Tropical Root Crops

RESEARCH STRATEGIES FOR THE 1980s

Proceedings of the First Triennial Root Crops Symposium of the International Society for Tropical Root Crops - Africa Branch
TROPICAL ROOT CROPS: RESEARCH STRATEGIES FOR THE 1980s

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EDITORS: E.R. TERRY, K.A. ODURO, AND F. CAVENESS

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Effect of Maize Plant Population and Nitrogen Application on Maize – Cassava Intercrop

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We studied the effects that maize populations had on the performance of maize and cassava intercropped on an Egbeda soil (oxic paleustalf) at Ibadan. Maize and cassava were spaced 100 × 100 cm, cassava planted between maize along the same row. Maize plants/hill were varied from 1 to 7 giving a population 10–70 × 10^3 plants/ha. Increasing maize populations from 10 to 30 × 10^3 plants/ha significantly increased maize grain yield and had no significant effect on cassava root yield. Higher populations, however, had no effect on grain yield but significantly depressed root yield. It seems that three maize plants/hill is optimum. The effects of nitrogen rates on intercropped maize and cassava were studied on Alagba soil (oxic paleustalf) at Ikenne. The soil had been Eupatorium fallow before the study. In the first year, no response to N was observed on sole or intercropped maize, but, with early harvest, root yield of TMS 30395 showed significant depression with N application and intercropping. During the second year, both the sole and the intercropped maize showed a significant response to N but not the cassava crop. Maize–cassava intercropping appears to be more efficient than the corresponding sole crops as indicated by the higher land equivalent ratios (LERs).

In traditional farming systems in the humid tropics, cassava is known to be intercropped with a number of annual food and tree crops (Weber et al. 1978). According to Okigbo and Greenland (1976), about half the cassava grown in tropical Africa is intercropped. The most popular forms of cassava intercropping are mixed intercropping in which the associated crops have no distinct row or spatial arrangements and relay intercropping in which the associated crops are grown simultaneously only during part of the life cycle of each crop. Though in humid tropical Africa cassava is known to be mixed with a wide variety of crops, some principal staple food and subsidiary crops can be identified (Okigbo 1978). Ezeilo et al. (1975) reported that cassava–maize, cassava–yam, and cassava–yam–maize are dominant mixed cropping systems on acid Ultisols in the forest zone of southeastern Nigeria. Agboola (1979) also reported that yam–maize–melon, yam–maize–cassava, and maize–cassava are widespread mixed cropping systems in the derived savanna and forest zone of southwestern Nigeria, which is dominated by high base status Alfisols and associated Entisols. Wilson and Agboola (1979) claimed that maize–cassava mixed cropping systems are the most popular and widespread in West Africa. They attributed this popularity to the high compatibility and complementarity of the crops, the fast-growing maize exploiting the environment early and the slow-growing cassava exploiting it later.

Despite the importance of the maize–cassava mixed cropping system, little information exists on the effects of intra- and interspecific competitions.
Similarly, there is little information on the effects of soil fertility on the performance of the intercropped maize and cassava. Further studies, therefore, have been carried out on the subjects, and some of the results are reported in this paper.

**EFFECT OF MAIZE DENSITY**

In traditional maize–cassava mixed intercropping there is no set plant density, spacing, or spatial arrangements. However, wide intraspecific spacing appears to be common, high plant density being obtained by close interspecific spacing. Wilson and Adeniran (1974), in one study, observed intraspecific spacing for cassava ranging from 50 to more than 200 cm with a mean of $100 \times 140$ cm. Wilson (unpublished data) also observed that in West Africa farmers plant between 5 and 10 maize seeds/hill at spacings ranging from 50 to $120 \times 120$ to 200 cm. Some of the farmers thin to three plants/hill, but others allow all surviving plants to mature. The effects of varying maize densities on intercropped maize and cassava are not well understood, so a field trial was carried out at Ibadan in southern Nigeria.

