Intercropping with Cassava
Proceedings of an international workshop held at Trivandrum, India, 27 Nov - 1 Dec 1978
Editors: Edward Weber, Barry Nestel, and Marilyn Campbell
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Cosponsored by the
Central Tuber Crops Research Institute (Indian Council for Agricultural Research)

and the
International Development Research Centre

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Multiple Cropping Cassava and Field Beans: Status of Present Work at the International Centre of Tropical Agriculture (CIAT)

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The cassava program at the International Centre of Tropical Agriculture (CIAT) has basically been developing monoculture systems for cassava production. However, an agroeconomic survey in Colombia showed that about 40% of cassava is grown in mixed culture (Diaz and Andersen 1977). The authors furthermore estimated that in Latin America the figure of 40% is probably fairly representative. Okigbo (1976) estimated that in Africa about half the cassava is grown in mixed cropping systems. In general, the mixed cropping systems are used by the smaller farmers from the lower income groups. In the last 2 years, the CIAT Cassava Program has started serious investigations on cassava intercropping systems.

The cassava crop is among the most efficient calorie producers (250 kilocalories ha\(^{-1}\) day\(^{-1}\)) of the major crops (Coursey and Haynes 1970). The protein content of cassava is, however, very low and hence in CIAT we decided to concentrate on cassava grain legume mixes, so as to give a combination that might more nearly satisfy dietary requirements.

The emphasis of the research has been on cassava and *Phaseolus vulgaris* as CIAT has expertise on both these crops. We have not tried to develop multiple cropping systems as such, but rather have attempted to define what parameters are important in determining the yield of the two crops when grown together and later use this knowledge to design more efficient systems of production.

The cassava crop is generally slow to cover the ground, with complete cover occurring some 3 months after planting. Changing the spatial arrangement from rectangular to square can further delay the time to full ground cover without apparently reducing cassava yield (Cock et al. 1978). The cassava crop is, however, highly sensitive to early competition (Doll and Piedrahita 1974). The bean crop develops very rapidly and often completes its growth cycle in 90 days or less. This led us to the hypothesis that it should be possible to grow a bean crop under the cassava crop, in such a manner that it did not compete for light but utilized the light not intercepted by the cassava.

Not only has multiple cropping been suggested as a means for maximizing capture of solar energy, but also as a probable control method for diseases and pests. This pest control could be of tremendous importance for the small farmer with limited resources who cannot use purchased inputs to control disease and pests. Hence we have started to investigate the advantages of mixed cropping in this context.

Whilst planning the trials to investigate multiple cropping systems we became aware that experimental design was often necessarily extremely complex. Many of the trials done previously on multiple cropping systems have used a number of different treatments and cropping systems; however, the results have been difficult to interpret because of the enormous number of interactions. In our trials we have tried to study the effects of varying only one parameter and have observed this factor in detail. The authors feel that this approach may not necessarily lead to immediate optimum solutions to multiple cropping systems but that it will eventually give the insight necessary to design successful multiple cropping systems.

**Experimental Site**

All experiments were carried out at CIAT headquarters, which is located 3° north of the equator, at 1050 m above mean sea level, on a heavy fertile alluvial soil. Mean annual temperature is 24 °C with little seasonal change; the rainfall is bimodal with two wet and two dry seasons with a total of approximately 1100 mm per year. Beans were irrigated as necessary during the dry periods. The characteristics of the different cassava clones and grain legumes are shown in Table 1.
Table 1. Characteristics of cassava and dry bean varieties used in the experiments.

**Cassava: Manihot esculenta (Crantz)**

M Mex 11  
A germ-plasm collection variety; has a medium early growth vigour, single erect stemmed and late branched; a good and stable yield performance.

M Mex 59  
A germ-plasm collection variety; has a moderate early growth vigour but early branched type; heavy foliage stand 3 months after germination; also a good and stable root producer.

M Col 113  
A germ-plasm collection variety; has a poor early growth vigour, early branched type; heavy foliage stand 3 months after germination.

**Bean: Phaseolus vulgaris L.**

P 302  
A black bush bean with a growth habit II, indeterminate erect type; growth cycle 80 days at CIAT conditions; a good yielder.

P 566  
A bush black bean with growth habit II, indeterminate erect type, growth cycle less than 80 days at CIAT conditions.

P 498  
A black bean with growth habit IV, indeterminate prostrate type, growth cycle more than 90 days at CIAT conditions.

