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CORN AND BEAN INTERACTIONS IN MIXED CULTURE

QUARTERLY PROGRESS REPORT

to

AGENCY FOR INTERNATIONAL DEVELOPMENT

AID Grant No. AID/ta-G-1435
PIO/T No. 3177757

and to

WORLD FOOD INSTITUTE
Iowa State University

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December, 1978

10p

In this report, preliminary findings from the third phase (Trial 7821) and the current status of the fourth and final phase (Trial 7837) of this study are presented.

PHASE 3 (TRIAL 7821)

Previous reports have indicated that temporal aspects of competition may be a fundamental part of the observed interaction between associated bean and maize crops. To examine temporal aspects of resource competition we are comparing the dynamics of resource acquisition -- beginning of accumulation, rates of gain and loss, and end of activity -- in monoculture and associated systems.

Simple accumulation curves of leaf area, dry weight and nutrient status are useful for comparing the gross cumulative effects of treatments. However, the time-varying nature of growth (in leaf surface, dry weight and nutrients and numerical factors) is better reflected in the rates of change in these parameters throughout the plant growth cycle. Growth rate curves can thus be used to see how the activity of a given organ system (leaf blades, structural and reproductive components) changes with time as well as to compare organ function either within or between treatments.

Although data analysis is incomplete, preliminary results are presented comparing the growth strategies of the two bean habits, bush and climbing, (II and IV) represented by cultivars P566 and P364, respectively, grown in monoculture and in association with maize. The observed differences in growth strategy between the bush and climbing habits may explain the more depressive effect of maize on the Type IV versus the Type II bean.

Node Production

Cumulative curves of node, raceme and pod numbers of the representative bean cultivars from the two growth habits in two systems are presented in Fig. 1. Node number will be used as an index of potential vegetative growth because both vegetative structure and leaf number are directly dependent on node number.

In both growth habits, node accumulation patterns followed the same general trend, rising to maximum values at 54 days and falling afterwards. The Type IV cultivar was characterized by higher node numbers at each date than the Type II. Beans grown in association with maize followed the same basic patterns as in their respective monocultures but with a major difference between the habits. The Type II cultivar responded to associated maize with a reduction in vegetative growth, commencing after 33 days. Maximum node number in association was some 21% less than in monoculture (427 vs. 543 nodes/m^2), a ratio which persisted until the final harvest (82 days), when associated beans had retained 269 vs 361 nodes/m^2 in monoculture (a difference of 26%).

A wholly different type of response to associated maize was exhibited by the Type IV cultivar. Whereas node production was moderately reduced during early growth, identical node maximums were achieved by 54 days.

Following attainment of maximal node structure, Type IV beans grown in both cultural systems began to lose nodes, initially more rapidly in associated culture, although by final harvest (92 days) retained node numbers were similar, 458 vs. 496 nodes/m^2 in association and monoculture (an 8% difference).

In response to associated maize, two different types of vegetative strategies may be discerned, that of the Type II habit being one of restraint, versus the persistent structural growth exhibited by the Type IV cultivar.

An additional difference between the habits is evident in the relation between maximal node number and node number retained at final harvest, particularly in association. Although the Type IV cultivar generated more total nodes, it failed to retain and use its node potential as effectively as did the Type II cultivar. Between the time of maximal accumulation (54 days) and the last green harvest (82 days), the Type IV had lost 23 and 36% of its maximal node number in monoculture and association, respectively, versus losses of 17 and 18% in the Type II cultivar at last green harvest at 75 days. (Reference to the last green harvest instead of to the final harvest is necessitated by the ready loss of structural material by the increasingly brittle plants during the final drying process.)

The late-formed nodes, being quickly abscised, did not participate in either leaf area expansion or pod retention. (Lost nodes were necessarily the last formed, because of the successive nature of node generation).

