WEED SPECIES DIVERSITY IN CASSAVA (*Manihot esculenta* Crantz) MONOCULTURE IN ASHANTI REGION OF GHANA

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**ABSTRACT**

This study was aimed to assess weed species diversity and composition in cassava monoculture at Crop and Soil Sciences Department research field, Kwame Nkrumah University of Science and Technology, Kumasi. The experimental design was a randomised complete block design and replicated four times. The treatment factors were six weeding methods (Butachlor (4L/ha) + 2 hoe-weedicings, Terbulor (4L/ha) + 2 hoe-weedicings, three hoe weedicings, three cutlass weedicings, weed-free and weedy check) and two cassava varieties (Ampong and Dokuduae). Twenty-five weed species belonging to twelve different families were recorded and overall weed flora was composed of 80% broad-leaved weeds, 12% kinds of grass and 8% sedges. The results revealed that *Cyperus rotundus*, *Spigelia anthelma* and *Panicum maximum* were the three dominant and major weed species. *Panicum maximum* recorded the highest relative frequency while *Spigelia anthelma* and *Cyperus rotundus* showed higher values of relative density, relative abundance and important value index under both varieties.

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1 Introduction

Ghana has been ranked the third largest producer of cassava in Africa, producing an estimated 10 million tonnes (FAO, 2009) and accounts for a daily calorie intake of 30% (FAO, 2006). Dangwal et al. (2010), defined weeds as plants that grow among agricultural crops which reduce yield by competing for nutrients, sunlight and space. The knowledge of weed species diversity is fundamental to understanding the dynamics of weeds versus crops (Albuquerque et al., 2012), therefore weeds show variation in levels of occurrence and diversity at different seasons and locations. However, according to Roschewitz et al. (2005), spatial heterogeneity of weed species within a field may contribute to the higher degree of weed diversity in intensively managed fields.

Farmers in Kumasi identify weeds as emerging problems in sustainable cassava production; hence inadequate management of weeds stands out among the factors responsible for the low productivity of cassava. According to FAO (2009), food production losses due to weeds are approximated USD 95 billion/year of which more than 70% is lost in poor countries. The initial slow growth rate of cassava exerts little coverage of the soil, thus enables weeds to grow profusely due to the availability of moisture and nutrient in abundance (Silva et al., 2007). Hakim et al. (2010) reported that cultural practices, cropping systems, type of crop, location and season caused a difference in weed vegetation and distribution. In Kumasi, farmers faced a wide range of weeds and very few scientists have attempted to study the variation in weed species composition, abundance, importance and ranking. It is therefore, significant to identify weed species associated with Ampong and Dokudua cassava varieties in monoculture cropping pattern, in order to facilitate the formulation of an appropriate weed management strategy and enhance yield stability. Thus, this study was undertaken to assess weed species diversity, composition, distribution and severity prevailing in cassava monoculture.

2 Materials and methods

The study was conducted in the Crop and Soil Sciences Department research field (latitude 6° 43 North and longitude 1° 36 West), Kwame Nkrumah University of Science and Technology Kumasi, located in the Ashanti region of southern Ghana. The rainfall pattern in the study area was bimodal. The major period ranged from May to mid-August and minor period ranged from September to mid-November. The average monthly temperatures during the experimental period ranged from 28°C - 34°C, rainfall recorded 2.4 - 183 mm, and relative humidity 47–689%. Soil samples were collected from 0-15cm and 15-30cm depth randomly prior to land preparation and 200g of each sampled depth were put into labeled polythene bags, air-dried and subjected to analysis.

The experimental area was ploughed using a tractor-mounted plough, followed by disc harrowing. The plot size was 24m² (4m x 6m). The plots and replicates were separated 0.5m and 1m apart respectively. The total number of plots was 48 given a total land area of 1445m². Planting was done using 20 cm stem cuttings obtained from Council for Scientific and Industrial Research (CSIR), Fumesua-Kumasi, at 1m space apart giving 10,000 plants/ha.

2.1 Experimental design and treatment

The experimental design was a randomised complete block design and replicated four times. The treatment factors were six weeding methods (butachlor supplemented with 2 hoe weeding, terbulator supplemented with 2 hoe weeding, 3 manual weeding with a hoe, 3 manual weeding with a cutlass, manual hoe weeding every 2 weeks and no weeding) and two cassava varieties (Ampong and Dokudua).

