Short communication

# Water hyacinth-based vermicompost on yield, yield components, and yield advantage of cassava+groundnut intercropping system

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**Abstract**

A field trial was conducted to assess the potential of water haycinth [*Eichhornia crassipes* (Mart) Solms-Laubach] + animal manure (cow dung/poultry manure) compost for improving the productivity of cassava (*Manihot esculenta* Crantz) + groundnut (*Arachis hypogaea* L.) intercropping system. The treatments consisted of four nutrient sources (control, 200 kg NPKMg of 12:12:17:2 mixture ha$^{-1}$, 40 Mg ha$^{-1}$ of water hyacinth+poultry manure vermicompost, and 40 Mg ha$^{-1}$ water hyacinth+cow dung vermicompost), three cropping densities (50 000, 100 000, and 200 000 plants ha$^{-1}$), and three cropping patterns (sole cassava, sole groundnut, and cassava+groundnut intercropping) in factorial randomized complete block design with three replicates. Sole groundnut yield decreased significantly ($p<0.05$) when intercropped with cassava. However, water hyacinth-based vermicompost increased cassava fresh tuber yield over mineral fertilizer. Average land equivalent ratio (LER) and area time equivalent ratio (ATER) indicated 39% to 81% land utilization efficiency. Aggressivity index showed that cassava is the dominant crop in the cassava-groundnut intercropping system.

**Keywords:** Aggressivity, *Eichhornia crassipes*, Vermicompost, Land equivalent ratio

Water hyacinth, *Eichhornia crassipes* (Mart) Solms-Laubach, a floating aquatic weed, is a major environmental hazard in the Nigerian waterways. While its physical removal has been unsuccessful and operational costs are exorbitant, utilization of this weed as organic manure opens up new vistas for control. Application of water hyacinth manure has been reported to improve the growth and yield of several crops (Majid, 1983). However, investigations on the potential of water hyacinth for improving soil nutrient status and yield of intercropping systems are scarce. Therefore a study was conducted to assess the effect of water hyacinth + animal manure vermicompost on the yield and competition indices of cassava (*Manihot esculenta* Crantz) + groundnut (*Arachis hypogaea* L.) intercropping systems.

The field trial was conducted at the Teaching and Research Farm, Abraka (latitude 5°46' and longitude 6°5') on a well drained leached tropical soil in the humid rainforest zone of Southern Nigeria in the July 2008 to June 2009 cropping season with the following treatments: four nutrient levels – no mineral fertilizer and vermicompost (control), 200 kg NPKMg 12:12:17:2 mixture ha$^{-1}$, 40 Mg ha$^{-1}$ of water hyacinth + poultry manure vermicompost (VP), and 40 Mg ha$^{-1}$ of water hyacinth + cow dung vermicompost (VC); three cropping densities (50 000, 100 000, and 200 000 plants ha$^{-1}$); and three cropping patterns (sole groundnut, sole cassava, and cassava-groundnut intercrop), arranged in a factorial experiment with a randomized complete design having three replicates. Vermicomposts were prepared using a mixture of water hyacinth and cow dung or poultry manure in the ratio 75:25 (dry weight basis). Earthworms (*Lumbricus terrestris*