Growth Component Dynamics

Having compared the two growth habits using the cumulative curves of Fig. 1, we now compare the growth component dynamics (nodes, racemes and pods) displayed in Figs. 2 and 3. In these figures, values calculated over the weekly harvest interval are plotted at midweek -- for example, values at day 30 pertain to the week from 26 to 33 days.

Type II cultivar -- Figure 2.

Maximum rates of increase in node number occurred in the week centering on (WCO) 30 days, by which time Type II associated beans had attained 313 and monoculture beans 323 nodes/m^2. Subsequent rates of change in node numbers followed similar patterns, including a slowdown in node production rate which occurred in the WCO 37 days. Flower appearance occurred at 37 days in both systems (*). This slowdown was followed by resumption of a higher rate of node production in the next week in both systems (WCO 44 days).

Following the secondary maximum at WCO 44 days, node production rate dropped sharply and linearly, becoming negative (i.e., node loss) after WCO 50 days. Node production was positive for four measured weeks, resulting in node maximums of 427 and 543 nodes/m^2 in association and monoculture, respectively. Of the difference of 116 nodes/m^2, 75% was accounted for by branch nodes which were sharply reduced in association.

Highest rates of node loss occurred in WCO 57 days, coinciding with the first week of pod and raceme loss in both cultural systems. After one week of node loss, node number stabilized (node losses approached zero).

<u>Type IV cultivar -- Figure 3</u>.

The relationship of node production rate with time was basically the same in the Type IV beans as in those of the Type II habit. Highest rates of increase occurred at the first sampled week (WCO 30 days) in both systems, by which time associated beans had attained 401 and monoculture beans 453 nodes/m^2. Following this, rate of node increase fell nearly linearly in monoculture, becoming slightly negative by WCO 57 days. In association, after the initial high rate of node increase, the node production trend stabilized for three weeks near the rate of 15 nodes/m^2/da, during which time the monoculture rate continued to fall.

Of the node production slowdown noted at WCO 37 days in Type II systems, a hint is evident in the associated Type IV data but not in the monoculture data. In Type IV beans, flowering occurred at 40 days in both systems (*).

As in the Type II systems, node production was positive for four measured weeks in both cultural systems, and although monoculture beans tended to produce their nodes earlier than associated beans, both had identical node numbers (709 nodes/m^2) at 54 days, the time of maximum node accumulation. Greatest rates of node loss occurred at WCO 57 days in association (as in the Type II systems) and at WCO 64 days in monoculture. Heavy node loss continued for two successive weeks in association. Although the high rate of node loss coincided with the first week of pod and raceme loss in monculture (WCO 64 days), heaviest node loss in association preceded pod and raceme loss by one week.

Discussion

Competition between vegetative and reproductive growth processes determines both maximum vegetative structure (source capacity) and thus sink or yield potential. Node generation occurred for one week after onset of measurable pod growth (47 days) in both habits, in both cultural systems. However, whereas onset of pod growth roughly corresponded with cessation of node generation in the Type II cultivar (both systems), substantial overlap occurred in the two processes in the Type IV cultivar, especially in association.

Node production after
onset of pod growth (47 days)

System	Number of nodes produced/m^2	Percentage of node maximum*
Monoc. II	24	4
Assoc. II	11	3
Monoc. IV	49	7
Assoc. IV	92	13

*at 54 days.

Furthermore, leaf area expansion, which ceased at 47 days in the Type II cultivar (both systems) and in the Type IV cultivar in association, continued on to 60 days in monoculture IV (marked by↑in Fig. 2 and 3). Greater infringement of vegetative activities into the reproductive cycle could represent greater intraplant competition for resources.

Rate of change in node number after attainment of maximum node number appeared to be related to pod and raceme dynamics. In every case except associated Type IV, node loss began in the same week as did pod and raceme loss. It appears that cessation of reproductive activities (cessation of pod number accumulation) was associated, possibly causally, with node senescence. Perhaps node retention depended on the presence of viable pods, whose continued production would, in turn, depend on the duration of the flowering interval (37 to 50 days in Type II, 40 to 60 days in Type IV).

