AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

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Batch 73

1. SUBJECT CLASSIFICATION
A. PRIMARY
Serials Y-AF00-0000-0000
B. SECONDARY
Food production and nutrition-- Plant production

2. TITLE AND SUBTITLE
Corn and bean interactions in mixed culture; progress report,Oct.-Dec.1977

3. AUTHOR(S)
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4. DOCUMENT DATE
1977

5. NUMBER OF PAGES
8p. 9p

6. ARC NUMBER
ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
CIAT

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(Research summary)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAF-044

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Beans
Maize

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/ta-G-1435 GTS

15. TYPE OF DOCUMENT

AID/ta G-1435 GTS
CIAT PN-AAF-044

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

Prepared by:

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December, 1977

The research discussed in this report is part of an ongoing investigation being conducted at CIAT. The basic working document for this grant is the "Report on Discussions With Laing and Francis at CIAT, March 14, 1977". The objectives, methods, and approach to Phase I were detailed in our first Quarterly Progress Report (September, 1977).

The results of Phase I were discouraging in one respect. One of the objectives was to identify strong and weak competitors with maize within each of the four bean types, these bean lines to be used in subsequent competition studies. However, the results showed clearly that all bean lines included in the experiment of Phase I were depressed to the same extent,compared to their performance in monoculture. Thus, it was not possible to choose a strong and a weak competitor for Phase II; hence, the next experiment will concentrate on reasons for yield reduction *per se* in associated culture.

The experiment being conducted under Phase II is outlined as follows:

Objectives:

1. to quantify the light environment of bean and maize crops under both monoculture and associated culture conditions

2. to separate and quantify the main effects of root and shoot level competition, and their interaction, in associated culture of bean and maize.

Methodology:

1. design - split, split, split-plot, using treatments as the first split, bean growth habits as the second split, and maize populations as the third split.

2. four replications

3. plots: for conventional associations and monocultures,

5 beds x 8 m long

for shaded treatments,

7 beds x 8 m long

for treatments with bent maize,

9 beds x 8 m long,

leaving outermost rows and 1.5 m on either end as borders.

4. treatments (4):

a. monoculture beans

b. normal associations between maize and bean, but with beans (Type IV only) artificially supported

c. association between maize and bean where the maize is artificially bent either over or away from the beans.

d. normal association between maize and bean, supplemented by artificial shading of the bean.

populations:	bean,	240,000 pl ha^{-1} for Type II (P566)
		120,000 pl ha^{-1} for Type IV (p364)
	maize,	20,000 pl ha^{-1} (HZ10 for all)
		40,000
		60,000

Two bean varieties, one in each of Types II and IV will be planted in an array of 12 central treatments, with appropriate maize and bean monoculture controls. A 3 x 4 factorial with 3 levels of root and 4 levels of shoot competition will be established as follows:

ROOT LEVEL COMPETITION

1. Minimum level. Maize population 20,000 pl ha^{-1}

2. Intermediate level. Maize population $40,000^{-1}$

3. Maximum level. Maize population 60,000 pl ha^{-1}

These treatments will be applied using bean populations at constant levels. The idea is to increase the degree of competition afforded by the maize roots on the bean roots. It is recognized that shoot level competition will be affected concomitantly with changes in maize populations. We will explain how we propose to deal with this in the following sections.

SHOOT LEVEL COMPETITION

1. Minimum level of shading; facilitated light penetration achieved by bending the maize stalks away from the beans. This will be accomplished and maintained using artificial supports.

2. Lower intermediate level of shading; normal association

3. Higher intermediate level of shading; restricted light penetration, achieved by bending the maize stalks over the beans. (Note that this is the same treatment as in 1, but in the alternate rows.)

4. Maximal level of shading; restricted light penetration to bean achieved by imposing artificial shades above the beans.

The absolute degrees of shading imposed by these four treatments will not be directly comparable although we may be able to account for the differences using covariate analysis. However, the effect that we are particularly interested in examining is the interaction between root and shoot level competitions. These can be assessed by comparing the shapes of the response curves using conventional profile analysis.

