Effects of cassava density on productivity of plantain and cassava intercropping system.

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Akind薳mi

Abstract — Introduction. An experiment was conducted at Ayipe, Osun State, Nigeria, to determine the appropriate cassava density in association with plantain in order to achieve maximum yield. Materials and method. Plantain at a density of 1,066 plants ha⁻¹ was intercropped with cassava at three densities (5,000, 7,000, and 10,000 plants ha⁻¹). Both crops were also planted in monoculture at the highest densities in the intercrop. The experiment was arranged in a randomized complete block design with four replications. Results. For the highest cassava densities, plantain shoot number was increased by 89%, while the number of fingers per bunch and number of hands per bunch were significantly reduced in the intercropping system. Plantain bunch weight also decreased significantly as cassava density increased in the intercropping system. Bunch yield was reduced by 44 and 56% at 7,000 and 10,000 plants ha⁻¹ of cassava, respectively. On the other hand, Cassava tuber yield increased with increase in density. The total relative yield of the two crops was greater than 1.0 in all the intercrops. At present price level (10 naira per kg for plantain and 9.00 naira per kg for cassava), plantain in intercrop with 5,000 plants ha⁻¹ gave a higher return than plantain intercropped with other population densities of cassava or monoculture of the two crops. Discussion. If plantain is the major crop and must be intercropped with cassava, farmers should not intercrop plantain with cassava at a population greater than 5,000 plants ha⁻¹.

Musa (plantains) / Manihot esculenta / cropping systems / companion crops / spacing / yields / Nigeria

Effects de la densité de plantation du manioc sur la productivité du plantain et du manioc dans un système d'association plantain / manioc.

Résumé — Introduction. Une expérimentation a été conduite à Ayipe, dans l'état d'Osun au Nigéria, pour déterminer la densité de plantation du manioc donnant le meilleur rendement dans une culture associée plantain / manioc. Matériel et méthodes. Du plantain cultivé à 1,066 plants ha⁻¹ a été associé à une culture de manioc (3,000, 7,000 et 10,000 plants ha⁻¹). Parallèlement, les deux productions ont été plantées en monoculture (1,066 plants ha⁻¹ pour le plantain, 10,000 plants ha⁻¹ pour le manioc). L'essai a été conduit en blocs en répétition totale avec quatre répétitions. Résultats. Avec les densités de manioc les plus élevées, le temps de sortie des rejets du plantain a été augmenté de 80%, tandis que le nombre de doigts et de mains par régime étaient significativement réduits dans les cultures associées. Le poids du régime a également diminué de façon significative en même temps qu'augmentait la densité des plants de manioc entrant dans l'association. Le rendement en régime a été réduit de 44% pour le plantain associé à du manioc à 7,000 plants ha⁻¹, et de 56% avec du manioc à 10,000 plants ha⁻¹. Par ailleurs, le rendement en tubercules du manioc a augmenté avec la densité des plants. Le rendement relatif global pour les deux cultures a été supérieur à 1 dans tous les cas d'association. Avec le prix actuel de 10 naira kg⁻¹ de plantain et de 9,00 naira kg⁻¹ de manioc, c'est l'association plantain / manioc à 5,000 plants ha⁻¹ qui donne le meilleur profit par rapport aux autres densités testées dans l'association ou aux deux monocultures. Discussion. Si le plantain exploité en culture principale doit être associé avec le manioc, il est recommandé de ne pas planter le manioc à une densité supérieure à 5,000 plants ha⁻¹.

Musa (plantains) / Manihot esculenta / système de culture / plante de cultures associées / espacement / rendement / Nigéria
1. Introduction

The wide interrow space of plantain coupled with the greater length of time it takes to completely shade the interrow makes plantain lend itself very well to interplanting with other crops. Farmers with small landholdings have few choices to cope with food problems. They depend almost entirely on intercropping in order to produce enough food to satisfy their dietary and cash requirements. Plantain is usually grown in intercrop with food crops such as melon, soybean, maize and sweetpotato (1-3). Under such conditions, efficient use of growth resources may be achieved and increase in land productivity may be expected through this crop combinations.

Cultivation of cassava in the country by farmers has recently increased tremendously. The rapid expansion of cassava production is due to its adaptation to shorter periods of fallow, its ability to thrive without irrigation in areas where the dry season ranges from 1 to 3 months as well as an increase in demand for cheaper staple foods in urban centres (4).