2.2 Data collection

Weed species were assessed according to the quantitative survey method using 0.5m x 0.5m iron square quadrat, thrown randomly in three different locations within each plot, cut at ground level and counted. Weed species were identified according to families, mode of reproduction, growth habit and vegetative cycle by using Akobundu & Agyakwa (1987) handbook of West African weeds.

The harvested weeds were brought to the weed science unit of the Council for Scientific and Industrial Research (CSIR), Kumasi, where they were oven dried at 65°C, until they reached to constant weight. The weed status relative frequency, relative density, relative abundance and importance value index were determined using the theory of Das (2011) and Albuquerque et al. (2013).

2.3 Analysis of data

Analysis of Variance was performed using Proc GLM statement in Statistical Analysis System (SAS) 9.3 version. The Student Newman-Keuls (SNK) test was used to compare treatment means at 0.05 level of probability. Before analysis, raw data for weed density values were transformed by adding a value of one to all scores to eliminate zero data point and converted to log base 10 (Log10). A descriptive analysis was conducted on relative frequency, relative density, relative abundance and importance value index parameters for the collected species.

3 Results and discussion

3.1 Weed Species Taxonomy

The experimental field consisted of 25 weed species belonging to 12 different families, comprising of 52% annuals, 24 % perennials and annual/perennial respectively (Table 1). A similar result was reported by Albuquerque et al. (2008) in assessing weed interference on cassava productivity. Among
variously reported families, Asteraceae was found to be the most dominant family in the weed flora of the cassava crop with a percentage of (25%), this was followed by Euphorbiaceae (17%), Poaceae (13%), Commelinaceae (9%), Cyperaceae (8%), Fabaceae (8%), Portulacaceae, Loganiaceae, Malvaceae, Molluginaceae, Convolvulaceae, and Rubiaceae (4%) respectively (Table 1). These results are similar to the previous work of Singh et al. (2007) and Hussain et al. (2009) who have been reported varying weed flora of cassava crops. A total of 80% of these weed species were reproduced by seeds, 16% by seeds/cuttings and 4% by seeds/roots. Most of the weeds in this study were found in annual nature and they couldn’t survive in unfavourable conditions and complete their life cycle in one season (Singh et al., 2008). It was observed that grasses existed only to the extent of 12%, broadleaved 80% and sedges 8% among the weed flora (Table 1).

3.2 Quantitative Measures of Weed Species in Dokuduade and Ampong cassava varieties

Panicum maximum was the most common and predominant species with the higher relative frequency of 10.57% and it was followed by M. verticillata 10.13% under Dokuduade variety (Table 2). While analysis of the data showed that P. maximum, S. anthelma and C. rotundus had a highest relative frequency (10.00%) respectively under Ampong variety and it was followed by M. verticillata and C. hirtus 9.17% (Table 2). The consistent frequency of P. maximum, S. anthelma and C. rotundus indicates their ability to adapt to a wide range of climatic conditions and available resources thus higher infestations on the crops. This result agrees with the report of Embrapa (2006) that Asteraceae, Poaceae and Euphorbiaceae were the most frequent weeds in cassava crops. T. triangulare, S. acuta, R. cochinichinensis and B. atifolia had the lowest relative frequency (0.44%) under Dokuduade variety, while T. triangulare, S. acuta, I. involucrata and C. iria recorded lower relative frequency (0.42%) in Ampong variety. For both varieties, S. anthelma, P. amarus, P. maximum, M. verticillata, M. pudica, E. heterophylla, C. hirtus and C. erecta species occurred at a relative frequency ≥ 5%.