It is, however, critical to achieve a broad range of absolute levels of light penetration within each population so that a substantial degree of overlap in shading levels can be achieved between populations. This point is illustrated by the diagram of hypothetical response curves (p. A2). The four points within each population correspond to the four shadding treatments. Note that the absolute level of shading imposed by the first treatment is different for each maize population (for each degree of root competition). Similarly for the second, third and fourth shading treatments. However, since it is the shapes of the curves and not the specific treatments used to construct the curves that are important, this is not a problem. It is hoped that a broad enough range of shading can be elicited within each population to permit meaningful comparison of the response curves.

CONTROLS

1. monoculture beans

   a. normal Type II
   b. normal Type IV
   c. oppositely entrained Type IV, as the control for the Type IV beans in the associated treatments. Note that in all four shading treatments, the beans are artificially supported. This is necessary in some of the treatments due to the mechanics of the shading treatments. It is considered necessary in the other shading treatments so that a valid interpretation of treatment effects can be made. It is possible, however, that the process of separating the beans from the maize in associated culture may modify bean (or maize) growth. Thus, both normally entrained and oppositely entrained treatments in bean monocultures will be grown. The difference here is in the distance between the bean rows; in normally entrained rows a distance of 60 cm separates the entraining plants, while in oppositely entrained rows, only 40 cm is available for light penetration between supported plants.

2. monoculture maize

a. normal, at 20,000 pl ha^{-1}
40,000 pl ha^{-1}
60,000 pl ha^{-1}

b. artificially bent, at 40,000 pl ha^{-1} only.

3. normal association, Type IV beans with maize at 40,000 pl ha. This is included to see if the process of artificially separating bean from maize growth in associated culture modifies growth of either crop.

TREATMENT SUMMARY

Using 3 levels of root competition (3 maize populations) x 4 levels of shading x each of the 2 bean types, equals 24 treatments in the central array.

Controls for the beans, 3 treatments
Controls for the maize, 4 treatments
Control for the bean/maize association, 1 treatment

In total, there are 32 treatments.

6. Data Collection:

Bean and maize growth and development will be evaluated using a series of harvests of blocks of plants within each plot. Blocks will be selected at random, leaving sufficient plants between harvested blocks to prevent border effects.

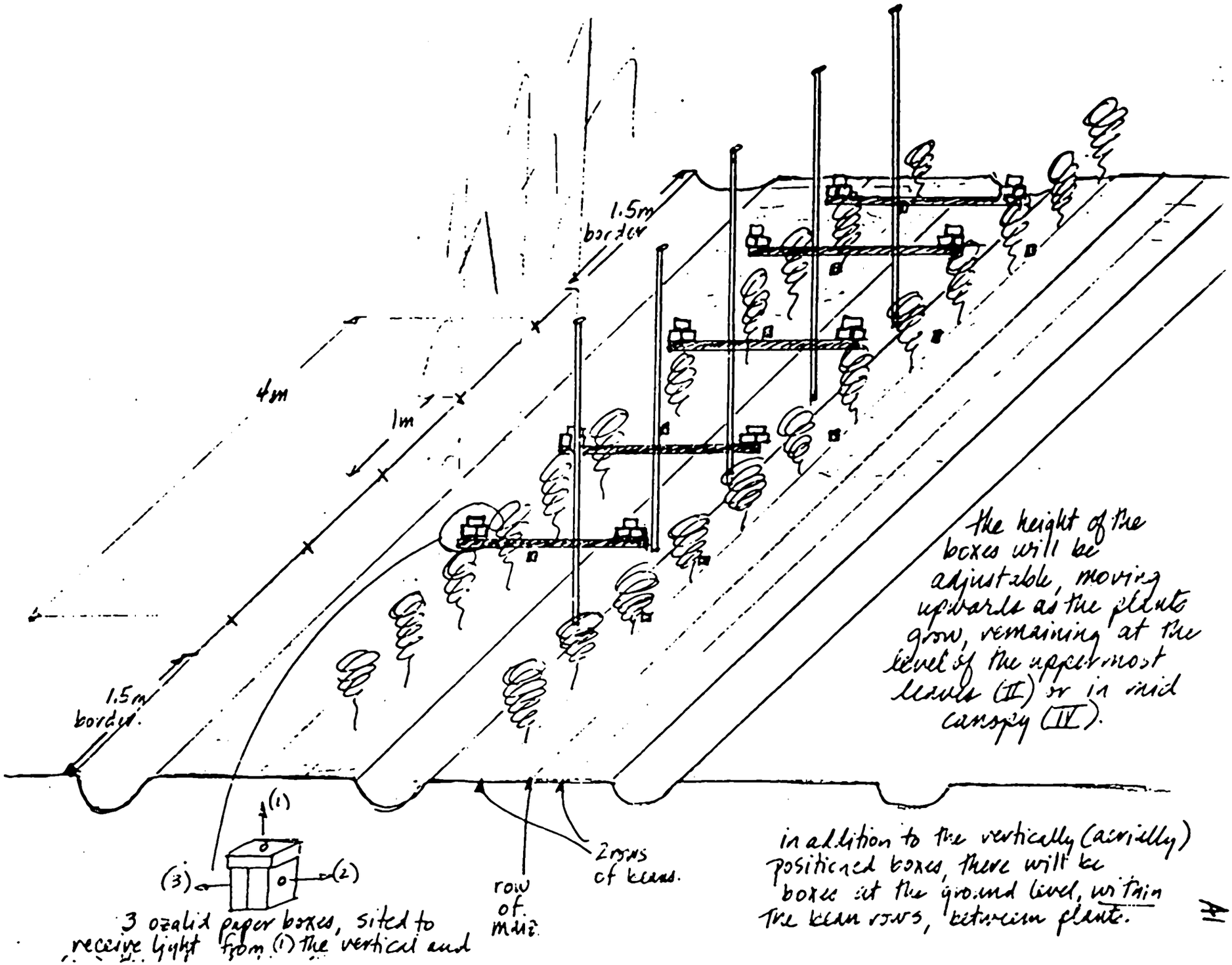
In addition to dry weight partitioning, leaf area and plant structure attributes measured at each harvest, plant height and width will be evaluated at regular intervals, in situ. Temporal data, emphasizing developmental progressions through flowering, and senescence, will also be taken.