It is a common practice by the peasant farmers to intercrop without adequate knowledge of the optimum populations of the companion crops that are compatible with the main crop. Consequently, high densities of the companion crops may lead to competition between the crops and the expected yield advantage due to intercropping may be small. It is therefore necessary to evaluate the effect of different populations of cassava on the growth and yield of plantain to ascertain the appropriate cassava density that will achieve optimum yield and income of the intercropping system.

2. Materials and Methods

The experiment was carried out between 1991 and 1993 at University of Ibadan/ITA on-farm adaptive research (CPAR) station, Ayeye Osun state of south western Nigeria. Ayeye is situated in the forest zone, about 50 km south east of Ibadan at 70°15’ latitude. The experimental site lies in a zone of Atlantic soils with ‘Tegeda’ (Oxic paleustoll) as dominant soil series. The soil of the site was sandy loam (Table 1). Rainfall pattern in the area is bimodal with long and short rainy seasons separated by a short period of uncertain rainfall (Table 2).

Swede suckers of false horn plantain (Musa paradiisiaca cv. Aghabada) were planted in 30 x 30 cm holes at a spacing of 3 x 2 m to give a population density of 1 666 plants ha^-1. The suckers were treated with 5 G Furadan at 2 kg active ingredient per ha to control plantain weevils (Cosmopolites sordidus) and nematode: Cassava (Plambeus exsulans cv. TMS 30 572) cuttings were planted within the interrows of plantain suckers at 1 x 2 m (5 000 plants ha^-1), 1 x 1.2 m (7 000 plants ha^-1) and 1 x 1 m (10 000 plants ha^-1) for the intercrop combinations. Plantain and cassava soles were planted at 3 x 2 m (1 666 plants ha^-1) and 1 x 1 m (10 000 plants ha^-1) respectively. Thus the treatment were: 1. Plantain sole; 2. Plantain + cassava (5 000 plants ha^-1); 3. Plantain + cassava (7 000 plants ha^-1); 4. Plantain + cassava (10 000 plants ha^-1); 5. Cassava sole.

Rasal fertilizer application of NPK (15-15-15) was done at the rate of 500 kg ha^-1 in two equal parts. The first dose was applied at 2 months after planting and the second dose was applied at 4 months after planting.

The experimental design was a randomised complete block with four replications in each season. The plot size was 13 x 10 m.

Data collected on plantain include pseudostem height and girth, number of functional leaves, number of days to shooting, number of hands per bunch, number of fingers per bunch and bunch weight.

Data on growth and yield components of cassava included stem height, girth, number of branches per plant, tuber number per plant, tuber length and fresh tuber weight.

Plantain was harvested at 90 days after planting while cassava was harvested at 18 months after planting.

The analysis of variance (ANOVA) procedure was used for statistical analysis of all data and mean comparison was done using Duncan’s multiple range test. The efficiency of intercropping relative to sole cropping was determined using Land Equivalent Ratio (LER) as proposed by BRI (5).

Table 1. Physical and chemical properties of the soil at the experimental site where productivity of plantain intercropped with cassava was studied (Nigeria).

<table>
<thead>
<tr>
<th>Soil parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (H2O)</td>
<td>5.60</td>
</tr>
<tr>
<td>Organic matter</td>
<td>2.00</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>0.24</td>
</tr>
<tr>
<td>Potassium (%)</td>
<td>4.40</td>
</tr>
<tr>
<td>Exchangeable Ca (cmol kg^-1)</td>
<td>7.32</td>
</tr>
<tr>
<td>Exchangeable Mg (cmol kg^-1)</td>
<td>1.96</td>
</tr>
<tr>
<td>Exchangeable Na (cmol kg^-1)</td>
<td>0.18</td>
</tr>
<tr>
<td>Exchangeable K (cmol kg^-1)</td>
<td>0.02</td>
</tr>
<tr>
<td>Exchangeable H4 (cmol kg^-1)</td>
<td>0.25</td>
</tr>
<tr>
<td>Total acidity</td>
<td>0.01</td>
</tr>
<tr>
<td>Effective CEC (cmol kg^-1)</td>
<td>18.5</td>
</tr>
<tr>
<td>% Sand</td>
<td>74.1</td>
</tr>
<tr>
<td>% Silt</td>
<td>13.1</td>
</tr>
<tr>
<td>% Clay</td>
<td>12.8</td>
</tr>
</tbody>
</table>

Table 2. Rainfall distribution (mm) in the Nigerian site where productivity of plantain intercropped with cassava was studied from 1991 to 1993.