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L) were introduced two weeks later. The vermicomposts were allowed to decompose for a period of 45 days. Improved cassava (var. TMS 30572) and groundnut (var. Spanish 205, early maturing 100 to110 days) were planted in 6 x 4.5 m plots. Cassava and groundnut were intercropped in the ratio of 1:2 in all densities. Both crops were planted on the same date. While cassava was harvested 12 months after planting, groundnut was harvested 110 days after planting. Cassava and groundnut yield components were determined from the inner 6.8 $m^2$ and cassava storage root yield and groundnut seed yield were obtained from the gross plot of 27 $m^2$. The intra- and interspecific competition in the cassava+groundnut intercropping system were assessed using land equivalent ratio, LER, area time equivalent ratio, ATER and Aggressivity index, A (Willey, 1985). LER, an assessment of the biological efficiency of the intercropping situation was calculated as: $LER = (Yij/Yii + Yji/Yjj)$, where $Y$= yield per unit area, $Yii$= sole crop yield of crop $i$ (cassava), $Yjj$= sole crop yield of crop $j$ (groundnut), $Yij$ and $Yji$= yield per unit area of $i$ intercropped with $j$ and $j$ intercropped with $i$. Values of LER greater than 1 indicates that there is advantage for intercropping compared to sole cropping. To accommodate the temporal domains of the intercrops, i.e., the time period taken for a crop to occupy the land from planting to harvest, the area time equivalent ratio, ATER was calculated as: $ATER = (LiTi + LjTj)/T$, where $Li$ = relative yield of crop $i$ (cassava), $Lj$ = relative yield of crop $j$ (groundnut), $Ti$=duration (days) for crop $i$, $Tj$ = duration (days) for crop $j$, $T$ = duration (days) of the whole intercropping system. Aggressivity index, A was expressed as: $Aji = (Yij/Yii \times Zij) - (Yji/Yjj \times Zji)$ – where $Zij$ and $Zji$ = proportion of intercrop area initially allocated to crop $i$ and $j$. If A = 0, the component species are equally competitive, however, for situations were $A \neq 0$, both species will have the same numerical values, only that the value of the dominated species will be negative. Data were subjected to analysis of variance (ANOVA) for factorial and randomized complete block designs. Comparison of means was made by the Duncan multiple range test, DMRT ($p< 0.05$).

Results indicate that seed yield of groundnut was significantly ($p<0.05$) increased by water hyacinth + animal manure vermicomposts (Table 1). Likewise, significant ($p<0.05$) increases in yield and yield components of cassava were observed following vermicompost application. Enrichment of soil nitrogen and phosphorus by addition of vermi-composts might be a plausible explanation. Water hyacinth+poultry manure vermicompost was more effective in promoting groundnut yield, while cassava root yield was promoted more by water hyacinth+cow dung vermicompost. Increasing plant population density from 50 000 to 200 000 plants $ha^{-1}$ in both sole and intercrops increased seed yield significantly. However, seed yield of groundnut was significantly ($p<0.05$) reduced when intercropped with cassava, regardless of whether mineral fertilizer and organic manures were applied. The progressive fall in groundnut yield under increasing cassava density may be due to shading by the taller cassava and interspecies competition. Increasing plant population density from 50 000 to 100 000 plants $ha^{-1}$ increased the fresh weight of tuber and fresh root tuber yield. However, a further increase to 200 000 plants $ha^{-1}$ decreased the same. Intercropping cassava with groundnut had no profound adverse effects on the former. Cassava being a long duration crop with an initial slow growth rate allows it to recover from the earlier competitive effects, if any, when intercropped with groundnut. Amanullah et al. (2006) also observed no significant effect in yield of cassava when intercropped with cowpea.

Yield advantage of intercropping was observed for all nutrient sources and plant population densities (Table 2). Average LER and ATER indicated that 39 to 81% more land would have been planted under sole crops to produce the same quantities of cassava and groundnut as obtained under intercropping. This advantage of intercropping over sole cropping

*Table 1.* Effect of nutrient sources, density, and cropping system on yield and yield components of groundnut and cassava in the humid rainforest zone of Southern Nigeria.

| Treatments | Groundnut | | | Cassava | | |
|---|---|---|---|---|---|---|
| | Number of pods plant$^{-1}$ | Number of seeds pod$^{-1}$ | Seed yield (Mg ha$^{-1}$) | Number of tubers plant$^{-1}$ | Fresh weight tuber$^{-1}$ (kg) | Fresh root tuber yield (Mg ha$^{-1}$) |
| Nutrient sources (N) | | | | | | |
| Control | 14.02a | 1.66a | 0.98b | 6.5b | 140.5c | 10.9c |
| 200 kg ha$^{-1}$ NPKMg | 14.55a | 1.72a | 1.13b | 7.9b | 158.7b | 15.6b |
| 40 Mg ha$^{-1}$ VP | 16.67a | 1.76a | 1.46a | 10.0a | 189.8a | 19.4ab |
| 40 Mg ha$^{-1}$ VC | 15.78a | 1.75a | 1.45a | 10.8a | 195.3a | 20.3a |
| Density (D, plants ha$^{-1}$) | | | | | | |
| 50 000 | 16.41a | 1.71a | 1.02c | 8.8a | 173.0ab | 13.9b |
| 100 000 | 15.39a | 1.75a | 1.25b | 9.6a | 179.2a | 19.8a |
| 200 000 | 13.97a | 1.70a | 1.49a | 8.1a | 161.0b | 16.1ab |
| Cropping System (S) | | | | | | |
| Sole | 16.22a | 1.74a | 1.33a | 8.3a | 167.9b | 16.4a |
| Intercropped | 14.29a | 1.69a | 1.17b | 9.3a | 174.2a | 16.8a |
| Interactions | | | | | | |
| N x D | 2.91ns | 0.07ns | 1.75ns | 3.16* | 1.02ns | 4.26** |
| N x S | 6.18** | 4.65** | 16.63** | 8.98** | 21.40** | 21.62** |
| D x S | 9.82** | 2.33ns | 16.25** | 72.65** | 72.70** | 2187.70** |