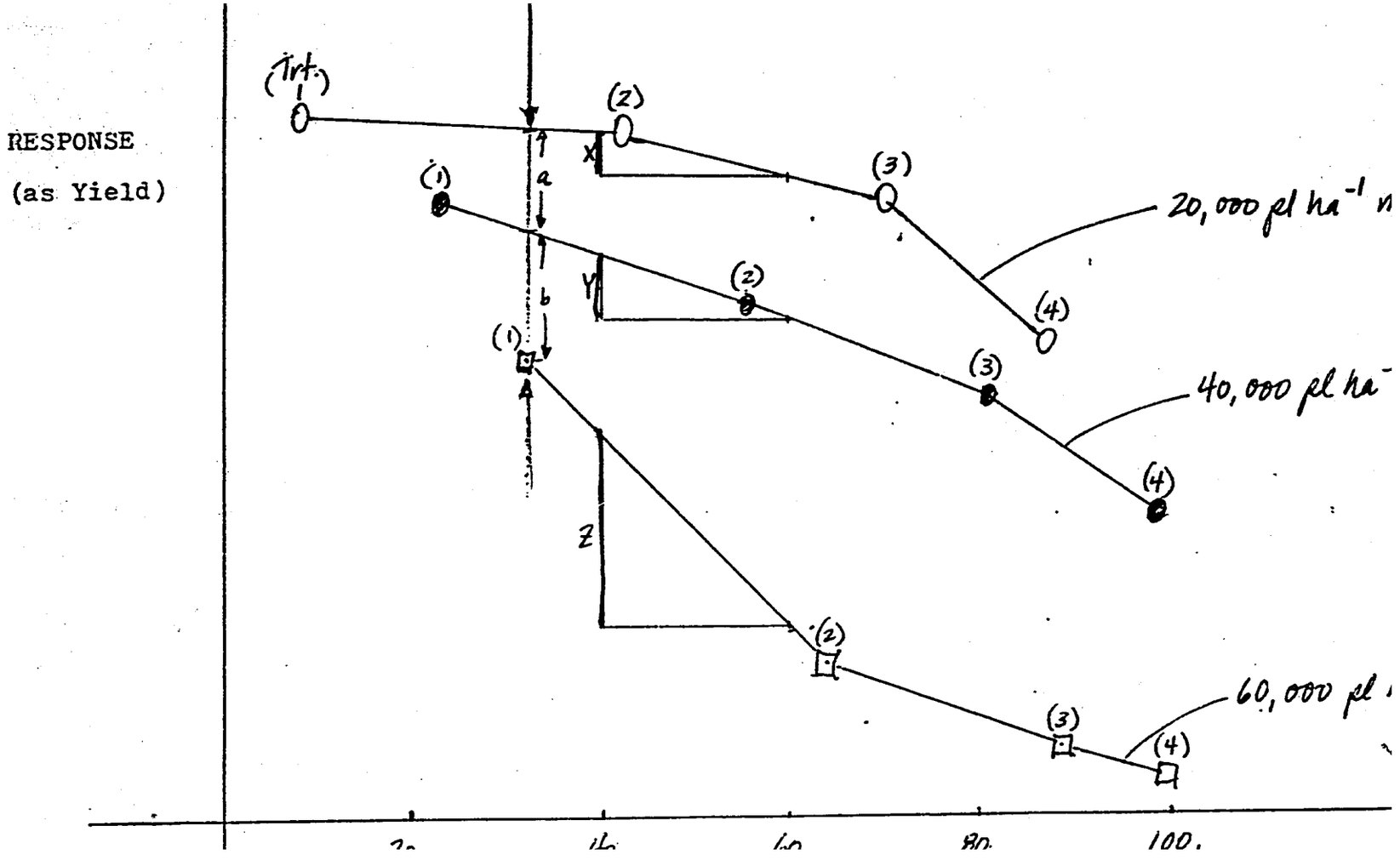
It is proposed also that intensive data collection be restricted to selected treatments rather than to all treatments. Maize monocultures can be evaluated primarily by yield data. Similarly, some of the associated treatments can be evaluated using simple, nondestructive measurements, as well as final yield. Intensive data collection would be warranted in the beans from normal associations, monocultures, bent maize and artificially shaded treatments at 40,000 pl ha^{-1} maize (the optimal maize population for normal associated culture). This would make data collection more manageable without losing too much information.

