ATLANTIC ZONE PROGRAMME

Report No. 19
Field Report No. 68

PRODUCTION AND PARTITIONING OF DRY MATTER IN EDDOE *(COLOCASIA ESCULENTA VAR. ANTIQUORUM)*

H. Waaijenberg
E. Aguilar

February 1993

CENTRO AGRONOMICO TROPICAL DE
INVESTIGACION Y ENSEÑANZA - CATIE

UNIVERSIDAD AGRICOLA
DE WAGENINGEN - UAW

MINISTERIO DE AGRICULTURA Y
GANADERIA DE COSTA RICA - MAG

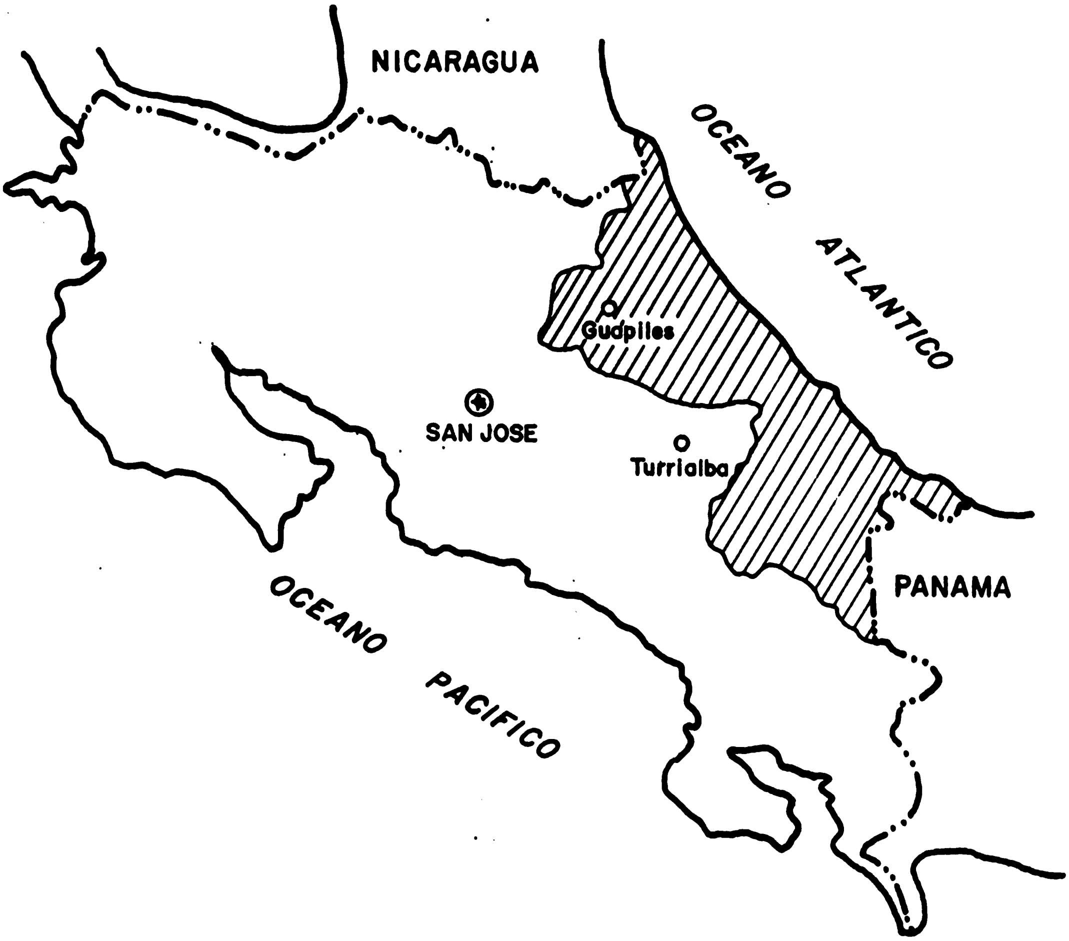

Figure 1. Location of the study area.

PREFACE

General description of the research programme on sustainable Landuse.

The research programme is based on the document "elaboration of the VF research programme in Costa Rica" prepared by the Working Group Costa Rica (WCR) in 1990. The document can be summarized as follows:
To develop a methodology to analyze ecologicaly sustainable and economically feasible land use, three hierarchical levels of analysis can be distinguished.
1. The Land Use System (LUS) analyses the relations between soil type and crops as well as technology and yield.
2. The Farm System (FS) analyses the decisions made at the farm household regarding the generation of income and on farm activities.
3. The Regional System (RS) analyses the agroecological and socio-economic boundary conditions and the incentives presented by development oriented activities.

Ecological aspects of the analysis comprise comparison of the effects of different crops and production techniques on the soil as ecological resource. For this comparision the chemical and physical qualities of the soil are examined as well as the polution by agrochemicals. Evaluation of the groundwater condition is included in the ecological approach. Criterions for sustainability have a relative character. The question of what is in time a more sustainable land use will be answered on the three different levels for three major soil groups and nine important land use types.

Combinations of crops and soils

	Maiz	Yuca	Platano	Piña	Palmito	Pasto	Forestal I II III
Soil I	x	x	x		x	x	x
Soil II						x	x
Soil III	x			x	x	x	x

As landuse is realized in the socio-economic context of the farm or region, feasibility criterions at corresponding levels are to be taken in consideration. MGP models on farm scale and regional scale are developed to evaluate the different ecological criterions in economical terms or visa-versa.

Different scenarios will be tested in close cooperation with the counter parts.

The Atlantic Zone Programme (CATIE-AUW-MAG) is the result of an agreement for technical cooperation between the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), the Agricultural University Wageningen (AUW). The Netherlands and the Ministerio de Agricultura y Ganadería (MAG) of Costa Rica. The Programme, that was started in April 1986, has a long-term objective multidisciplinary research aimed at rational use of the natural resources in the Atlantic Zone of Costa Rica with emphasis on the small landowner.

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ABSTRACT

In Costa Rica yields of eddoe (*Colocasia esculenta* var. *antiquorum*) cormels are generally low. To find out the physiological reasons for this, the accumulation and partitioning of dry matter was monitored from 1 to 8 months after planting, in an experiment comparing five management regimes. The rate of total dry matter accumulation was low: the maximum observed was 107 kg/ha/day. Furthermore, the partitioning was unfavourable: only 9 t/ha of the highest tuber yield of 37 t/ha (fresh) consisted of marketable cormels. Yields were strongly related to the leaf area, which built up late in the crop cycle, reached a low peak, and declined soon after. Eddoe leaves have long petioles and are short-lived, and therefore make inefficient use of the dry matter allocated to them. The low leaf area index constrains the dry matter production by the crop, allowing weeds to grow strongly and compete with the crop and hamper the harvest. The dry matter has to be partitioned over several sinks, but only one of these, the cormels, is marketable. These problems might be solved by selecting or breeding for a more efficient plant type, and by ensuring rapid and even sprouting of seed cormels so that the canopy closes quickly.

KEYWORDS

Colocasia esculenta var. *antiquorum*, eddoe, dry matter, accumulation, partitioning, leaf area, corm, sucker, cormel.

INTRODUCTION

In the Atlantic Zone of Costa Rica the eddoe (*Colocasia esculenta* var. *antiquorum*) is grown mainly as a cash crop; its cormels and occasionally also the corms are exported to the USA. The yields of marketable cormels tend to be low, about 7 t/ha (MAG, 1991). The experimental work done so far has focused on agronomy and provided little explanation for the yields obtained (GONZALEZ & GONZALEZ, 1986; RIOS & RODRIGUEZ, 1986; JIMENEZ, 1987).

There are few published reports of research on eddoe. The crop has received scant attention in reviews (WANG & HIGA, 1983; CHANDRA, 1984) and a description of the SUBSTOR - Aroid model developed by IBSNAT does not even mention eddoe (GOENAGA et al., 1991). Most research on *Colocasia esculenta* has been done on taro (*C. esculenta* var. *esculenta*), which is grown in Hawaii, the Pacific islands and the Philippines, where it is an important staple food. Assumptions about the development of eddoe have to be based on extrapolations from taro, which belongs to the same species but is grown for the main corm, or from tania (*Xanthosoma sagittifolium*), which is another species but like eddoe is grown for the cormels (WILSON, 1984a,b). However, eddoe, taro and tania differ in their morphology and duration of growing period.

The present study, carried out between March and November 1989 in the Atlantic Zone of Costa Rica, monitored the production and partitioning of dry matter through the life cycle of the eddoe plant, in relation to the growth and decline of the leaf canopy and the yields of corms and cormels. As ecological conditions and management practices influence the behaviour of the crop, the experiment was carried out under five management regimes, varying from supposedly optimal care to almost total neglect. As we will show, the experiment not only yielded tubers and information, but also raised several questions. These confirm that not only is eddoe an underexploited crop, it is also underinvestigated (NATIONAL ACADEMY OF SCIENCES, 1975; WILSON, 1984b).