VC: water hyacinth+cow dung vermicompost; VP: water hyacinth+poultry manure vermicompost; ns- not significant; * significant at 5%, ** significant at 1%

In each column means followed by the same letter (s) do not differ significantly at 5% level.

*Table 2.* Assessment of yield advantage through competitive indices in the humid rainforest zone of Southern Nigeria.

| Nutrient sources and population density (plants ha$^{-1}$) | LER | ATER | (ATER + LER)/2 | Aggressivity index (A) | |
|---|---|---|---|---|---|
| | | | | groundnut | cassava |
| 0 kg ha$^{-1}$ (control) | | | | | |
| 50 000 | 1.83 | 1.23 | 1.53 | –0.54 | 0.54 |
| 10 0000 | 1.81 | 1.22 | 1.52 | –0.54 | 0.54 |
| 200 000 | 1.77 | 1.18 | 1.48 | –0.48 | 0.48 |
| 200 kg ha$^{-1}$ NPKMg | | | | | |
| 50 000 | 1.88 | 1.26 | 1.57 | –0.55 | 0.55 |
| 100 000 | 1.92 | 1.26 | 1.59 | –0.50 | 0.50 |
| 200 000 | 1.84 | 1.24 | 1.54 | –0.50 | 0.50 |
| 40 Mg ha$^{-1}$ VP | | | | | |
| 50 000 | 1.98 | 1.36 | 1.67 | –0.64 | 0.64 |
| 100 000 | 1.95 | 1.34 | 1.66 | –0.63 | 0.63 |
| 200 000 | 1.89 | 1.24 | 1.59 | –0.60 | 0.60 |
| 40 Mg ha$^{-1}$ VC | | | | | |
| 50 000 | 2.14 | 1.47 | 1.81 | –0.70 | 0.70 |
| 100 000 | 1.94 | 1.31 | 1.63 | –0.59 | 0.59 |
| 200 000 | 1.87 | 1.28 | 1.58 | –0.60 | 0.60 |

LER: land equivalent ratio; ATER: area harvest equivalent ratio; MAI: monetary advantage index; VP: water hyacinth+poultry manure vermicompost; VC: water hyacinth+cow dung vermicompost.

may be attributed to the differences in spatial distribution of root mass of different crops, which allows the system to explore a greater soil volume (Ghosh et al., 2006). LER and ATER increased consistently with application of vermicompost but decreased with increasing plant population density. Lower intercropping ratio at high population density is indicative of yield decline as a result of population pressure. As population pressure increased further, yield declined steeply, even when other major factors of production were not limiting.

Aggressivity indices show that cassava is the dominant crop in the cassava + groundnut intercropping system as a result of its better ability to capture light and soil resources or a combination of both. This is consistent with the Crimes Theory of Competitive Success in which the species with greater capacity for resource capture will be the superior competitor (Grace, 1990). The results from this study further indicates that water hyacinth + cow dung or poultry manure vermicompost improved crop yield of cassava and groundnut under sole and intercropping situations; VC, in particular, resulted in higher productivity in cassava + groundnut intercropping. This indicates the potential of this underutilized biomass as biofertilizer for soil fertility restoration and consequent enhanced crop productivity. As regards to plant population density, under sole cropping, yield was optimum at the medium density of 100 000 plants $ha^{-1}$, however with intercropping; low density of 50 000 plants $ha^{-1}$ gave optimal yields.

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