To summarize, we visualize plant growth as a process of dynamic equilibrium between the two competing functions of vegetative and reproductive growth. In the Type II habit, the balancing appeared more finely tuned so that the amplitude of overshooting in both processes (excess node and pod generation) was minimized. The Type IV habit, however, represented an exploitative habit more oriented toward actively seeking growth resources. As such, under the controlled conditions of this study, greater overshooting occurred in both functions (likely accompanied by greater intraplant competition as reflected in higher node and pod losses), particularly in the associated culture.

It must be emphasized, however, that in a less optimal environment than on the CIAT station proper, particularly one characterized by temporary resource limits (such as drought which affects both leaf and pod retention), the more flexible Type IV habit would likely be better adapted to compensating for lost pods and thus, maintaining yield stability.

PHASE 4 Trial 7837

In the previous three studies we have quantified aspects of competition between the associated crops, focusing primarily on competition for light energy from which photosynthetic energy and thus yield, is derived. However, light energy affects more than photosynthesis, including direct effects on plant and air temperature with secondary effects on metabolic activity, plant water status and plant development. In the opposite direction, thermal re-radiation determines plant and air temperatures at night, affecting a range of factors from plant development to the duration of dew-fall, which can influence disease dynamics. The presence of overhanging maize leaves and stalks, by intercepting radiation in both directions, could thus influence the diurnal energy budget in diverse and potentially significant forms.

The overhanging maize crop would also restrict air movement directly above the bean crop. Wind-generated turbulent transport is the mixing process by which energy and water vapor are lifted from the CO_2 is brought down to the crop surface during the daytime. Limitations in turbulent transport could then affect crop temperature and CO_2 availability, particularly in bright sunshine when the maize (a C_4 crop) would be photosynthesizing most actively.

It is possible, then, to envision theoretically plausible modifications to the bean microclimate deriving from the associated maize. The fourth and final experiment in this series was designed to measure light energy penetration, plant temperature, and water relations to determine if the above postulated effects are quantitatively meaningful. The spatial relationship between the leaves of bean and maize affects both light competition and the response to presumed microclimate factors. Thus, complementing these microclimate measurements, the leaf area distributions of bean and maize in both vertical and horizontal dimensions, are being compared using a special harvesting procedure.

Methodology

Six treatments incorporating monocultures and associations of beans (growth habits II and IV represented by P566 and P364, respectively) and maize (Suwan-1) were planted on 25 September 1978 with first irrigation on 28 September (day 1). Due to anticipated edge effects on surface turbulence (with concomitant effects on sensitive microclimate factors), blocks were large (up to 40m x 40m) and unreplicated.

Cultural practices were, as discussed in previous reports, designed to maintain an optimal growth environment for both crops. However, due to the necessity for crop surfaces unbroken by alleys, we were unable to enter the crop after 18 days. After this time then, no chemical applications were made.

Results will be presented in the following report.