MATERIALS AND METHODS

Experimental site

The experiment was carried out in a farmer's field in La Lucha, Guácimo canton, Atlantic Zone of Costa Rica (mapsheet Guácimo 3446 I, 584.2 E, 248.3 N). The site was located on a flat, recent alluvial terrace at an altitude of about 15 m above sea level. The soil was an Andic Dystropept with loamy texture, friable and well drained. The groundwater fluctuated between 1-2 m below the soil surface. The topsoil (0-20 cm) had the following properties: bulk density 1.07 g/cm^3, water retention 0.50 g/cm^3 at pF-2.0 and 0.33 g/cm^3 at pF-4.2, pH-H_2O 6.5; organic matter 4.8 %; CEC and exchangeable Ca, Mg, K, Na of 29.0, 19.3, 2.7, 1.9 and 0.4 meq/100 g soil, respectively.

The field had been used for annual crops, mainly maize, for several years. At the start of the experiment it was lying fallow and covered with grasses, the main being ones *Eleusine, Digitaria, Rottboellia*, *Paspalum* and *Cyperus* spp.

Weather conditions

Table 1 summarizes the weather conditions during the experiment. Compared with normal conditions, March was somewhat drier, June much wetter, and August and October much drier. The substantial amounts of rainfall and the characteristics of the soil make it unlikely that the crop suffered from drought stress during its growth.

Plant material

Farmers in the Atlantic Zone of Costa Rica do not distinguish cultivars of eddoe (MAG, 1991). Indeed, all the plant material we observed looked similar. The seed cormels used in the experiment were obtained from a local farmer. They probably had little genetic variation, as all were derived from the few cormels with which he started several years ago. A sample has been deposited at the Department of Tropical Crop Science, Wageningen Agricultural University, The Netherlands.

We used cormels with an average fresh weight of 31 g (9 g dry matter). They were harvested one month before the start of the experiment and were kept in the shade.

Design and treatments

The experiment had a random block design: 5 treatments x 4 replications = 20 plots of 163 m2 or 494 plants. The treatments were:

1 - Maximum care: fertilizer and control of pests, diseases and weeds.
2 - As 1, but without fertilizer.
3 - As 1, but with poor weed control.
4 - As 1, but without pest and disease control.
5 - Minimal care: no fertilizer or control of pests and diseases and with poor control of weeds.

Cultivation methods

The land was prepared by slashing the grass and then doing two cross-wise cultivations with a tractor-drawn disk harrow. Two days later, on 3rd March 1989, the seed cormels were planted by hand, at 5-10 cm depth, and spaced at 75 cm x 44 cm (30 300 plants/ha).

One month after planting the gaps were filled in with plants from border rows, which were replaced with plants grown outside the experiment. Replacement plants, although showing comparable growth, were excluded from the observations.

In all plots the suckers were removed monthly to maintain plants with a single shoot instead of bushes with shoots of different ages.

Plots with **fertilizer**, at planting received 150 kg/ha of 10-30-10 ($N-P_2O_5-K_2O$), followed by 150 kg/ha of 20-3-20 at 2 MAP and 200 kg/ha of 20-3-20 at 4 months after planting (MAP).

Plots with **weed control** were sprayed the day after planting with 2 l Gesapax 500 FW (amethryn) + 2 l Prowl 500E (pendimethalin) per ha. At 1.5 and 2 MAP 1 l/ha Fusilade (fluazifop-butyl) was applied. Subsequently these plots were kept clean weeded. Plots with poor weed control received no herbicide at planting. After the Fusilade applications the weeds were occasionally slashed with a machete, so that they were only just prevented from overgrowing the eddoe.

Seed cormels for plots with **pest and disease control** were submerged for 10 minutes in a solution of 800 cc Busamar (TCMTB) and 250 cc Furadan 4F (carbofuran) per 200 l water before planting, and Furadan 10G was applied in the planting hole at a rate of 10 kg/ha. From 2-8 MAP the foliage was sprayed every week with one of the following, in rotation: Kocide (copper hydroxide; 0.4 kg/ha), Benlate (benomyl; 0.3 kg/ha) and Agrimicin 500 (streptomycin; 0.6 kg/ha).

Observations and analysis

From 1 to 8 MAP, every month a random sample of 3.3 m^2 (10 plants of which on average 2 were replacements) was harvested from each plot. The observations included counting and weighing the plants, roots, sprouts, corms, suckers, cormels and leaves and measuring leaf areas. Only the live biomass was taken into account; dead leaves still attached to the plant were discarded. At 7 MAP the cormels were graded into two classes: the first (export quality) class was of egg-shaped cormels whose fresh weight exceeded 50 g ($\approx$ 12.3 g dry matter), the second (seed quality) class contained cormels that were deformed or weighed less. For the determination of dry matter contents subsamples were oven-dried for 48 hours at 75 °C.

At 1 MAP the leaf areas were estimated by tracing the outline of all leaves on paper, cutting out the shapes and determining their areas photometrically. At 2-8 MAP the length (N) of the midrib was measured and the leaf area (A) was estimated using the equation: $A = c \times N^2$. For the constant at 1, 3, 5 and 7 MAP, random samples of 5 leaves were taken per plot and N and A were determined (by measuring tape and photometrics, respectively). The constant increased from 1.24 (1 MAP) via 1.35 (3 MAP) and 1.48 (5 MAP) to 1.52 (7 MAP); the lowest R^2 was 0.97 (100 leaves). It appears that the shape of the leaves changed during the crop cycle.

As well as the monthly harvests, non-destructive observations were also made. For these another sample of 3.3 m2 was chosen in each plot. Sample plants and leaves were marked and from 55 to 235 days after planting (DAP) the following observations were made per leaf at 6-12 day intervals: date of appearance (half or more unfurled), date of death (half or more dead) and length of the midrib (to determine leaf area). The frequent handling of these plants seemed to affect their later growth, which was slightly less than that of other plants.

The data were subjected to analysis of variance, correlation and regression using SPSS-PC+ software. The standard errors of the means are presented in the figures and tables.

RESULTS AND DISCUSSION

There was a large variation between plants, especially at the start (uneven sprouting) and at the end of the experiment (uneven dying). This resulted in large standard errors, but nevertheless most differences in growth and yield were clear and statistically significant. We present and discuss the results for each plant organ in sequence (see the schematic represention of eddoe plant morphology in Figure 1). We also discuss qualitative observations, in addition to the quantitative data summarized in Tables 2 and 3 and Figures 2 to 6.

Seed cormels

The dry weights of the seed cormels, 9 g at planting and diminishing with time, were too small to be shown in Figure 2. At 1 MAP the total dry weights of seed cormels and young plants were still the same or less than the dry weights of the material planted; the young plants still depended on the reserves of the seed cormels. In many cases the seed cormels were not absorbed completely by the new plants, but remained living until the final harvest at 8 MAP.

Roots

Roots were the first visible organs of the sprouting seed cormel. Before the central bud showed any activity it was often already surrounded by a circle of roots (Figure 1). From 4 MAP most of the roots (in terms of numbers and weight) were growing out from suckers and especially from cormels, rather than from the corm. The roots were fleshy and white, looked healthy, and were 40 cm or more long. The tangle of roots hampered the harvesting and cleaning of the cormels. The weights of the roots, which had very low dry matter contents, were too small to be shown on the scale of Figure 2.

Sprouts

At 1 MAP 70 % of the seed cormels had sprouted and at 2 MAP 80 %, with no differences between treatments. Some cormels were affected by rot, others just did not sprout. Of those that did, 17 % had more than one sprout; the largest one was retained and the smaller ones were removed.

Sprouting might be improved by even stricter selection of seed cormels. Each should be squeezed hard to detect rot and checked for having only one main bud, removing any lateral ones. Poor sprouting might also be due to dormancy of the cormel (WILSON, 1984a). A longer interval between harvest and planting might break the dormancy, but on the other hand increase losses from deterioration.

Although outwardly similar, some seed cormels sprouted up to one month earlier than others. A study in 1990 (not reported here) showed that slow starters remained poor growers. This phenomenon could account for the large variation between individual plants in number and area of leaves, earliness and yield. (For research it would be more useful to count the age of the plants not from the date of planting but from that of sprouting.)

Interestingly eddoe, like cereals and bananas, has a mechanism to regulate the depth of the future corm in the soil. Seed cormels planted deeply produced the equivalent of the hypocotyl of cereals, on top of which the new plant was formed (Figure 1). Therefore, planting deeply to maintain the future corm completely below the ground and to remove the need for earthing up may be counter-productive; it could retard the emergence of the new sprout and exhaust the reserves of the seed cormel.