**Planting Date**

When the relative date of planting of beans and cassava (P 302 and M Mex 11 respectively) was altered, the relative yield of the two crops changed markedly (Fig. 1). The yield of beans was greatest when the beans were planted before the cassava and lowest when planted after. The yields of cassava were completely in the opposite direction. The maximum reduction of cassava yield was 25% when the beans were planted 2–4 weeks before the cassava. Planting cassava and beans at the same time gave the highest Land Equivalent Ratio (LER) (1.7). The LER was corrected for total time of land use, which was greater when beans were planted before the cassava (Fig. 2). The yield of fresh cassava was 35 t/ha and of beans (14% moisture) 2.9 t/ha when planted at the same time; these high yields suggest great potential for cassava–bean mixed cropping systems.

Soybeans (var. ICA-Tunia) were planted 1 month before, at the same time, and 1 month after cassava. The medium vigour late branching M Mex 11 and the vigorous early branching M Mex 59 cassava clones were used. When soybeans were planted 1 month after cassava, yield was essentially zero and when planted 1 month before the cassava, soybean yields were the same in mono or mixed culture. When planted at the same time as the cassava, yields of soybeans were slightly reduced (Fig. 3). Yield of cassava roots was very variable due to a high percent of root rot caused by very heavy rain just before harvest. The total harvested biomass of cassava was, however, very greatly reduced by planting soybeans before cassava. It appears once again that the optimum planting date is both crops at the same time (Fig. 4).

![Fig. 1. Yield of cassava (root dry matter) and beans (14% moisture content) at different relative planting dates.](image)

**Plant Population**

To study different plant populations using a traditional randomized block design it was necessary either to use a restricted number of plant populations or a very large experiment so as to eliminate border effects. To avoid these problems the cassava plant population was varied by systematically changing the distance between plants in the row. Hence each population is bordered on one side by a slightly lower plant population and on the other side by a slightly higher plant population.

In a monoculture system, the yield of the two bean varieties P 302 and P 498 were not significantly different and were not insignificantly increased by increasing the plant population up to 40 plants/m². The yield of P 498 in association was not affected by
changes in plant population, but P 302 showed a tendency for yield to increase with increasing plant population. The bean yields in association with M Col 113 were always higher than with M Mex 11 (Fig. 5). M Col 113 is less vigorous than M Mex 11 in the early stages. Bean yields decreased as the cassava density increased (Fig. 6). The maximum yield of cassava in monoculture was 39.4 metric tonnes (t) per hectare with M Mex 11, and 26.0 t per hectare with M Col 113. The cassava yield of M Mex 11 increased as cassava population increased either in monoculture (Fig. 7) or in association (Fig. 8),
whereas the yield of M Col 113 tended to decline when the plant population increased. The yields of M Col 113 when intercropped with P 302 were sometimes higher than in monoculture of M Col 113 itself. This apparent anomaly is probably due to a reduction of early growth, which reduces leaf area index (LAI) to the optimum level and consequently improves yield (CIAT 78). Intercropping M Col 113 with the more vigorous P 498 did not give the same result, probably because the competition of the P 498 with the cassava reduced LAI below the optimum and hence reduced yield. Cassava yields were not affected by bean population.

The cassava yields in association with P 498 were
less than those with P 302; however, P 498 gave higher yields in association than P 302. Hence it may be difficult to select bean varieties that yield well in association but do not greatly depress the cassava yield. The highest LERs were in fact obtained by the combination of P 302 and M Mex 11 (Fig. 9). It should be noted that the growth cycle of P 302 is 80 days and P 498 is more than 90 days. These LERs were obtained at normal monoculture densities for cassava (10 000 plants/ha) and beans (250 000 plants/ha).

Genotypic Variation

Twenty different cassava clones were planted 2 weeks before the black bean P 566. The bean yield was negatively correlated with the top growth of cassava 3 months after planting (Fig. 10) but there was no correlation between final cassava yield and bean yield. This suggests that cassava types can be selected that cause minimum reduction in bean yield but also yield well. Cock et al. (1978) have shown that late branching is a desirable character for high yields in monoculture; late branching varieties presumably will give less shade to the grain legume in the early stages.

When 20 cassava clones were planted with a 125-day soybean (var. ICA-Tunia) there was a negative correlation between cassava root yield and soybean yield (Fig. 11). This suggests that with a short season (less than 90 days), grain legume, cassava types can be selected that are both high yielding and also allow enough light to pass to enable the grain legume to yield well; however, in the case of longer season grain legumes this cannot be achieved as the low light interception of cassava for a period of 4 months is detrimental to its final yield.
Pest Control

The monoculture system has been criticized because the genetic and stand uniformity results in continuous pest susceptibility (Pimentel 1961; Southwood and Way 1970; Nickel 1973). Multiple cropping systems on the other hand are praised because the diversity of vegetation within the crop area can be used to give integrated pest management (DeLoach 1970; Dempster and Coaker 1974; Altieri et al. 1978).

