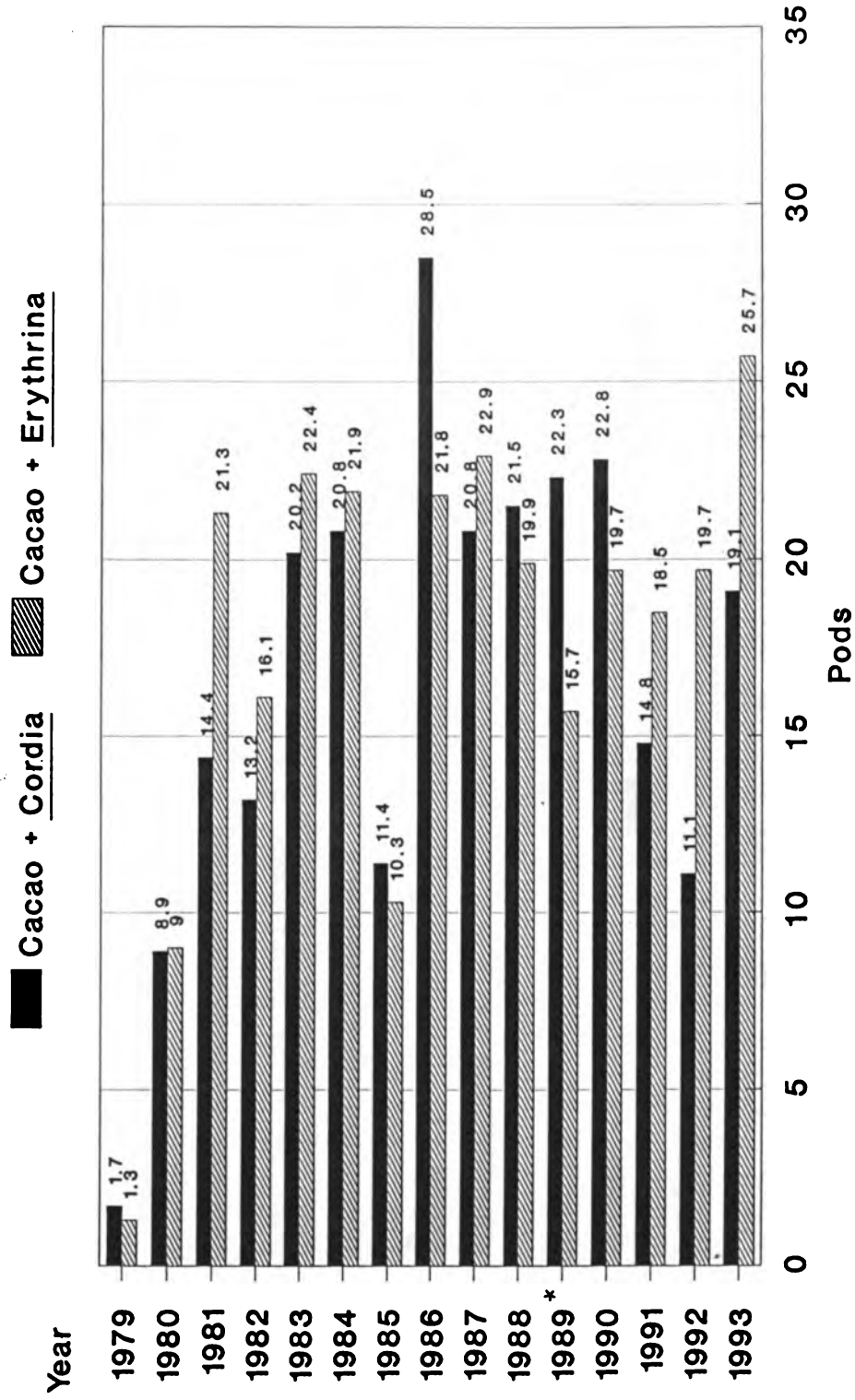


Figure 2. Average number of healthy pods per cacao tree under two shade systems. Turrialba, Costa Rica. 1979-1993.
 * = significant statistical difference at 5%