Leaves

From 1 to 3 MAP the number and area of the leaves increased rapidly, they reached a maximum between 3 and 5 MAP, and declined steeply between 5 and 7 MAP (Figures 3 and 4). The small leaf area and low crop height during the first and last months of the growing period made eddoe susceptible to competition from weeds. The leaf area indexes observed (the highest LAI was 2.4) were low but not unusual for *Colocasia* (WILSON, 1984a,b).

In all treatments the appearance and disappearance of new leaves were almost linear with time; see the example presented in Figure 5. However, the treatments differed in the length of intervals between leaf appearances, the longevity of the leaves and the number of leaves produced during the crop cycle. Compared with the other treatments, plants under weed stress had longer intervals between new leaves, made fewer leaves, and these leaves lived longer (Table 2). As a result, the differences in the number of leaves decreased between 2 and 5 MAP (Figure 3).

Figure 6 shows the relation between the area per leaf and the rank number. The circled numbers present the shortest and longest longevity observed per treatment; the former occurred just before the largest leaf was produced and the latter just after. This points to a possible explanation for the variation in leaf number and longevity: shading by younger (and larger) leaves accelerates the death of the older ones. That means that the longevity is least in a rapidly closing crop and greatest when the leaf sizes decrease again, but before the crop starts to mature. This hypothesis explains the low LAI values of *Colocasia*, and implies that it is difficult to increase the LAI by denser planting. Mutual shading of leaves may vary per cultivar; the plants in the experiment had rather horizontal laminas, which may cause an unfavourable light distribution within the canopy, resulting in low photosynthetic rates.

The irregularities on the right-hand side of Figure 6 are because the mean leaf areas for high rank numbers were based on fewer plants which usually had larger leaves; not all plants reached the maximum number of leaves. There was a large variation in the number of leaves formed per plant, both between and within treatments. Plants which formed more leaves also had larger leaves; within treatments R^2 varied between 0.35 and 0.64 (26-35 plants), pooled over all treatments R^2 was 0.68 (156 plants).

Usually the leaf area and yield in *Colocasia* and *Xanthosoma* are strongly correlated (WILSON, 1984a, b). In our experiment we also found statistically significant correlations between the leaf area at 4 MAP and the yield of first quality cormels ($R^2 = 0.71$), of all cormels ($R^2 = 0.74$), of corms ($R^2 = 0.87$) and of all tubers ($R^2 = 0.90$) at 7 MAP (correlations between means per plot; observations at 4 and 7 MAP were on different plants).

Eddoe leaves are not only essential for yield but also represent a large investment with a high depreciation rate. Figure 2 shows, for example, that at 4 MAP about 55 % of all biomass was present in leaves (39 % in petioles and 16 % in laminas), which all died within 45-57 days (varying with the treatment). The early collapse of the base of the petiole, often a first symptom of the imminent death of the leaf, probably interferes with the reallocation of assimilates or minerals to other parts of the plant. Therefore, eddoe is certainly not very efficient in building up and maintaining leaf area.

Corms

The corms of eddoe can be eaten, and according to some farmers they taste better than cormels. However, in Costa Rica they have little commercial value and sometimes they are just thrown away, which means the loss of one-third to one-half of the dry matter accumulated by the crop (Figure 2 and Table 3).

For the plant the corm is not superfluous, but the centre of all activity. It carries the leaves, suckers and cormels, and the larger the corm the larger are the leaf area ($R^2 = 0.87$) and the yield of first quality ($R^2 = 0.62$) and all cormels ($R^2 = 0.67$) (correlations between means per plot; observations at 4 and 7 MAP were on different plants).

Suckers

In Costa Rica, where they are not used for propagation, suckers are considered a nuisance. Their cormels mature irregularly and later than those of the main corm. This is not a problem in home gardens but it is undesirable in commercial production. Farmers try to suppress suckers by earthing up or by removing the suckers by hand.

The presence of suckers in Figure 2 may seem surprising, as once a month all visible suckers were removed. However, to prevent damage to the mother corm they had to be cut some distance away, and in some cases the part left underground continued to grow for a while.

Suckers started to appear from 1.5 MAP as slender shoots growing from buds on the corm. Between 3 and 4 MAP they formed small, round corms, which had large contact surfaces with the mother corm and were strongly attached to it. Plants under weed stress made fewer and smaller suckers than those with other treatments (Figure 2 and Table 3). There was little direct competition for assimilates between suckers and cormels, as the latter appeared when the beheaded suckers had nearly reached their maximum weight (Figure 2).

Cormels

The cormels are the marketable product of the eddoe. Large and well shaped ones - quality norms vary with demand and supply - are exported to the USA and small ones are used as planting material.

Between 3-4 MAP the suckers already present developed small corms; later, no new suckers were formed. In the same period the plants began to make cormels (Figure 2). Unlike the suckers, these new side-tubers had small surfaces in contact with the corm, were oval in shape, and did not grow out into shoots. The number and weight of the cormels varied between treatments (Figure 2 and Table 3). There were also differences between plants with the same total cormel weight; some made many small cormels, others few large ones.

One might expect that suckers, which form earlier, would occupy the lower positions on the corm, and cormels, which form later, would be higher up on the corm. We made no detailed observations, but our impression was that cormels occurred at the same level or below suckers. ~~Some leaves had several small bud-like structures in their axils, in addition to the large central bud. The hypothesis that suckers develop from the latter and cormels from the former, may explain why suckers and cormels occur at the same level and their differences in surface in contact with the mother corm.~~

WILSON (1984b) suggested that selection or breeding for plants with fewer leaves might mean fewer cormel "sites" (the context indicates that she meant buds). In our experiment most plants had more than enough cormels for high yields, but many of them seemed not to have enough assimilates to bring all cormels to the weight required for first quality (see the large numbers of small cormels in Table 3). Other plants lacked corm surface for the number of cormels they had, which resulted in deformed cormels (Figure 1).

Farmers harvest between 6 and 7 MAP, because delay leads to the sprouting of cormels, which makes them unfit for export. At 8 MAP more than half of the plants grown without weed stress already had one or more sprouted cormels. The corms of plants whose leaves had died were surrounded by cormel sprouts; apparently some kind of apical dominance had been released. This implies that the harvest time in relation to the physiological stage of the mother plant determines the dormancy of seed cormels.

Yields

Yields are the result of the production of dry matter and its partitioning to the desired parts. The maximum dry matter accumulation of treatment 4 at 6 MAP was 330 g/plant or 10.0 t/ha (Figure 2). The largest increase for treatments 1 and 4 between 3 and 4 MAP (Figure 2) and with an LAI of 2.1 (Figure 4) was only 107 kg/ha/day (135-145 kg/ha/day if adjusted for leaves that died during the month). For comparison, maize grown simultaneously, between 2 and 3 MAP and with an LAI of 2.4, accumulated 260 kg/ha/day aboveground dry matter. The low rates for the eddoe appear to be attributable to the small leaf area and photosynthetic efficiency and high turnover of leaves.

The partitioning of dry matter to the cormels was unfavourable (Table 3). The result of the best treatment corresponded to a fresh tuber yield of 37.2 t/ha at 7 MAP. This was composed of 18.1 t/ha main corms, 5.5 t/ha sucker corms and 13.6 t/ha cormels, of which 9.4 t/ha were of first quality. In short, the desired harvest product was only a quarter of the total tuber yield.

Treatments

Although the comparison of treatments was not an objective per se of the experiment, some observations are worth reporting.

There was a positive response to **fertilizers**, in spite of the good soil fertility. This conflicts with local view of eddoe as an undemanding or "rustic" crop.

The main **diseases**, *Corynespora cassiicola* and *Xanthomonas campestris* (LAGUNA et al., 1983), occurred only during short spells of very humid weather and did little harm. Frequent spraying had no visible effect on their incidence and severity. It may have caused some damage to leaves, spread of inoculum, and compaction of the soil, which explains why plants without disease control gave higher yields than those with maximum care.

Eddoe plants under **weed** stress had poor and heterogeneous growth, but showed fewer symptoms of diseases than those under other treatments. The latter may be attributable to the fact that the plants did not touch one another, were separated by weeds, and had smaller and less succulent leaves.

CONCLUSIONS

The production and partitioning of dry matter in eddoe are not efficient from an "economic" viewpoint. Compared with taro the eddoe has, in absolute and relative terms, a short period with a maximum LAI. Its dry matter has to be partitioned over several sinks, of which only the cormels are marketable. Some aspects of eddoe growth and cultivation deserve further attention.

Late and uneven **sprouting** of seed cormels leads to competition among eddoe plants and between eddoe and weeds, which increases costs and reduces yields. Methods are needed for selecting or manipulating seed cormels in order to promote early and uniform sprouting.