7. Application of Data to Realization of Objectives:

a. Light energy will be evaluated in the 12 central treatments for each bean type at regular intervals. The light environment will be assessed from both lateral and vertical vantages at the level of the uppermost bean leaves in Type II beans and perhaps at mid-canopy in the Type IVs. Light penetration to the ground level will also be measured. The proposed measurement system is illustrated in the attached diagram (p. A1). The proposed system would involve 40 measurements for each plot, for each of 21 treatments, over 4 reps, equalling 3360 measurements. These could best be handled at one rep per day over 4 days.

b. Root and shoot main effects and their interaction. Root main effects may be assessed by comparing the response differences between maize populations at a given level of shading. In the attached diagram (A2), the arrows indicate an arbitrary point of comparison between root level treatments. For example, the interval marked (a) would represent the difference in root effect between the 20,000 and 40,000 pl ha^{-1} maize treatments, at 30% shading. Similarly, the main effect of light may be assessed by comparing the magnitude response difference within a maize population for a given change in shading. In the attached diagram, the lines denoted (x), (y) and (z) represent the main effect of light (in this example, over the interval of a light reduction from 40% to 60% shading, for each maize population). The fact that the magnitude reduction in response is different between maize populations (between levels of root competition) would indicate an interaction between root and shoot level competition. In this example, a 20% reduction in light availability has a more negative effect when root competition is greater (at 60,000 vs. 20,000 pl ha^{-1} maize).


1.5m border
4m
1m
1.5m border.
(1)
(2)
(3)
row of maiz
2 rows of beans.
the height of the boxes will be adjustable, moving upwards as the plants grow, remaining at the level of the uppermost leaves (II) or in mid canopy (IV).
in addition to the vertically (axially) positioned boxes, there will be boxes at the ground level, within the bean rows, between plants.
3 ozalid paper boxes, sited to receive light from (1) the vertical and


RESPONSE
(as Yield)
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X
Y
Z
a
b
20,000 pl ha⁻¹
40,000 pl ha⁻
60,000 pl
100.