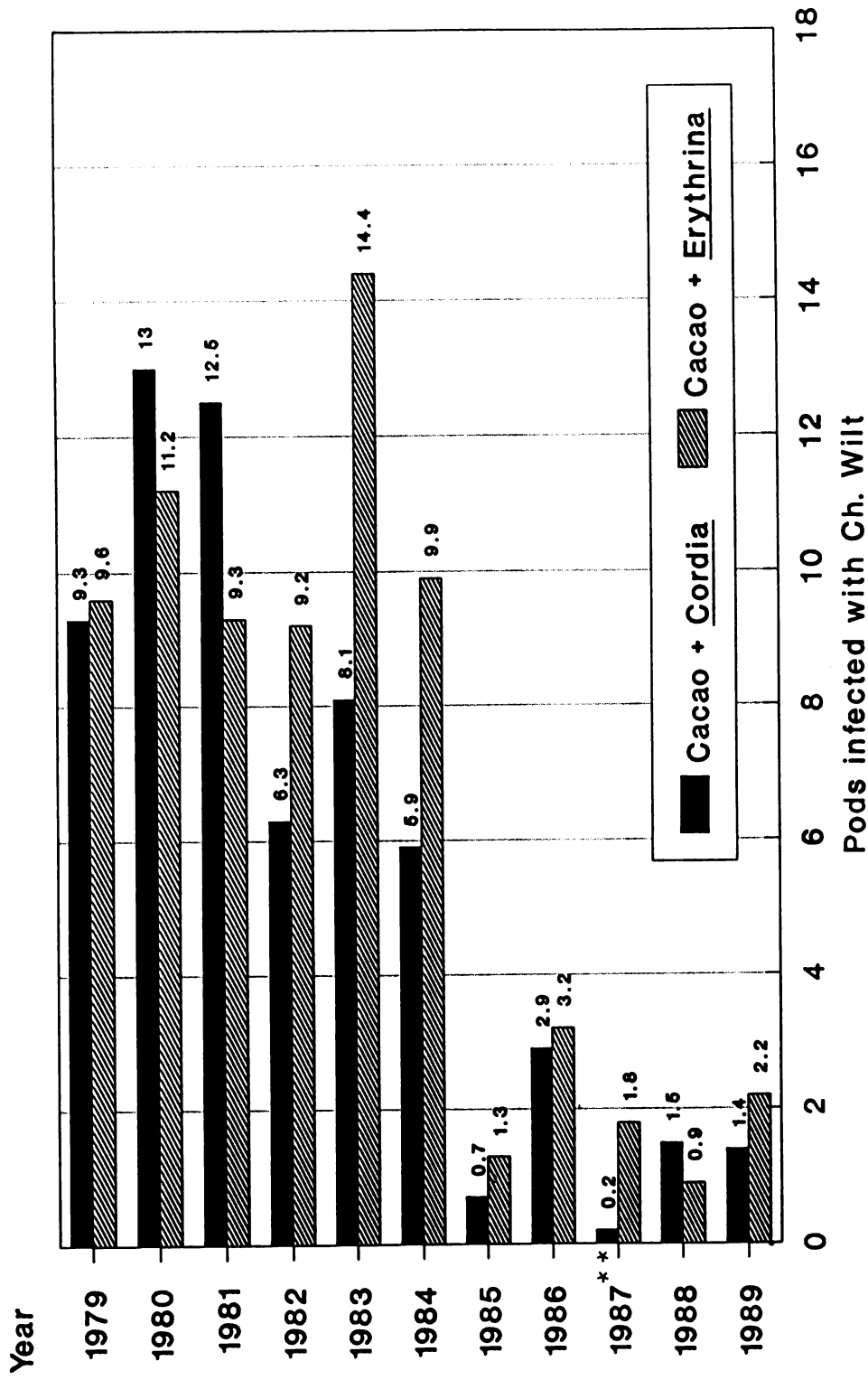


Figure 3. Number of pods per tree of cacao with Cherelle wilt under two shade systems. Turrialba, Costa Rica. 1979-1989.
 ** = significant statistical difference at 5%