The cormel yields of eddoe are strongly related to the **leaf area**, which builds up late in the crop cycle, reaches a low peak, and declines soon after. Because of their long petioles and short lives, eddoe leaves make inefficient use of the dry matter allocated to them. The low **leaf area** indexes result in low dry matter production by the crop and strong growth of weeds, which compete with the crop and hamper the harvest. These problems might be solved by selecting or breeding for a more efficient plant type, and by ensuring rapid and even sprouting of seed cormels so that the canopy closes quickly.

Although often mentioned in one breath, **suckers** and **cormels** are formed in distinct phases of the crop cycle ~~and may originate from different types of lateral buds,~~ Suckers have round tubers and, like the mother corm, produce leaves, suckers and cormels. Cormels are oval in shape and do not have leaves, suckers or cormels (the leaves made when they sprout are part of new plants). Suckers may not compete much with cormels for assimilates; if they are removed they cannot compete, and if they are left they have their own foliage when cormels start to appear. However, they may compete with the mother plant for nutrients and water and with the cormels for space on the limited surface of the mother corm. Among cormels there is competition for assimilates, as many plants produce more cormels than they can fill up to the weight required for the export market. Research needs to be done on practical methods to prevent suckering and to regulate the number of cormels.

In the course of the experiment several aspects of the **vegetative biology** of *Colocasia* came to attention: the regulation of plant depth by means of a "hypocotyl", the contribution of cormel roots to the total root mass, the transition from sucker to cormel formation, and the morphological differences between suckers and cormels. Surprisingly, these aspects have received little or no attention in the literature to date.

ACKNOWLEDGEMENTS

Numerous persons made valuable contributions to this publication: Sytze de Bruin, Fernando Cambronero, Guido Carvajal, Jorge Castro, Fernando Cruz, Manuel Chacón, Cornelie Hemmes, Roger Jiménez, Rosendo Jiménez, Victor Hugo Jiménez, Ildiko van de Linde, Anita Linnemann, Jorge Mora, Aguiles Rojas, Tjeerd Jan Stomph, Marius Wessel and Jan Wienk. CATIE and MAG cooperated with the identification of diseases and the analysis of soil samples.

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Table 1 Weather conditions in La Lucha, Guácimo canton, Costa Rica, March to October 1989.

	Monthly rainfall (mm)	Daily temperature		Mean daily sunshine (hours)
		mean minimum (°C)	mean maximum (°C)	
March	102	18.9	30.2	6.5
April	299	20.6	31.5	5.1
May	333	21.2	33.0	4.6
June	505	~~21.3~~ 22.1	31.8	3.0
July	500	21.7	31.7	3.6
August	149	21.4	32.~~0~~9	4.9
September	179	21.0	33.8	4.1
October	179	21.0	33.0	4.0

Table 2 Mean number of leaves, length of interval between leaves (days) and longevity (days) of the leaves of eddoe plants grown under five treatments.

Treatment	Number of leaves in 210 days	Leaf nos. 8-10 after planting		First 3 leaves after 90 days	
		Interval	Longevity	Interval	Longevity
Maximum care	18.1	7.6	44	7.3	48
No fertilizer	19.0	6.3	46	8.3	52
Poor weed control	14.4	9.8	55	10.2	55
No disease control	18.7	7.0	36	6.4	45
Minimum care	13.4	9.7	57	9.7	57
Standard error of the means	0.7	0.6	2	0.7	2

Table 3 Components of the harvest at 7 MAP of eddoe plants grown under five treatments (mean numbers and dry weights per plant).

	Total	Corm	Suckers		Cormels			
					First class		Second class	
Treatment	(g)	(g)	(#)	(g)	(#)	(g)	(#)	(g)
Maximum care	258	119	5.0	35	3.6	63	5.7	41
No fertilizer	212	97	3.9	33	2.8	45	5.1	37
Poor weed control	82	38	1.6	11	0.9	14	2.8	19
No disease control	313	161	3.8	41	4.2	76	4.5	35
Minimum care	74	35	0.9	6	0.7	9	3.2	24
Standard error of the means	16	9	0.3	4	0.5	9	0.6	4

ote: first class cormels are egg-shaped, with a fresh weight of more than 50 g (≈ 12.3 g dry); second class cormels are deformed or weigh less.

Figure 1 Schematic views of the eddoe plant (*Colocasia esculenta* var. *antiquorum*). Not on scale.

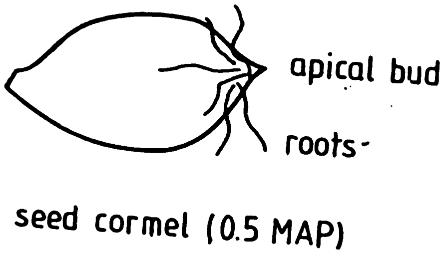
Figure 2 Accumulation and partitioning of dry matter in eddoe plants grown during eight months under five treatments.

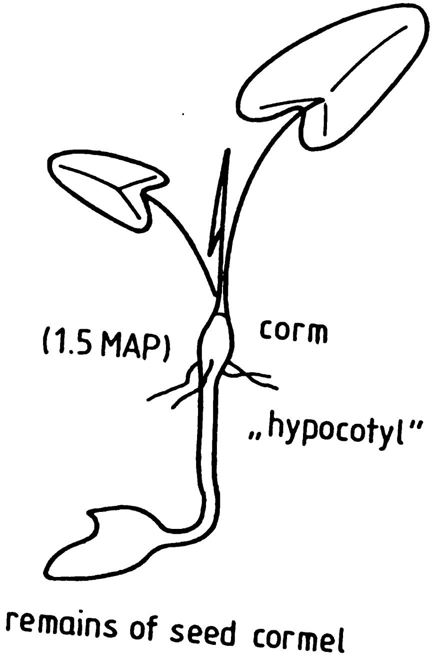
Figure 3 Mean number of leaves of eddoe plants grown during eight months under five treatments. For symbols see Figure 2.

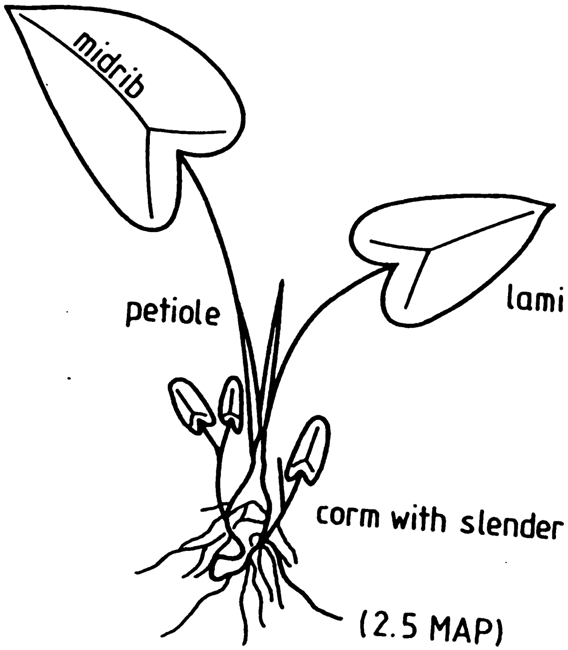
Figure 4 Mean leaf area of eddoe plants grown during eight months under five treatments. For symbols see Figure 2.

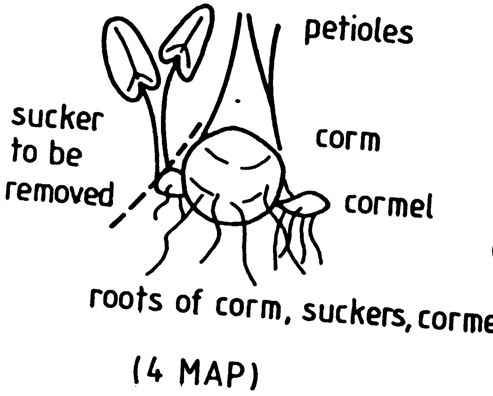
Figure 5 Mean day of appearance and longevity of the leaves of eddoe plants grown during eight months under maximum care (see text). For symbols see Figure 2.