<table>
<thead>
<tr>
<th>Month</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0.0</td>
</tr>
<tr>
<td>February</td>
<td>3.5</td>
</tr>
<tr>
<td>March</td>
<td>4.1</td>
</tr>
<tr>
<td>April</td>
<td>20.5</td>
</tr>
<tr>
<td>May</td>
<td>20.0</td>
</tr>
<tr>
<td>June</td>
<td>125.6</td>
</tr>
<tr>
<td>July</td>
<td>200.7</td>
</tr>
<tr>
<td>August</td>
<td>243.3</td>
</tr>
<tr>
<td>September</td>
<td>243.5</td>
</tr>
<tr>
<td>October</td>
<td>274.8</td>
</tr>
<tr>
<td>November</td>
<td>264.8</td>
</tr>
<tr>
<td>December</td>
<td>314.4</td>
</tr>
<tr>
<td>Total</td>
<td>1 546.0</td>
</tr>
</tbody>
</table>

3. Results

3.1. Vegetative growth of plantain and cassava

Intercropping plantain with different populations of cassava significantly increased plantain pseudostem height. The height increased with increase population density. Plantain in mixture with 10 000 plants ha^-1 of cassava gave the highest height. Contrariwise, plantain pseudostem girth significantly decreased with increase in cassava population while plantain number of functional leaves was not significantly influenced by intercropping in the two seasons (Table 1). Generally, the significant differences were more obvious in 1991 than in 1992, where no significant difference was observed at 9 months after planting.

When compared to sole plantain, increasing cassava population density to 10 000 plants ha^-1 significantly delayed plantain days to shooting by 85 and 92 d in 1991 and 1992, respectively. The pseudostem height increased by 22 % while the girth decreased by 20 % at shooting in both years (Table 1). Increasing cassava population to 10 000 plants ha^-1 significantly decreased number of suckers/stool in both years. Cassava stem height increased with increase in population. The stem height at 10 000 plants ha^-1 in both sole and intercrop gave the highest stem height, these were significantly higher than 5 000 plants ha^-1 in 1991 and than 5 000 and 7 000 plants ha^-1 in 1992 (Table 2). The least height was obtained at 5 000 plants ha^-1 in both years. The stem girth and number of stem branches per plant decreased with increase in cassava population density, while shoot weight per plant at 5 000 plants ha^-1 was the highest in intercropping system with plantain. However, there was no significant difference in plant height and girth between sole and intercropped cassava at 10 000 plants ha^-1.

3.2. Yield and yield components of plantain and cassava

Increasing population density of cassava significantly reduced plantain yield and...
Table III. Effects of different densities of cassava on the pseudostem height, girth, and functional leaves of plantain (1,666 plants ha⁻¹) in a plantain/cassava intercropping system (Nigeria).

<table>
<thead>
<tr>
<th>Intercropping system</th>
<th>Cassava density (plants ha⁻¹)</th>
<th>Pseudostem height (cm)</th>
<th>Pseudostem girth (cm)</th>
<th>Number of functional leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 map</td>
<td>12 map</td>
<td>6 map</td>
<td>12 map</td>
</tr>
<tr>
<td></td>
<td>5,000</td>
<td>7,000</td>
<td>5,000</td>
<td>7,000</td>
</tr>
<tr>
<td>Plantain sole</td>
<td>25.58</td>
<td>16.67</td>
<td>25.54</td>
<td>16.67</td>
</tr>
<tr>
<td>Plantain + cassava</td>
<td>166.17</td>
<td>185.67</td>
<td>166.17</td>
<td>185.67</td>
</tr>
<tr>
<td></td>
<td>179.60</td>
<td>220.60</td>
<td>179.60</td>
<td>220.60</td>
</tr>
<tr>
<td></td>
<td>222.67</td>
<td>277.67</td>
<td>222.67</td>
<td>277.67</td>
</tr>
<tr>
<td>Significance</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

Table IV. Growth response of plantain (1,666 plants ha⁻¹) at shooting to intercropping with three cassava densities (Nigeria).