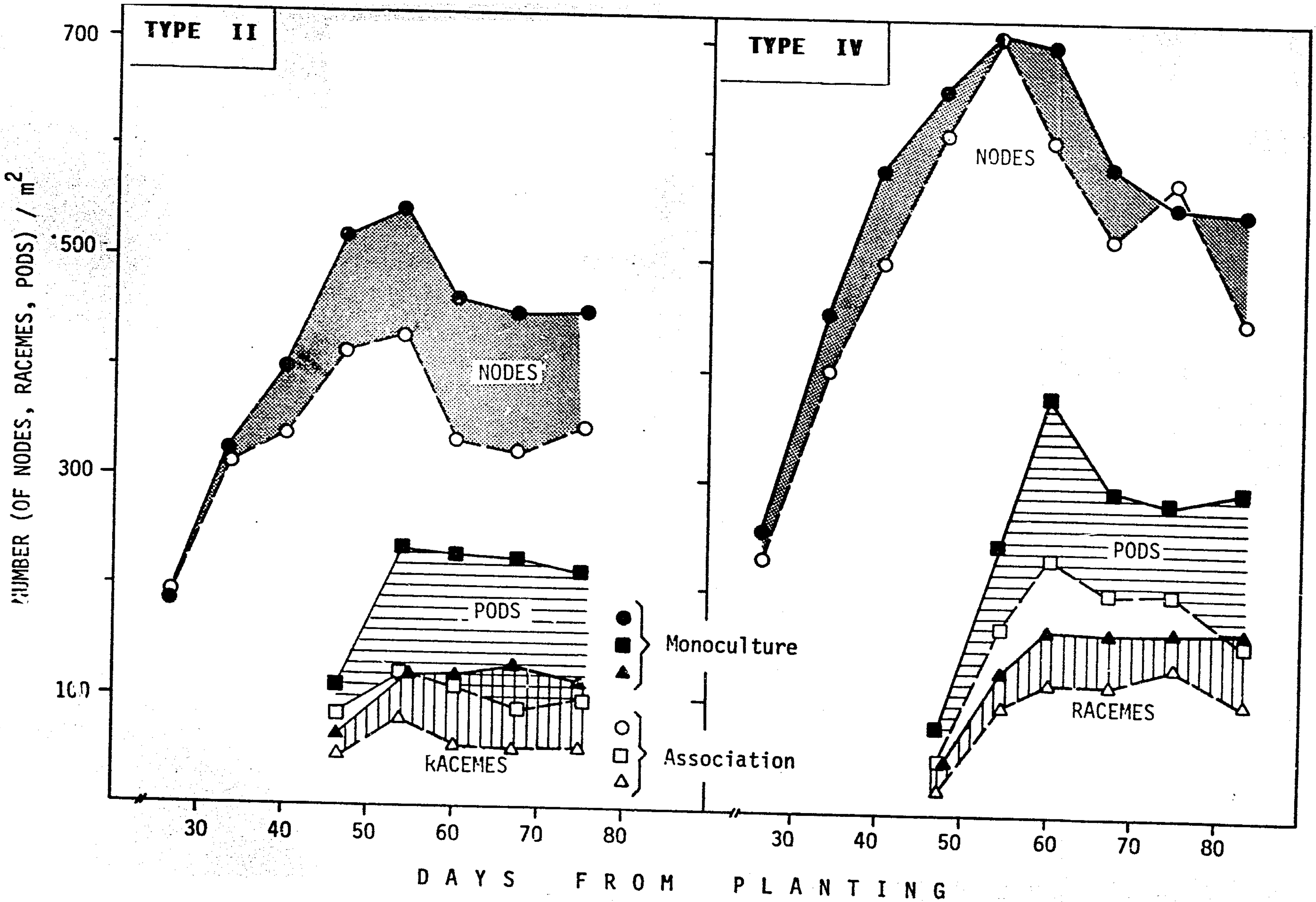

TYPE II
TYPE IV
NODES
PODS
RACEMES
Monoculture
Association
700
500
300
100
30
40
50
60
70
80
NUMBER (OF NODES, RACEMES, PODS) / m2
D A Y S F R O M P L A N T I N G

Figure 1

Figure 2.