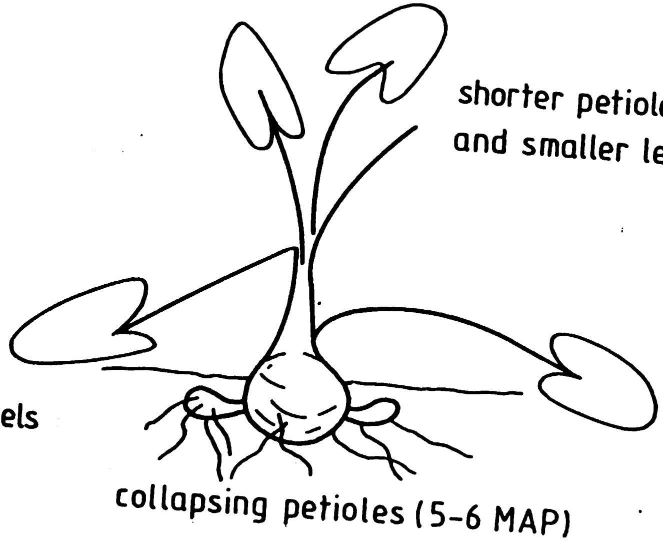
Figure 6 Mean area of the leaves of eddoe plants grown during eight months under five treatments. The circled numbers present per treatment the shortest and longest longevity observed (days). For symbols see Figure 2.

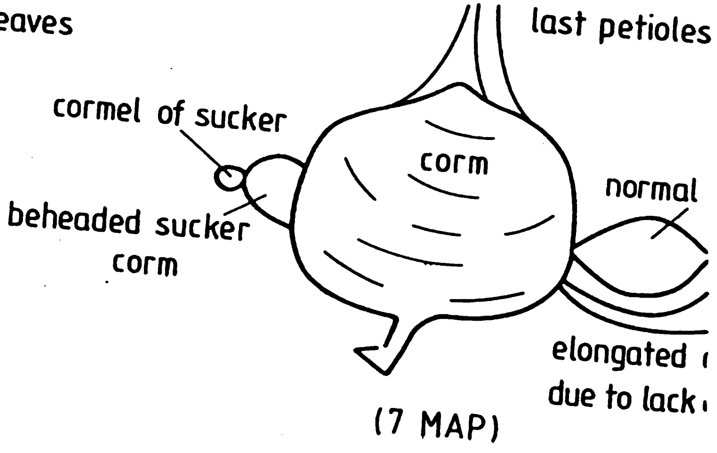

apical bud
roots-
seed cormel (0.5 MAP)


(1.5 MAP)
corm
„hypocotyl"
remains of seed cormel


midrib
petiole
lami
corm with slender
(2.5 MAP)


petioles
sucker
to be
removed
corm
cormel
roots of corm, suckers, cormels
(4 MAP)


shorter petioles
and smaller leaves
collapsing petioles (5-6 MAP)


last petioles
cormel of sucker
corm
normal
beheaded sucker
corm
elongated
due to lack
(7 MAP)

possible lay out Figure (2)

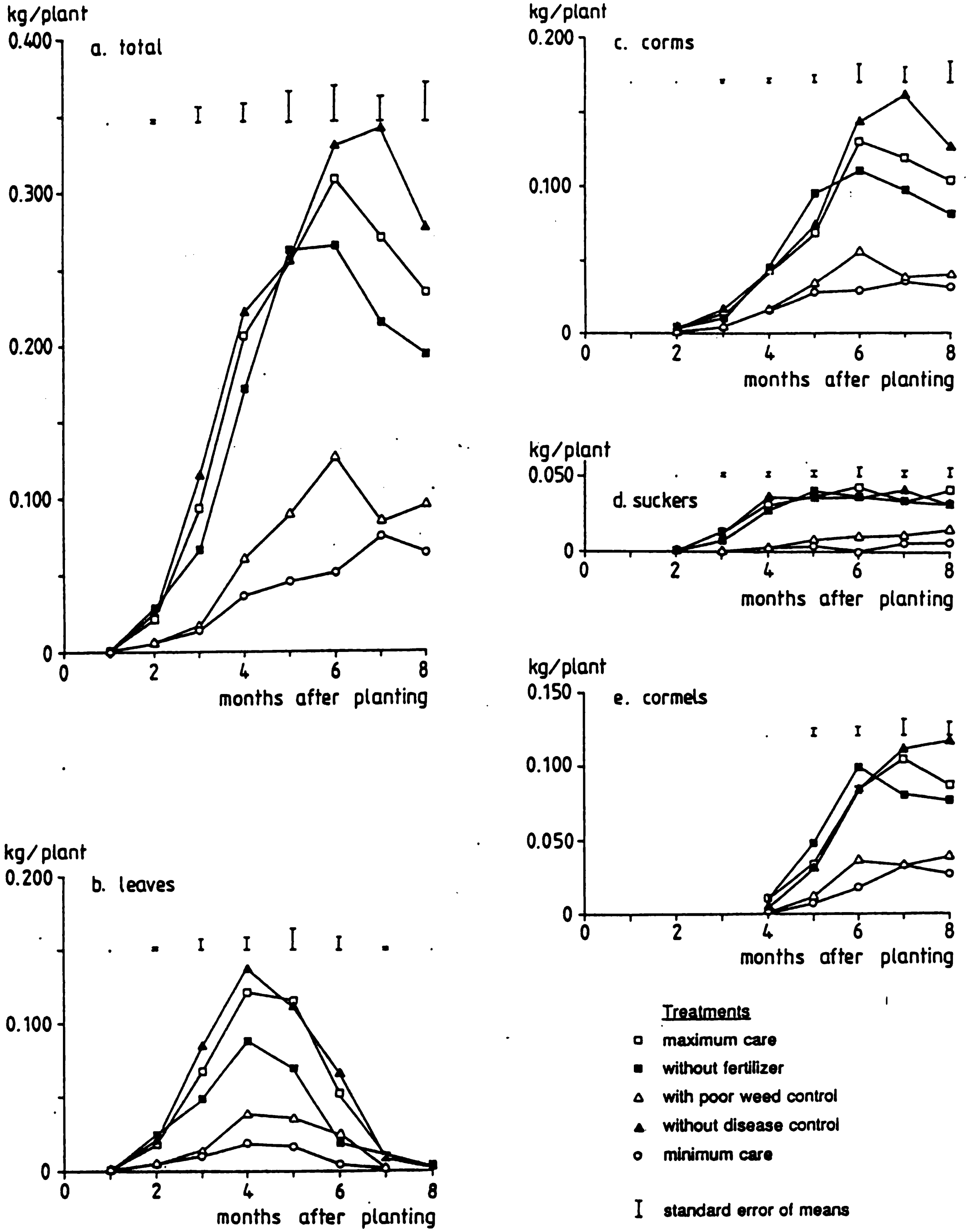


Figure 2 Accumulation and partitioning of dry matter in eddoe plants grown during eight months under five treatments.