The trial was located on sandy loam, Egbeda soil (oxic paleustalf). Maize variety TZPB was planted at a spacing of $100 \times 100$ cm with $1 - 7$ plants/hill to give $10000 - 70000$ plants/ha. Cassava was planted at the same time, spacing was also $100 \times 100$ cm, and the cassava was interspersed with maize along the same row (a population of $10000$ plants/ha). A control treatment of pure maize stand was added, at $75 \times 25$ cm spacing ($53200$ plants/ha). A fertilizer rate of $40 \ N - 20 \ P_2O_5 - 20 \ K_2O$ in kg/ha was applied to the maize crop. The trial was set up on a complete randomized block design with

![Fig. 1. Planting arrangement for maize–cassava intercrop.](image1)

![Fig. 2. Effect of maize intercrop on cassava yield from weed-free plots.](image2)
three replications. Cassava crop was harvested at 15 months after planting date.

Increasing the number of maize plants/hill from 1 to 3, which gave a corresponding population increase from 10,000 to 30,000 plants/ha, increased maize grain yield (Fig. 1) significantly (>5% probability level). Further increases in plant population above 30,000 plants/ha resulted in small but not significant yield increases. Highest yields from intercropped maize were observed at 70,000 plants/ha, which is almost equal to the yield obtained in the control. For unexplainable reasons, there appears to be some yield depression at 50,000 plants/ha, which was also observed in a similar trial at Ikenne.

Increasing maize plant populations has a pronounced effect on cassava root yields, particularly at high plant populations (Fig. 2). Increasing the maize population to 30,000 plants/ha resulted in some but not significant yield decreases. Significant root yield (>35%) decreases were obtained at maize plant populations ≥ 40,000 plants/ha.

It thus appears that a maize population of 30,000 plants/ha combined with a cassava population of 10,000 plants/ha is optimum. Wilson and Adeniran (1974) from their study on the effects of spacing in traditional maize-cassava intercropping systems also observed that maize and cassava yield can be improved if the spacing is adjusted to these populations.

Recent studies (Wilson, unpublished) on the effects of maize varieties and plant densities on intercropped cassava also have shown that increasing maize populations from 30,000 to 60,000 plants/ha has no significant effect on maize grain yield but significantly depresses root yields from cassava. Cassava root yield was observed to be more depressed by the intermediate-maturing TZP8 and local maize varieties than by the early-maturing TZE variety.

Though thinning the number of maize plants to three plants/hill may not be economic as far as maize grain yield is concerned, it may be economic in areas where green cob is sold. Cob size is negatively correlated with maize plant populations (Fig. 3); therefore thinning may have the advantage in increasing cob size. Sinhuprama (1978), for example, has shown that higher incomes can be obtained from maize-cassava intercropping where green cob rather than grain is harvested and sold.

**NITROGEN RESPONSE**

In traditional farming in humid tropical West Africa, maize and cassava are intercropped usually in the first year after land clearing and fallow-residue burning on the acid Ultisols. The intercrop is not normally continued because the nutrient deficiency and high soil acidity do not favour maize in subsequent years. In contrast, on highly basic Alfisol, where soil acidity is not a problem for the maize crop, the maize-cassava mixed cropping is often practiced for 2–3 years after bush fallow. Though decline in soil fertility with subsequent cropping is known to have an effect on crop yield, little information exists on the effects of changes in soil fertility on the performance of maize-cassava systems. A trial was, therefore, carried out at Ikenne, which is located about 60 km south of Ibadan, in the forest zone of southern Nigeria. The objective was to determine the nitrogen response by a maize-cassava intercropped system. The soil, an Alagba soil series, has a loamy sand texture derived from sandy sedimentary rocks, and, before this study, was newly cleared *Eupatorium* fallow. The soil had pH (in 1:1 soil:water ratio), 6.2; organic C, 1.22%; total N, 0.15%; CEC, 6.14 me/100 g; extractable Bray P-1, 4.3 ppm P.

In the trial, three nitrogen rates were compared (Table 1 and 2). Maize was planted at two spacings 1 × 1 m (three plants/hill) and 1 × 0.33 m (one plant/hill), giving 30,000 plants/ha, and cassava was planted at 1 × 1 m spacing, giving 10,000 plants/ha. Phosphorus was applied at a rate of 60 kg P₂O₅/ha and potassium at a rate of 90 kg K₂O/ha. During the first trial, cassava was harvested at 10 months, and in the second trial at 13 months after planting date.