<table>
<thead>
<tr>
<th>Cassava density (plants ha⁻¹)</th>
<th>Pseudostem height (cm)</th>
<th>Pseudostem girth (cm)</th>
<th>Time to shooting (weeks)</th>
<th>Number of suckers/plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>70.87</td>
<td>211.50</td>
<td>84.79</td>
<td>54.75</td>
</tr>
<tr>
<td>5,000</td>
<td>220.50</td>
<td>200.65</td>
<td>56.52</td>
<td>50.80</td>
</tr>
<tr>
<td>10,000</td>
<td>225.60</td>
<td>235.60</td>
<td>56.24</td>
<td>56.50</td>
</tr>
</tbody>
</table>

3.3. Productivity of the mixture

Land Equivalent Ratio (LER) of all plantain/cassava intercrop was greater than 1, and decreased with increase in cassava population density. Yields of 22.76 and 21.54 t ha⁻¹ were obtained in 1991 and 1992, respectively.

Table V. Effect of three cassava densities on the growth parameters of cassava in plantain/cassava intercropping system (Nigeria).

<table>
<thead>
<tr>
<th>Intercropping system</th>
<th>Cassava density (plants ha⁻¹)</th>
<th>Stem height (cm)</th>
<th>Stem girth (cm)</th>
<th>Number of branches per plant</th>
<th>Number of tubers per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 map</td>
<td>12 map</td>
<td>6 map</td>
<td>12 map</td>
<td>6 map</td>
</tr>
<tr>
<td>Plantain + cassava</td>
<td>5,000</td>
<td>7,000</td>
<td>5,000</td>
<td>7,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Plantain sole</td>
<td>5,000</td>
<td>12,000</td>
<td>5,000</td>
<td>12,000</td>
<td>5,000</td>
</tr>
</tbody>
</table>

Table VI. Yield parameters of plantain and cassava as affected by three densities of cassava in a plantain/cassava intercropping system (Nigeria).

<table>
<thead>
<tr>
<th>Intercropping system</th>
<th>Plant density (plants ha⁻¹)</th>
<th>Plant height (cm)</th>
<th>Plant girth (cm)</th>
<th>Bunch weight (kg)</th>
<th>Number of tubers</th>
<th>Tubers weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 map</td>
<td>12 map</td>
<td>6 map</td>
<td>12 map</td>
<td>6 map</td>
<td>12 map</td>
</tr>
<tr>
<td>Plantain sole</td>
<td>5,000</td>
<td>7,000</td>
<td>5,000</td>
<td>7,000</td>
<td>5,000</td>
<td>7,000</td>
</tr>
<tr>
<td>Plantain + cassava</td>
<td>5,000</td>
<td>7,000</td>
<td>5,000</td>
<td>7,000</td>
<td>5,000</td>
<td>7,000</td>
</tr>
</tbody>
</table>

* a, b, c means followed by a different letter in a column within a year are significantly different by the Duncan's multiple range test at 5% level.*

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Table VII. Yield, relative yield and gross return of plantain and cassava as affected by three densities of cassava in a plantain/cassava intercropping system (Nigeria).

<table>
<thead>
<tr>
<th>Intercropping system</th>
<th>Plantain density (plants ha⁻¹)</th>
<th>Relative yield (LER)</th>
<th>Plantain</th>
<th>Cassava</th>
<th>Plantain</th>
<th>Cassava</th>
<th>Plantain</th>
<th>Cassava</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Plantain</td>
<td>Cassava</td>
<td>Plantain</td>
<td>Cassava</td>
<td>Plantain</td>
<td>Cassava</td>
</tr>
<tr>
<td>Plantain sole</td>
<td>10000</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.05</td>
<td>1.05</td>
<td>1.05</td>
</tr>
<tr>
<td>Cassava sole</td>
<td>10000</td>
<td>0.88</td>
<td>0.88</td>
<td>0.85</td>
<td>0.85</td>
<td>0.80</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>Plantain + Cassava</td>
<td>10000</td>
<td>0.92</td>
<td>0.92</td>
<td>0.95</td>
<td>0.95</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
</tr>
</tbody>
</table>

4. Discussion

The growth of plantain was severely affected by the associated cassava in the intercropping system. Pseudostem height of plantain increased as cassava population density increased in the system without a corresponding increase in growth of the pseudostem. This may be due to competition for available nutrient and moisture. This was similar to the findings of Joseph [8] and Ndiobu [7]. The delay to flowering of plantain with increase in cassava population density might have resulted from the effects of competition between cassava and plantain on the photosynthetic development of plantain.