Sketch of experimental design and statistical analysis

REPLICATION 4

20/1
19/5
18/3
17/2
16/4

N

../. = plot number/treatment number

REPLICATIONS 1 TO 3

05/3	10/4	15/4
04/1	09/5	14/5
03/5	08/2	13/2
02/4	07/3	12/1
01/2	06/1	11/3

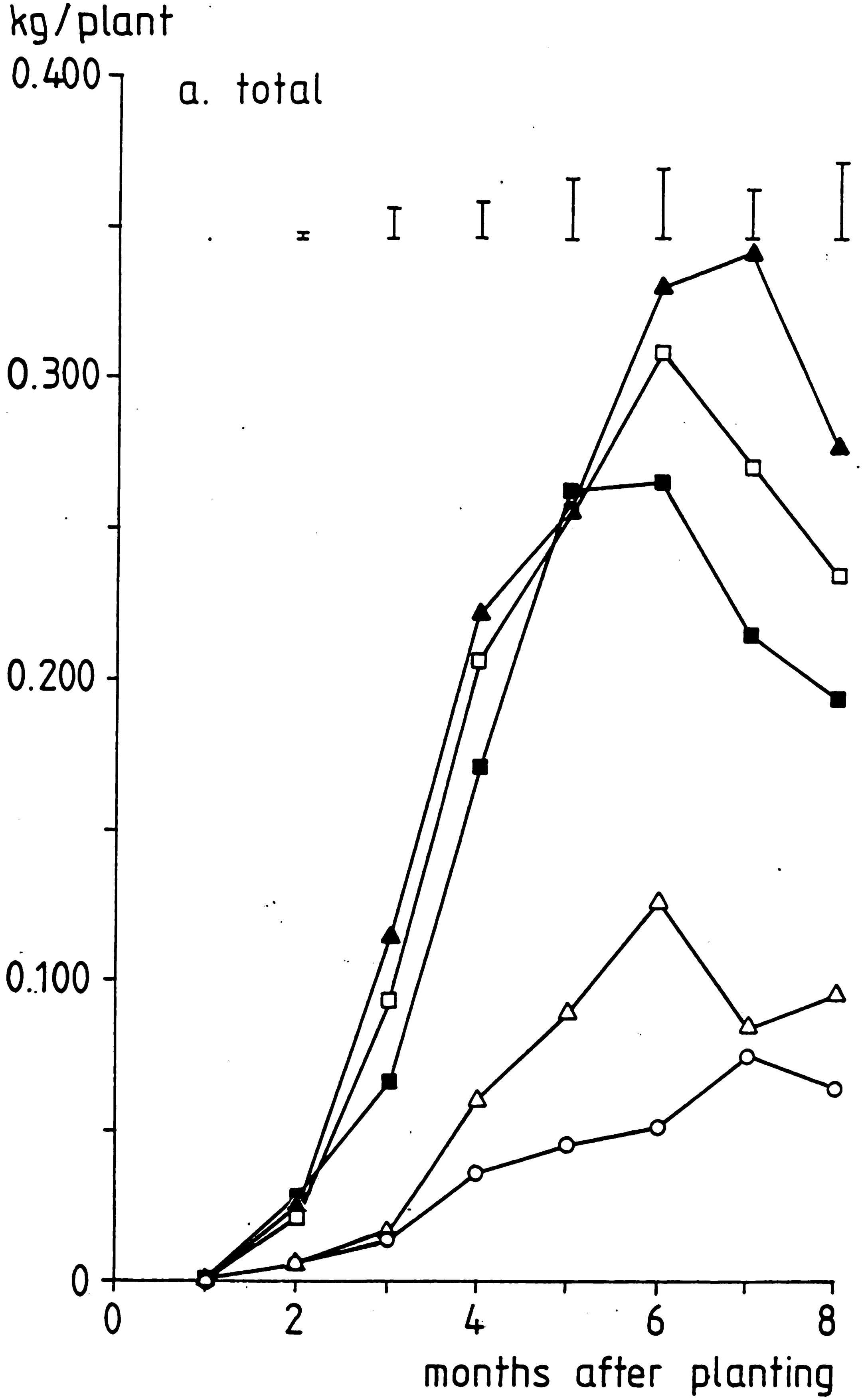
Source of variation	Degrees of freedom
Total	20-1 = 19
Replications (r)	4-1 = 3
Treatments (t)	5-1 = 4
Interaction/error	4x3 = 12

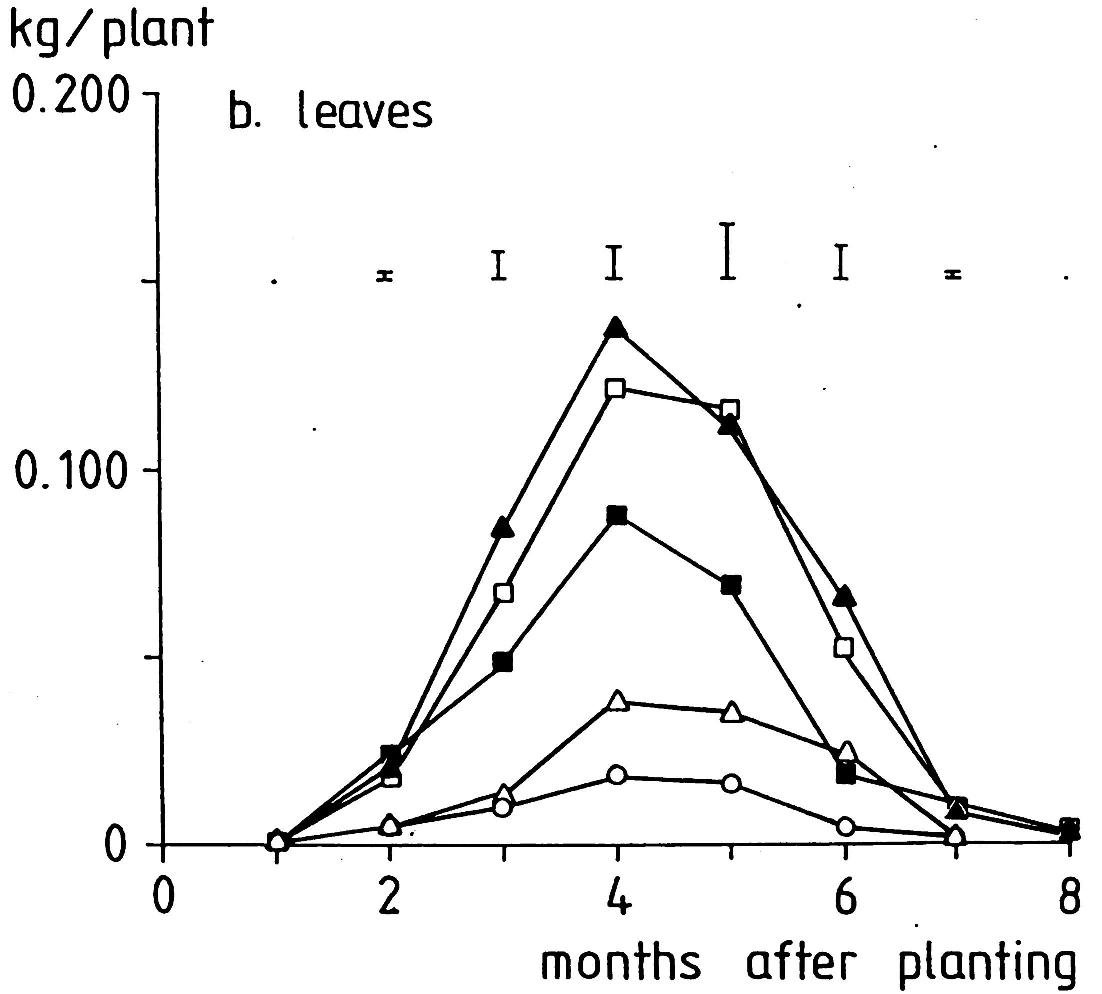
Standard error of means: $\sqrt{\text{error mean square} / r}$