On the newly cleared land, nitrogen application had no significant effect on the first or second season yields of maize in either the pure or intercropped stands (Table 1). Planting the maize at one or three plants/hill also had no effect on maize grain yield, and intercropping with cassava at a popula-

![Fig. 3. Effect of plant population on lodging in two cassava cultivars.](image-url)
Table 1. Effect of N application on yield of intercropped maize (variety TZPB) and cassava (variety TMS 30395) grown on Alagba soil (oxic paleustalf), 1979–80.

<table>
<thead>
<tr>
<th>N rate (kg N/ha)</th>
<th>Cropping mixture</th>
<th>Cassava fresh root yield (t/ha)</th>
<th>Maize grain yield (t/ha)</th>
<th>LER</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Maize (1 × 0.33 m, 1 plant/hill)</td>
<td>–</td>
<td>1.80</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 1 m, 3 plants/hill)</td>
<td>–</td>
<td>1.74</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Cassava (1 × 1 m)</td>
<td>30.12</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 0.33 m) + cassava (1 × 1 m)</td>
<td>29.11</td>
<td>1.93</td>
<td>1.90</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 1 m) + cassava (1 × 1 m)</td>
<td>28.89</td>
<td>1.87</td>
<td>2.00</td>
</tr>
<tr>
<td>60</td>
<td>Maize (1 × 0.33 m, 1 plant/hill)</td>
<td>–</td>
<td>2.30</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 1 m, 3 plants/hill)</td>
<td>–</td>
<td>2.40</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Cassava (1 × 1 m)</td>
<td>30.90</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 0.33 m) + cassava (1 × 1 m)</td>
<td>27.10</td>
<td>2.45</td>
<td>1.95</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 1 m) + cassava (1 × 1 m)</td>
<td>29.50</td>
<td>2.39</td>
<td>1.95</td>
</tr>
<tr>
<td>120</td>
<td>Maize (1 × 0.33 m, 1 plant/hill)</td>
<td>–</td>
<td>2.28</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 1 m, 3 plants/hill)</td>
<td>–</td>
<td>2.12</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Cassava (1 × 1 m)</td>
<td>28.65</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 0.33 m) + cassava (1 × 1 m)</td>
<td>24.85</td>
<td>2.52</td>
<td>2.05</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 1 m) + cassava (1 × 1 m)</td>
<td>29.68</td>
<td>2.10</td>
<td>2.05</td>
</tr>
</tbody>
</table>

There was a linear root-yield depression with increasing nitrogen rates from 0 to 120 kg N/ha. It appears that nitrogen application on this relatively fertile soil and also intercropping delay root bulking in cassava.

The second year, the maize crop was slightly

Table 2. Effect of N application on yield of intercropped maize and cassava (variety TMS 30395) grown on Alagba soil (oxic paleustalf), 1978–79.