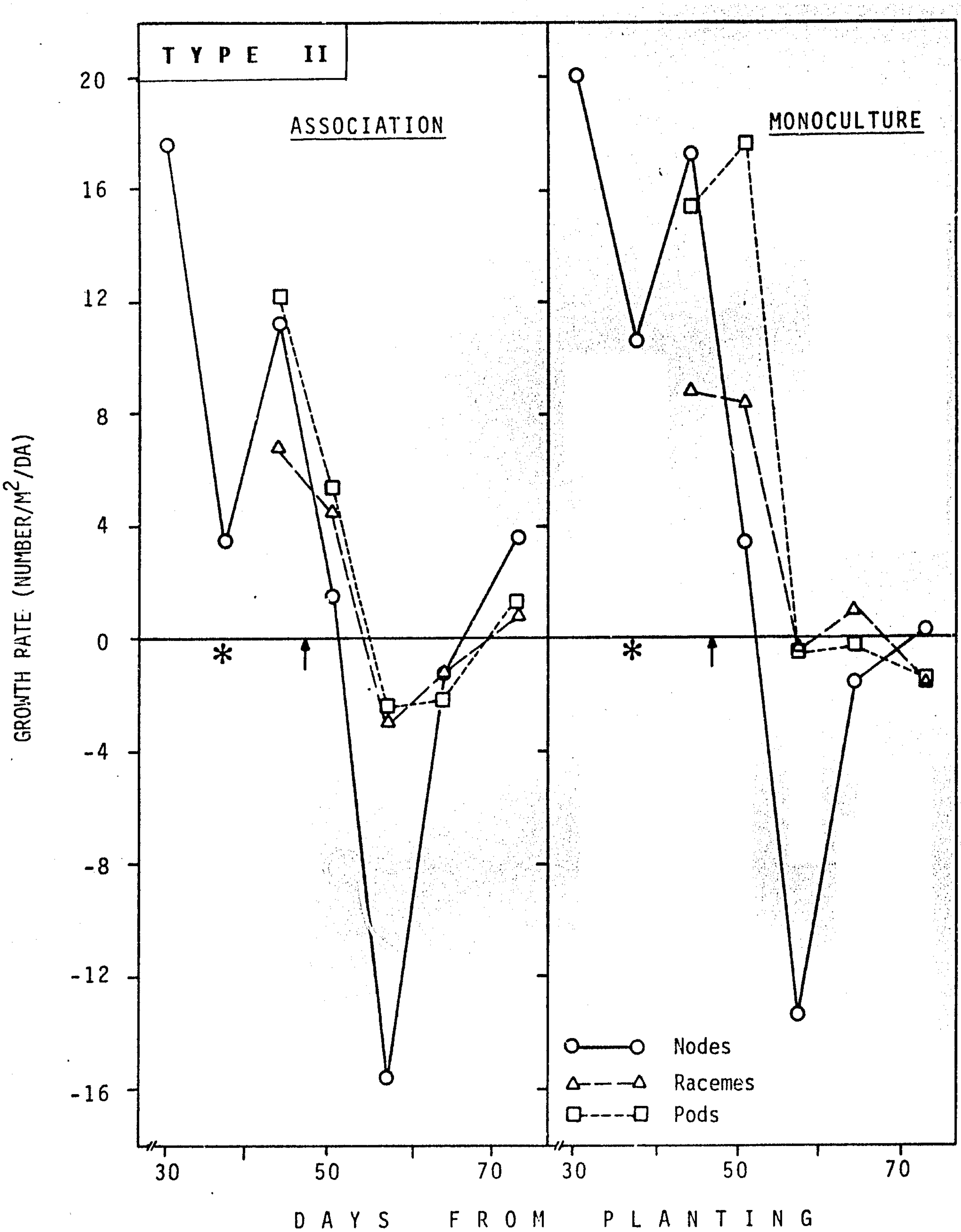
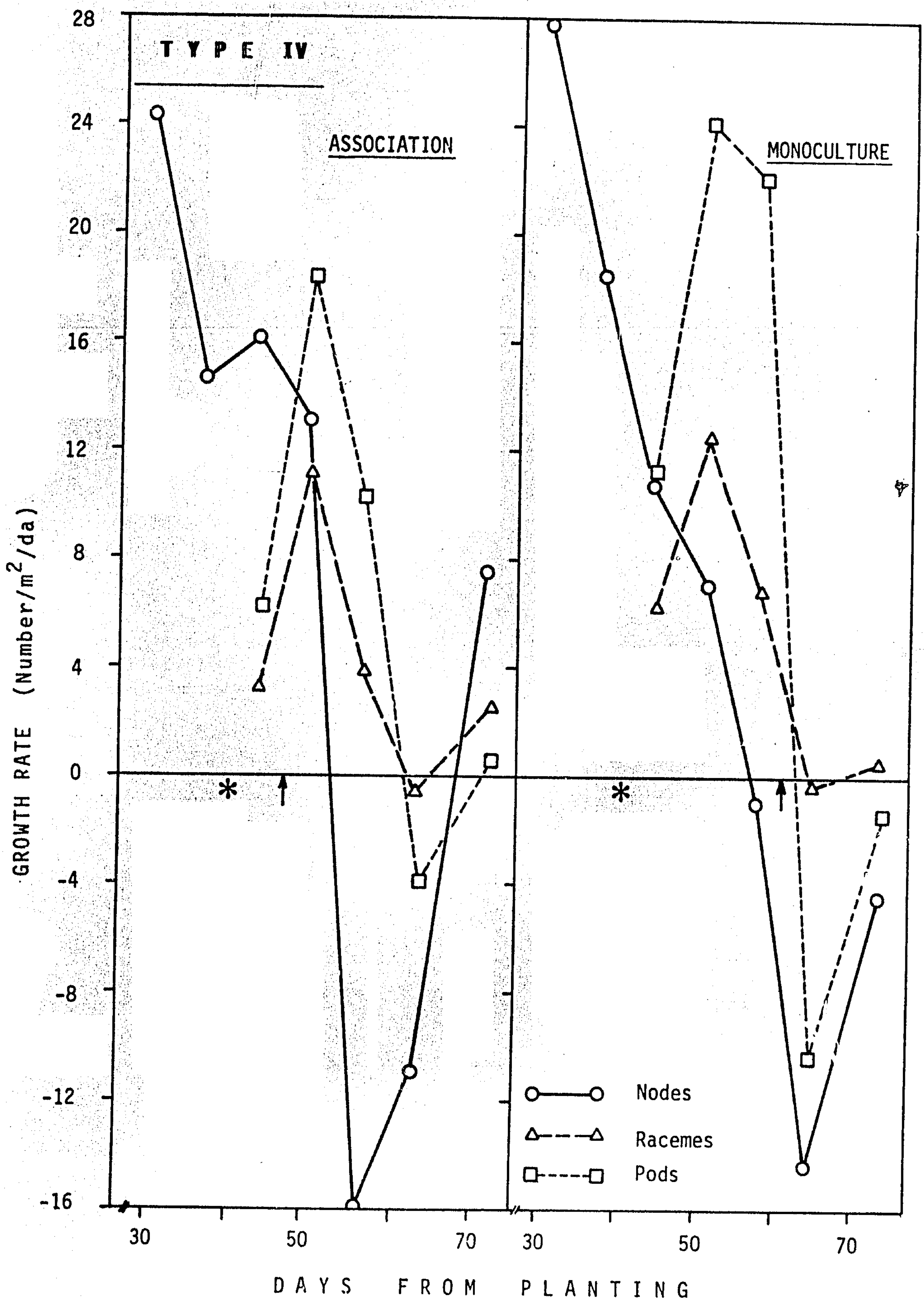

TYPE II
ASSOCIATION
MONOCULTURE
GROWTH RATE (NUMBER/M2/DA)
20
16
12
8
4
0
-4
-8
-12
-16
30
50
70
30
50
70
DAYS FROM PLANTING
Nodes
Racemes
Pods

Figure 3


TYPE IV
ASSOCIATION
MONOCULTURE
GROWTH RATE (Number/m²/da)
28
24
20
16
12
8
4
0
-4
-8
-12
-16
30
50
70
30
50
70
DAYS FROM PLANTING
Nodes
Racemes
Pods