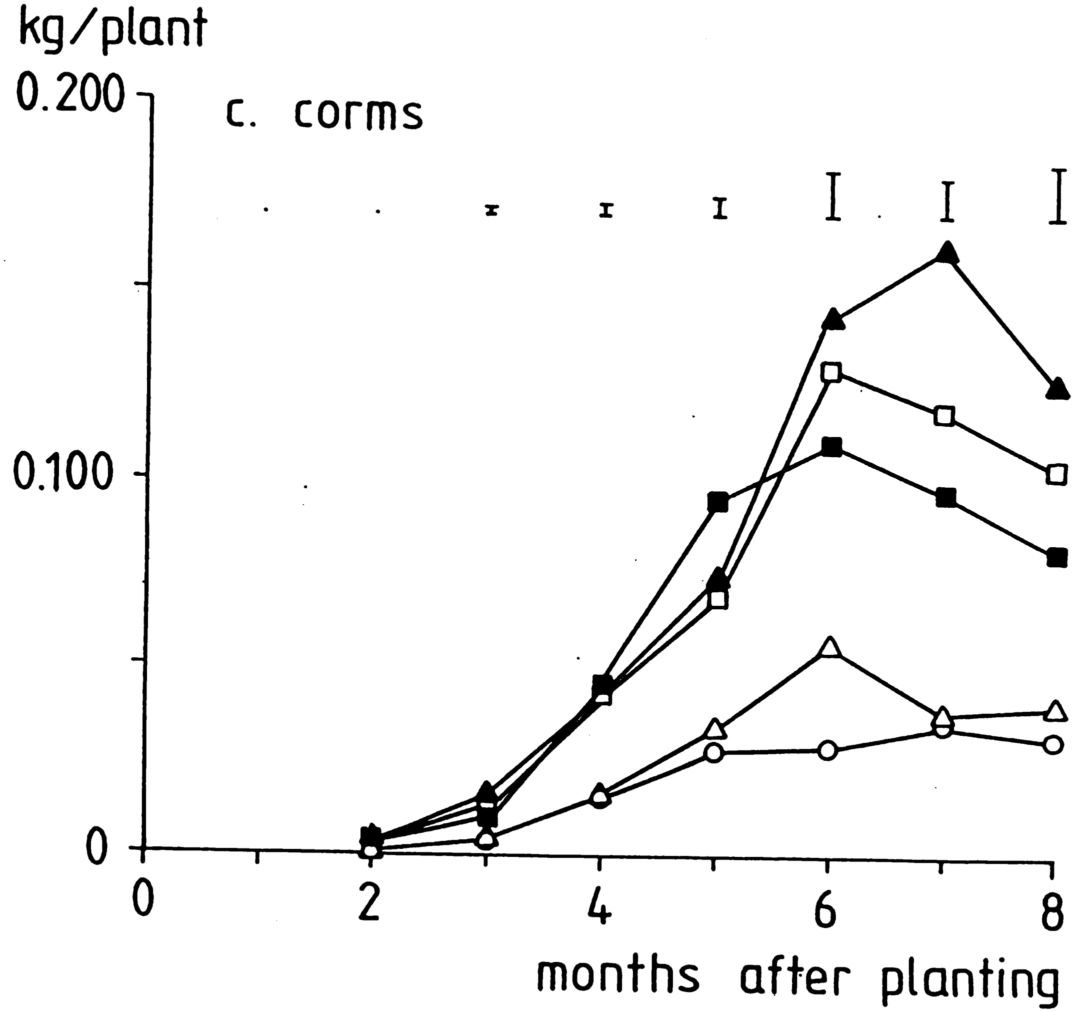
Treatments

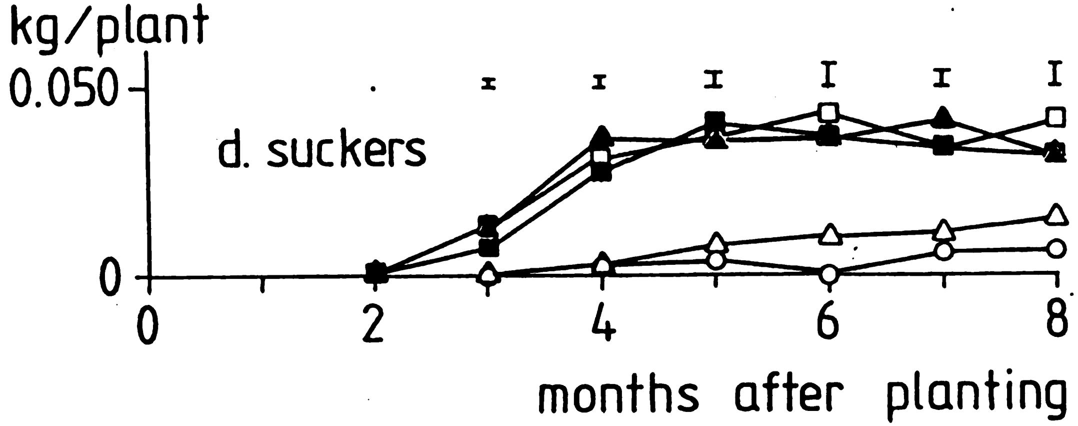
□ maximum care
■ without fertilizer
△ with poor weed control
▲ without disease control
○ minimum care