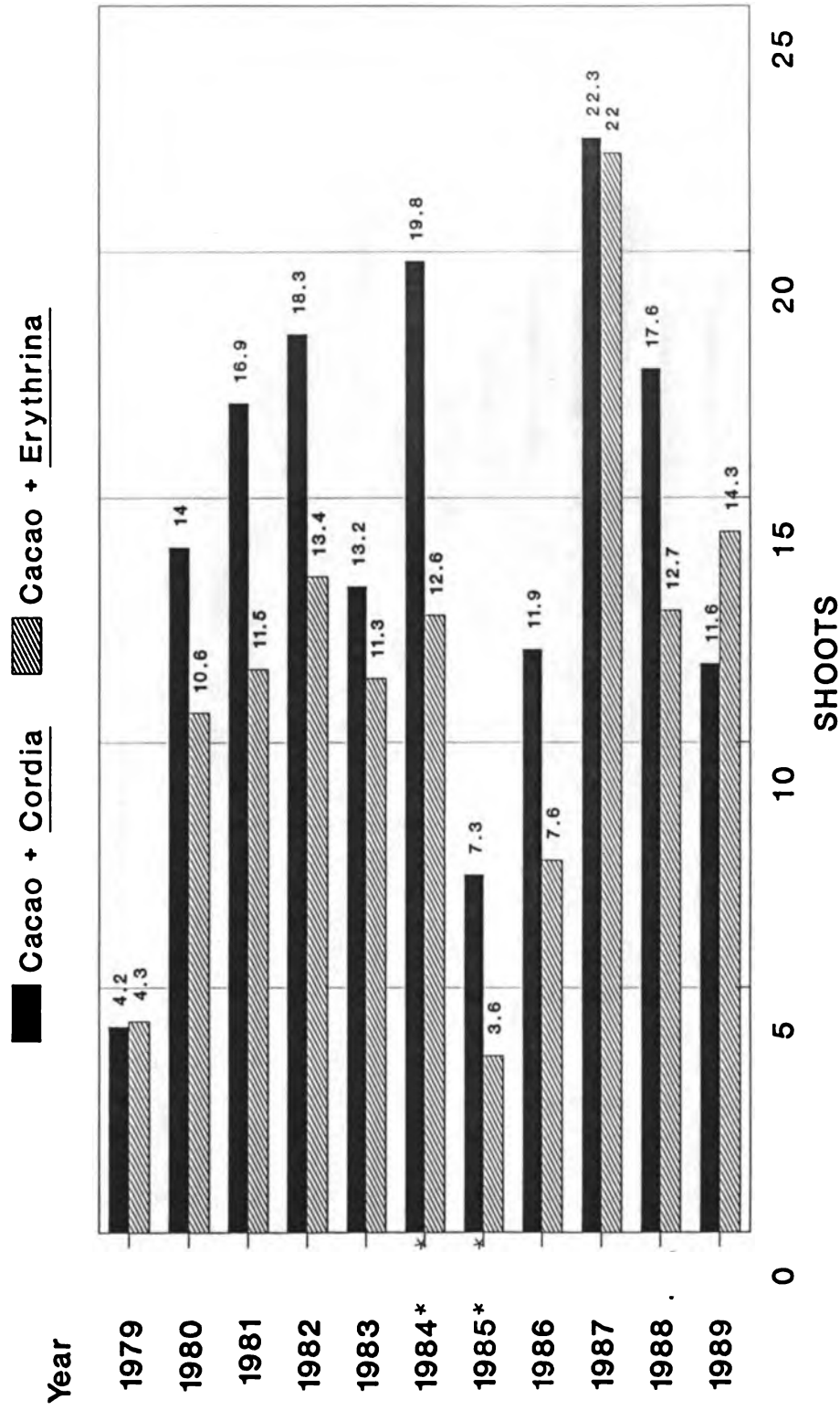


Figure 4. Number of shoots per tree of cacao under two shade systems. Turrialba, Costa Rica. 1979-1989.