Table 1 Diversity of weed species associated with cassava production in Kumasi

| Species                  | Family     | Mode of reproduction | Growth habit | Vegetative Cycle |
|--------------------------|------------|----------------------|--------------|------------------|
| Acanthospernum hispidum  | Asteraceae | Seeds                | Broadleaf    | Annual           |
| Ageratum conyzoides      | Asteraceae | Seeds/cuttings       | Broadleaf    | Annual           |
| Bidens pilosa            | Asteraceae | Seeds                | Broadleaf    | Annual           |
| Chromolaena odorata      | Asteraceae | Seeds/roots          | Broadleaf    | Perennial        |
| Syndrella nodiflora      | Asteraceae | Seeds                | Broadleaf    | Annual           |
| Tridax procumbens        | Asteraceae | Seeds                | Broadleaf    | Annual           |
| Croton hirtus            | Euphorbiaceae | Seeds              | Broadleaf    | Annual           |
| Euphorbia heterophylla   | Euphorbiaceae | Seeds            | Broadleaf    | Annual           |
| Euphorbia hirta          | Euphorbiaceae | Seeds             | Broadleaf    | Annual           |
| Phyllanthus amarus       | Euphorbiaceae | Seeds             | Broadleaf    | Annual           |
| Commelina benghalensis   | Commelinaceae | Seeds           | Broadleaf    | Annual/Perennial |
| Commelina erecta         | Commelinaceae | Seeds           | Broadleaf    | Annual/Perennial |
| Centrosema pubescens     | Fabaceae   | Seeds                | Broadleaf    | Perennial        |
| Mimosa pudica            | Fabaceae   | Seeds/cuttings       | Broadleaf    | Annual/Perennial |
| Borleria latifolia       | Rubiaceae  | Seeds                | Broadleaf    | Annual/Perennial |
| Ipomoea involucrata      | Convolvulaceae | Seeds/cuttings  | Broadleaf    | Annual/Perennial |
| Mollugo verticillata     | Molluginaceae | Seeds           | Broadleaf    | Annual           |
| Sida acuta               | Malvaceae  | Seeds                | Broadleaf    | Perennial        |
| Spigelia anthelma        | Loganiaceae | Seeds                | Broadleaf    | Annual           |
| Cyperus rotundus         | Cyperaceae | Seeds                | Sedge        | Perennial        |
| Cyperus iria             | Cyperaceae | Seeds                | Sedge        | Perennial        |
| Panicum maximum          | Poaceae    | Seeds                | Grass        | Perennial        |
| Digitaria ciliaris       | Poaceae    | Seeds                | Grass        | Annual           |
| Rottboellia cochinichinensis | Poaceae | Seeds                | Grass        | Annual           |
| Talinum triangulare      | Portulacaceae | Seeds/cuttings  | Broadleaf    | Annual/Perennial |
Table 2 Relative frequency, density, abundance and importance value index parameters of weed species in Dokuduade and Ampong cassava varieties.