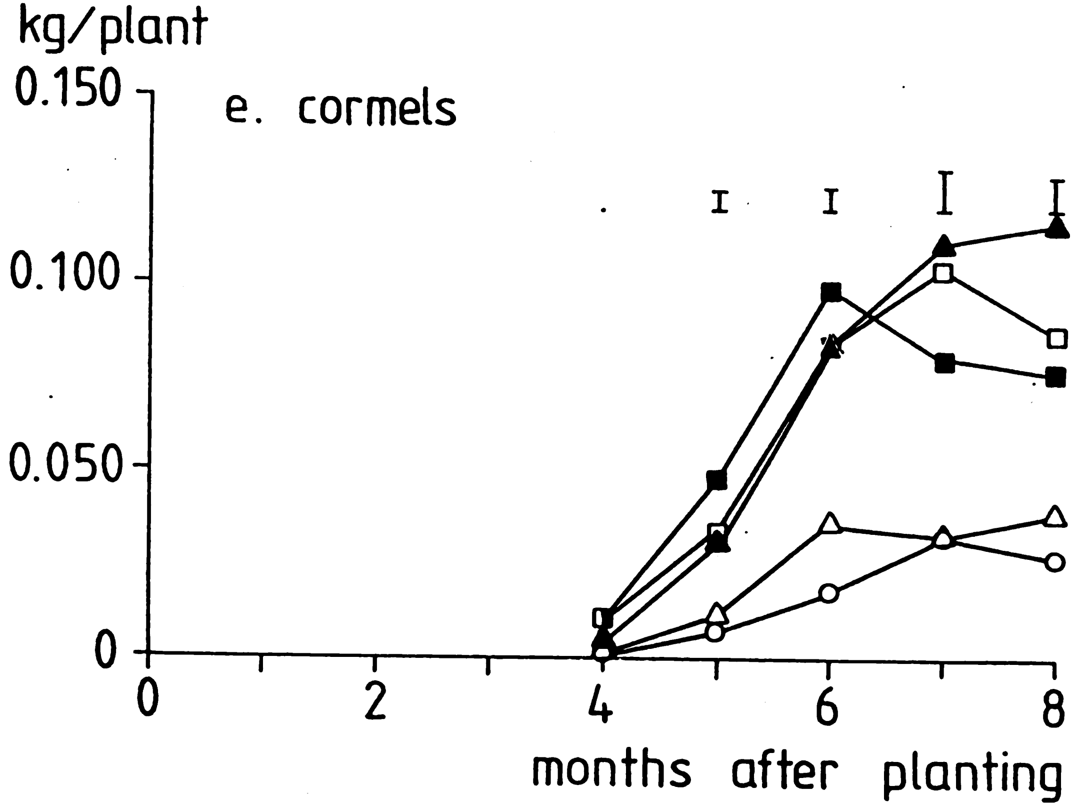
I standard error of means

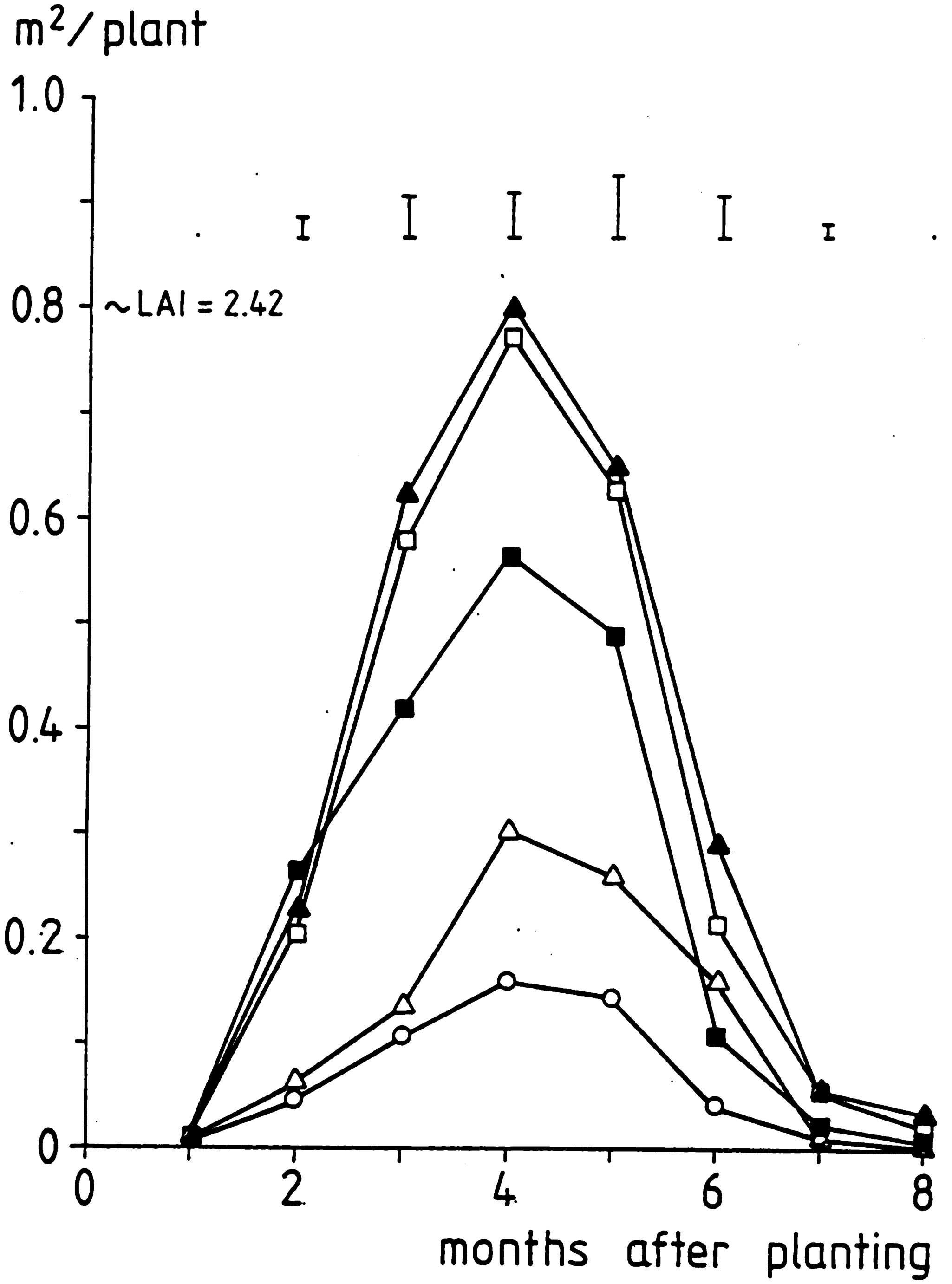

kg/plant
0.400
a. total
0.300
0.200
0.100
0
0
2
4
6
8
months after planting

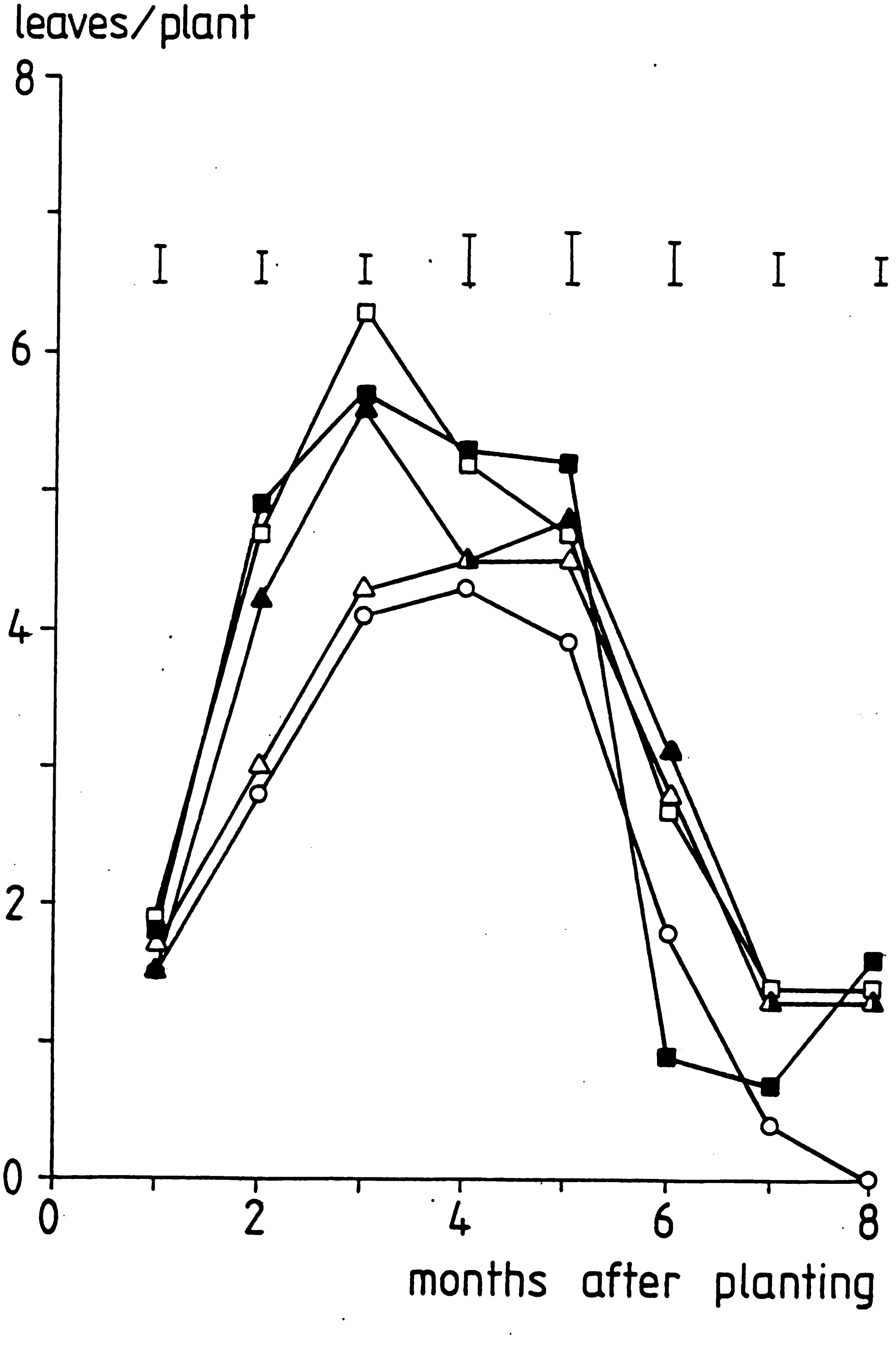

kg/plant
0.200
b. leaves
0.100
0
0
2
4
6
8
months after planting

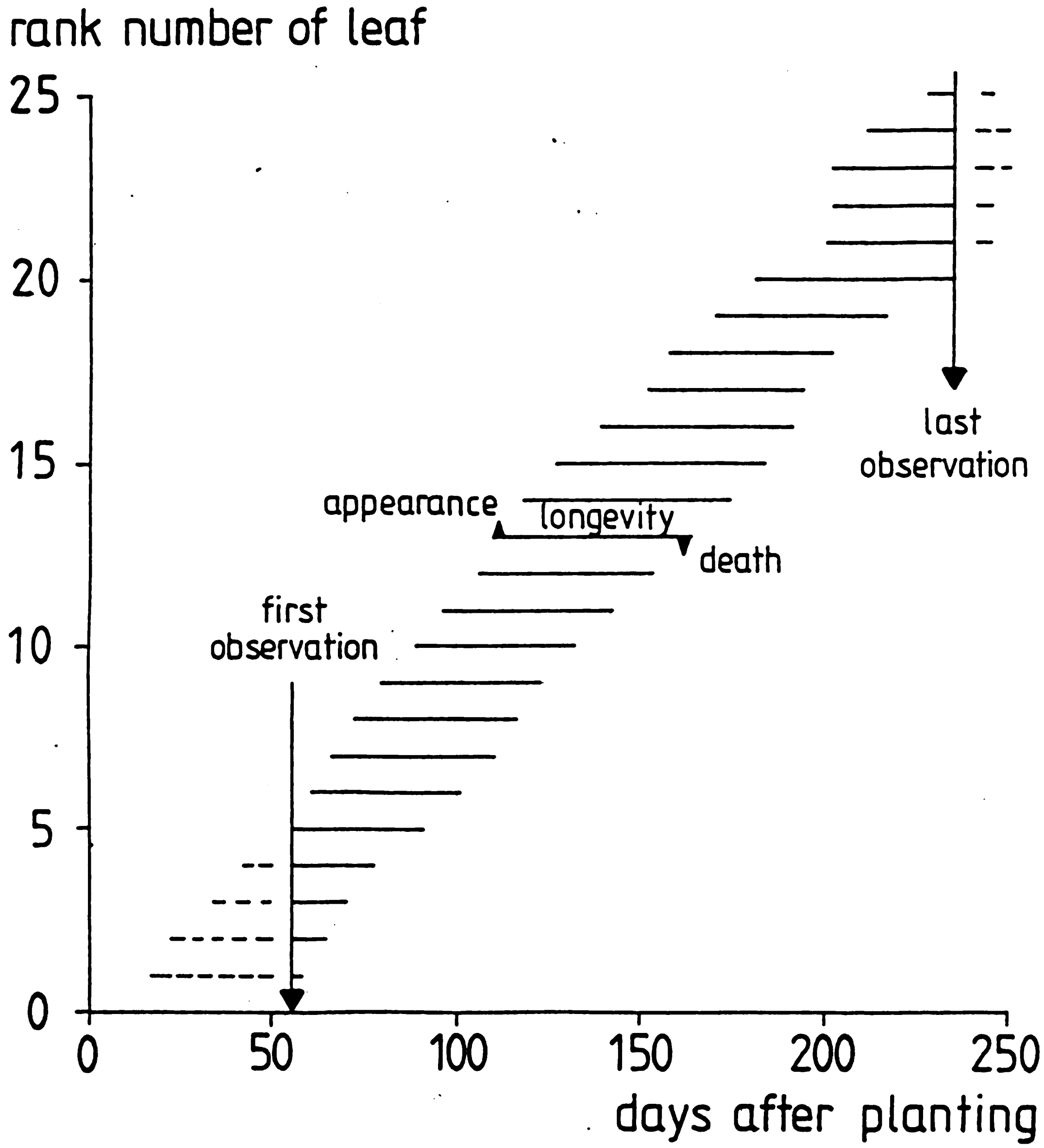

kg/plant
0.200
0.100
0
c. corms
0
2
4
6
8
months after planting


kg/plant
0.050
0
d. suckers
0
2
4
6
8
months after planting


kg/plant
0.150
0.100
0.050
0
e. cormels
0
2
4
6
8
months after planting


m²/ plant
1.0
0.8
0.6
0.4
0.2
0
~LAI = 2.42
0
2
4
6
8
months after planting


leaves/plant
8
6
4
2
0
0
2
4
6
8
months after planting


rank number of leaf
25
20
15
10
5
0
0
50
100
150
200
250
days after planting
first observation
last observation
appearance
longevity
death