<table>
<thead>
<tr>
<th>N rate (kg N/ha)</th>
<th>Cropping mixture</th>
<th>Cassava fresh root yield (t/ha)</th>
<th>First season (T2PB)</th>
<th>Second season (TZE)</th>
<th>Total</th>
<th>LER</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Maize—maize (1 × 0.33 m, 1 plant/hill)</td>
<td>–</td>
<td>6.24</td>
<td>0.66</td>
<td>6.90</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize—maize (1 × 1 m, 3 plants/hill)</td>
<td>–</td>
<td>6.16</td>
<td>0.49</td>
<td>6.65</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Cassava (1 × 1 m)</td>
<td>13.28</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 0.33 m) + cassava (1 × 1 m)</td>
<td>7.05</td>
<td>5.74</td>
<td>–</td>
<td>5.74</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 1 m) + cassava (1 × 1 m)</td>
<td>6.44</td>
<td>5.51</td>
<td>–</td>
<td>5.51</td>
<td>1.29</td>
</tr>
<tr>
<td>60 + 30b</td>
<td>Maize—maize (1 × 0.33 m, 1 plant/hill)</td>
<td>–</td>
<td>5.72</td>
<td>0.61</td>
<td>6.33</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize—maize (1 × 1 m, 3 plants/hill)</td>
<td>–</td>
<td>6.34</td>
<td>0.89</td>
<td>7.23</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Cassava (1 × 1 m)</td>
<td>11.04</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 0.33 m) + cassava (1 × 1 m)</td>
<td>5.92</td>
<td>5.60</td>
<td>–</td>
<td>5.60</td>
<td>1.37</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 1 m) + cassava (1 × 1 m)</td>
<td>5.82</td>
<td>6.13</td>
<td>–</td>
<td>6.13</td>
<td>1.43</td>
</tr>
<tr>
<td>120 + 30b</td>
<td>Maize—maize (1 × 0.33 m, 1 plant/hill)</td>
<td>–</td>
<td>6.06</td>
<td>0.79</td>
<td>6.85</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize—maize (1 × 1 m, 3 plants/hill)</td>
<td>–</td>
<td>6.12</td>
<td>0.69</td>
<td>6.81</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Cassava (1 × 1 m)</td>
<td>7.79</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 0.33 m) + cassava (1 × 1 m)</td>
<td>7.50</td>
<td>5.56</td>
<td>–</td>
<td>5.56</td>
<td>1.77</td>
</tr>
<tr>
<td></td>
<td>Maize (1 × 1 m) + cassava (1 × 1 m)</td>
<td>6.06</td>
<td>5.67</td>
<td>–</td>
<td>5.67</td>
<td>1.60</td>
</tr>
</tbody>
</table>

Maize crops slightly affected by drought; cassava harvested at 13 months.

Cassava harvested at 10 months; first season maize variety TZPB and second season maize variety TZE.

30 kg N applied during second season to cassava and TZE maize.
affected by drought during grain filling, which resulted in lower grain yields (Table 2). Despite the lower grain yields, the sole and intercropped maize showed significant responses to nitrogen application. As also observed in the previous year, intercropping with cassava had no effect on maize grain yield.

With later harvest (13 months), cassava root yields were higher in the second year (Table 2). Despite the higher root yields, no significant response to nitrogen application was observed — a reflection of the lower nitrogen requirements of the cassava crop. In the second year, intercropping with maize had no effect on cassava root yields.

At the time of harvest of the intercropped maize, distinct canopy differences were noticed between the sole and intercropped cassava. The sole cassava plants were vigorous, leafy, and showed good visual response to nitrogen in top growth. The intercropped cassava, on the other hand, was etiolated with poor branching smaller foliage. Despite this large difference in canopy at age 4–5 months, the intercropped and sole cassava had comparable root yields (Table 2). Oelsligle et al. (1975) reported similar observations in a nitrogen-response trial with sole and intercropped maize and cassava in Costa Rica. They postulated, on the one hand, that cassava plants in pure stands stored their excess photosynthate in roots during the early to mid part of the crop productive cycle, remaining thereafter relatively inactive metabolically till harvest. On the other hand, intercropped cassava, once released from direct competition with maize, rebuilt its photosynthetic apparatus and stored the bulk of its excess photosynthates in roots during a later part of its growth. Thus, given a sufficient growth period, intercropped cassava can produce yields comparable with those from pure stands.

High LER values are obtained with maize–cassava intercropping. Oelsligle et al. (1975) reported LER values in the range of 2.26–2.94, indicating the high productivity of the maize–cassava mixed cropping system.

CONCLUSIONS

Results from both trials clearly indicate the high productivity of the maize–cassava mixed cropping system. They also suggest that with the improved maize cultivar TZPB and the improved cassava cultivars TMS 30395 and TMS 30572, a maize population of 30,000 plants/ha combined with a cassava population of 10,000 plants/ha is well within the optimum range for maize–cassava intercropping. On relatively fertile soil, nitrogen application will benefit the maize crop more than the associated cassava crop.