According to Fukai and Trenbath [10], competition can greatly influence the physiological development of crops especially in additive intercropping to the extent of delaying flowering. This consequently resulted in a reduction in plantain number of bands, fingers and total bunch yield. Higher tuber length and tuber weight per plant of cassava in lower population density (5 000 plants ha⁻¹) was not enough to increase the total tuber yield more than the 10 000 plants ha⁻¹ because the total plant contributed to the total yield in the higher population density. The lower precipitation of 1992 and the resultant low soil moisture availability had caused soil moisture stress with a probable higher adverse effect on plantain than on cassava. This may be the reason for the lower yield obtained in the second season (1992).

Though increasing cassava population increased the Land Equivalent Ratio (LER) and the total revenue in the intercropping system, plantain yield was significantly depressed. This resulted in cassava contributing more to the LER as its population density increased. This is similar to the observation of Ofot and Stern [9] who reported high total LER when dominated crop species produced a high partial Relative Yield (LER) that is close to 1.0. In this study, plantain which is the dominant crop, increased by a partial LER lower than 1.0 as cassava population increased in the intercropping system. The LER and the total revenue of this system were highest at plantain with cassava as 5 000 plants ha⁻¹. This combined also gave highest Relative Yield compared to other treatments. It could be concluded from this study that intercropping plantain with up to 10 000 plants ha⁻¹ may be detrimental to plantain. Therefore, if plantain is the main crop and must be intercropped with cassava, farmers should not intercrop plantain with cassava at a population greater than 5 000 plants ha⁻¹.

References


Efectos de la densidad de plantación de mandioca en la productividad de plátano y mandioca dentro de un sistema de asociación plátano-mandioca.

Resumen — Introducción. Se realizó un experimento en la UEPE, estado de Osnub en Nigria, para determinar la densidad de plantación de mandioca que proporcione el mejor rendimiento en un cultivo asociado plátano/mandioca. Material y métodos. El plátano con una densidad de 1 666 plantas ha⁻¹ se asocia a un cultivo de mandioca con tres densidades experimentales de plantación (5 000, 7 000 y 10 000 plantas ha⁻¹). De forma paralela, se plantaron ambas producciones en monocultivos (1 666 plantas ha⁻¹ para el plátano, 10 000 plantas ha⁻¹ para la mandioca). Se realizó el ensayo mediante bloques de aleatorización total con cuatro repeticiones. Resultados. Con las densidades de mandioca más altas, aumentó en 89 el tiempo de brote de los híbridos de plátanos, mientras que el número de deditos y manos por racimo disminuyeron significativamente en los cultivos asociados. También disminuyó significativamente el peso del racimo a medida que aumentaba la densidad de plantas de mandioca en la asociación. El rendimiento de los racimos se redujo un 94 % en el plátano asociado a la mandioca con 7 000 plantas ha⁻¹ y un 54 % con mandioca a 10 000 plantas ha⁻¹. Por otra parte, el rendimiento de la mandioca en tubérculos aumentó con la densidad de plantas. El rendimiento relativo global para los dos cultivos fue superior a 1 en todos los casos de asociación. Con el actual precio de 10 naira kg⁻¹ de plátano y de 0,90 naira kg⁻¹ de mandioca, es la asociación plátano / mandioca a 5 000 plantas ha⁻¹ la que proporciona el mejor beneficio con respecto a las otras densidades probadas en la asociación plátano-mandioca. Discusión. Si el plátano explotado como cultivo principal debe asociarse a la mandioca, se recomienda que no se planten la mandioca con una densidad superior a 5 000 plantas ha⁻¹. © Ediciones científicas y médicas Elsevier SA

Musa (plantain) / Manihot esculenta / sistemas de cultivo / cultivos asociados / espaciamiento / rendimiento / Nigeria

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