To study the plant protection potential of the intercropping system, a field experiment was set up and the insect population was measured in a cassava bean intercropping system both with and without insect control systems.

The populations of lace bug and whiteflies were less in the intercropping system than in the cassava monoculture with or without plant protection. Hornworm populations were lower in the intercropping system than in the cassava monoculture without insecticide (Table 2).

Similar results were obtained in the beans: Diabrotica and Ceratoma and thrips populations were lower in the intercropping system compared to the monoculture system and the lowest insect population was found in the intercropping system when insecticides were applied (Table 3).

The yield of cassava was reduced little by mixed cropping with beans in the no insecticide treatment and the bean yield was essentially the same in the mixed and monocropping system (Fig. 12). Hence,
Fig. 8. Cassava yield when intercropped with P 302 and P 498 as affected by different cassava densities.

Fig. 9. Land equivalent ratio of different combinations as compared to best monoculture yield of cassava and bean.
Average stem and leaf weight of 20 cassava varieties at 3 months (g DM/plant)

Fig. 10. Bean yields relative to monoculture as affected by different cassava genotypes.

Fig. 11. Soybean yields relative to monoculture as affected by different cassava genotypes.
Table 2. Insect population in cassava monoculture vs. intercropping system cassava-bean, with and without insecticide treatment.

<table>
<thead>
<tr>
<th>Insect</th>
<th>Cassava monoculture&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Cassava intercropped&lt;sup&gt;b&lt;/sup&gt;</th>
<th>% in population reduction by different system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With insecticide&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Without insecticide</td>
<td>With insecticide&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lace bug, 3 leaves/plant</td>
<td>4.5</td>
<td>5.6</td>
<td>2.7</td>
</tr>
<tr>
<td>White fly</td>
<td>7.2</td>
<td>6.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Shoot fly/plot</td>
<td>2.1</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Hornworms/plot</td>
<td>0.5</td>
<td>0.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Hornworm eggs/parasitized plot</td>
<td>50.7</td>
<td>52.4</td>
<td>51.2</td>
</tr>
</tbody>
</table>

<sup>a</sup>Cassava variety M Mex 11.
<sup>b</sup>Bean variety P 566 with M Mex 11.
<sup>c</sup>Endosulfan.

Fig. 12. The effect of different input on yield of cassava-bean in association.
Table 3. Insect population in bean monoculture vs. intercropping system cassava–bean, with and without insecticide treatment.

<table>
<thead>
<tr>
<th>Insect</th>
<th>Cassava monoculture&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Cassava intercropped&lt;sup&gt;b&lt;/sup&gt;</th>
<th>% in population reduction by different systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With insecticide&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Without insecticide</td>
<td>With insecticide&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Leaf hoppers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Empoasca kraemeris)</td>
<td>89</td>
<td>229</td>
<td>80</td>
</tr>
<tr>
<td>/20 m&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrysomelides/20 m&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Trips/inch&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Scaphitophius/m&lt;sup&gt;2&lt;/sup&gt;</td>
<td>25</td>
<td>35</td>
<td>20</td>
</tr>
</tbody>
</table>

<sup>a</sup>Cassava: M Mex 11.
<sup>b</sup>P 566 x M Mex 11.
<sup>c</sup>Endosulfan.

In the case of low inputs, the LER was very close to 2 (1.95) whereas in the insecticide-treated plots it was 1.89. This data suggest that under minimum input technology, multiple cropping will show the greatest advantage.

**Conclusions**

Cassava can successfully be grown with short growth cycle grain legumes. High yields of both crops can be obtained and LERs of the order of 1.5 are quite feasible. Planting date is a very important determining factor in the system, and simultaneous planting appears preferable. It appears possible to select for cassava varieties that are high yielding and also combine well with short growth cycle legumes; however, if the legume growth cycle is greater than 90 days this may be difficult. Both bean and cassava plant populations could be varied considerably with little effect on the LER, and normal monoculture densities gave good mixed cropping yields.

The relative advantage of mixed cropping with beans and cassava was greatest at low input levels of insecticides, suggesting that mixed cropping systems may be most suitable for small-scale producers with limited resources to purchase inputs.