** = significant statistical difference at 1%

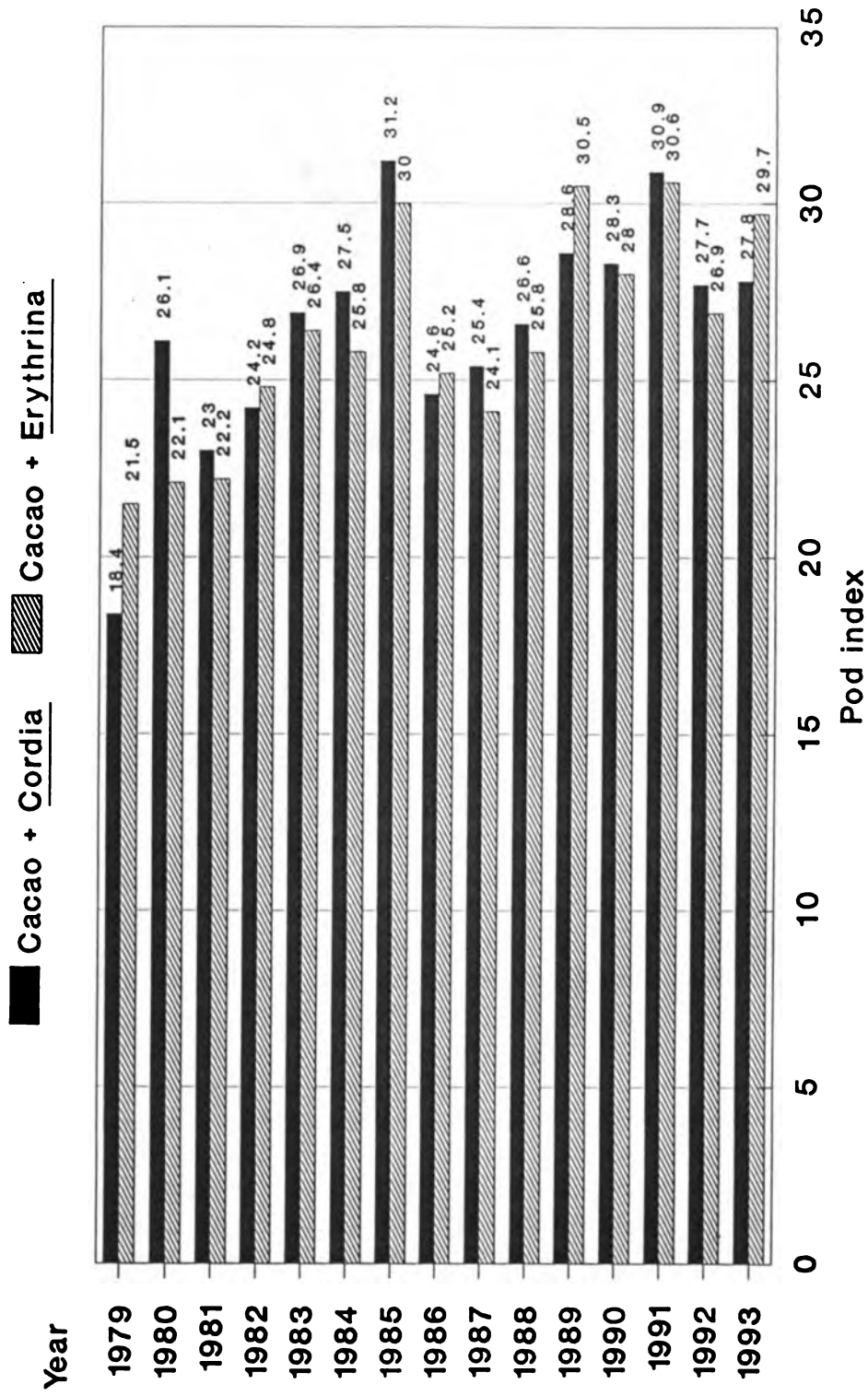


Figure 5. Cacao pod index per year of the hybrid CATONGO X POUND 12 evaluated under two shade systems. Turrialba, Costa Rica. 1979-1993.