| Species                        | Relative frequency (%) | Relative density (%) | Relative abundance (%) | Importance Value Index (%) | Relative frequency (%) | Relative density (%) | Relative abundance (%) | Importance Value Index (%) |
|--------------------------------|------------------------|----------------------|------------------------|---------------------------|------------------------|----------------------|------------------------|---------------------------|
| Acanthospernum hispidium       | 2.20                   | 0.28                 | 0.91                   | 3.39                      | 2.08                   | 0.79                 | 2.39                   | 5.26                      |
| Ageratum conyzoides            | 0.88                   | 0.17                 | 1.37                   | 2.42                      | 0.83                   | 0.21                 | 1.63                   | 2.68                      |
| Bidens pilosa                  | 0.88                   | 0.23                 | 1.82                   | 2.93                      | 1.67                   | 1.00                 | 3.81                   | 6.48                      |
| Boriria atifolia               | 0.44                   | 0.11                 | 1.82                   | 2.37                      | 2.50                   | 1.15                 | 2.90                   | 6.55                      |
| Brachiaria deflexa             | 1.76                   | 0.51                 | 2.05                   | 4.32                      | 2.08                   | 0.36                 | 1.09                   | 3.53                      |
| Centrocema pubecens            | 2.64                   | 0.73                 | 1.97                   | 5.35                      | 2.08                   | 0.36                 | 1.09                   | 3.53                      |
| Chromolaena odorata            | -                      | -                    | -                      | -                         | 0.83                   | 0.21                 | 1.63                   | 2.68                      |
| Commelina benghalensis         | 2.20                   | 0.79                 | 2.55                   | 5.54                      | -                      | -                    | -                      | -                         |
| Commelina erecta               | 7.49                   | 1.01                 | 0.96                   | 9.47                      | 7.92                   | 1.36                 | 1.09                   | 10.36                     |
| Cyperus rotundus               | 9.69                   | 24.34                | 17.88                  | 51.91                     | 10.00                  | 22.98                | 14.55                  | 47.53                     |
| Cyperus iria                   | -                      | -                    | -                      | -                         | 0.42                   | 0.64                 | 9.79                   | 10.85                     |
| Croton hirtus                  | 9.25                   | 7.44                 | 5.72                   | 22.41                     | 9.17                   | 7.52                 | 5.19                   | 21.88                     |
| Digitaria ciliaris             | 3.08                   | 3.32                 | 7.67                   | 14.08                     | 2.92                   | 2.58                 | 5.60                   | 11.09                     |
| Euphorbia heterophylla         | 7.05                   | 4.56                 | 4.61                   | 16.22                     | 8.33                   | 6.30                 | 4.79                   | 19.42                     |
| Euphorbia hirta                | 2.20                   | 0.39                 | 1.27                   | 3.87                      | 2.92                   | 1.15                 | 2.49                   | 6.55                      |
| Ipomoea involucrata            | 1.76                   | 0.28                 | 1.14                   | 3.18                      | 0.42                   | 0.07                 | 1.09                   | 1.58                      |
| Mimosa pudica                  | 5.29                   | 1.75                 | 2.35                   | 9.38                      | 7.08                   | 3.29                 | 2.94                   | 13.32                     |
| Molugo verticillata            | 10.13                  | 8.11                 | 5.70                   | 23.94                     | 9.17                   | 8.09                 | 5.59                   | 22.84                     |
| Panicum maximum                | 10.57                  | 13.58                | 9.14                   | 33.29                     | 10.00                  | 14.46                | 9.16                   | 33.62                     |
| Phylanthus amarus              | 6.61                   | 2.25                 | 2.43                   | 11.29                     | 5.42                   | 1.79                 | 2.09                   | 9.30                      |
| Rottboellia cochinchinensis    | 0.44                   | 0.06                 | 0.91                   | 1.41                      | 0.83                   | 0.14                 | 1.09                   | 2.06                      |
| Sida acuta                     | 0.44                   | 0.06                 | 0.91                   | 1.41                      | 0.42                   | 0.07                 | 1.09                   | 1.58                      |
| Spigelia anthelma              | 9.69                   | 24.68                | 18.12                  | 52.49                     | 10.00                  | 22.19                | 14.06                  | 46.25                     |
| Talumum triangulare            | 0.44                   | 0.06                 | 0.91                   | 1.41                      | 0.42                   | 0.14                 | 1.09                   | 1.65                      |
| Tridax procumbens              | 4.85                   | 5.30                 | 7.78                   | 17.92                     | 4.58                   | 3.51                 | 4.85                   | 12.94                     |

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Table 3 Weed density and biomass in Ampong and Dokuduade cassava varieties.

| Treatments             | Weed density (m²) | Weed biomass (g) |
|------------------------|------------------|-----------------|
| Variety                |                  |                 |
| Ampong                 | 52.50b           | 12.05b          |
| Dokuduade              | 79.12r           | 21.32r          |
| Weed treatments        |                  |                 |
| Hoe weeding            | 32.74c           | 5.65c           |
| Cutlass weeding        | 102.24b          | 21.42b          |
| Weed-free              | 20.39c           | 3.68c           |
| Butachlor + 2 hoe- weeding | 47.87c      | 7.42c           |
| Terbulor + 2 hoe-weeding | 17.89c         | 3.11c           |
| Weedy                  | 173.76r          | 58.86r          |

The result is supported by Azmi & Baki (2002) that almost similar pattern of weed dominance ranking was observed in the order of importance. The lowest values recorded for relative density, relative abundance and important value index were observed in R. cochinchinensis and A. hispidum for Dokuduade variety. While I. involucrata, C. erecta, C. pubecens and B. deflexa had the lowest relative density, relative abundance and important value index in Ampong variety. C. odorata and C. iria were absent in Dokuduade variety while C. benghalensis was absent in Ampong.

3.3 Weed density and biomass

Dokuduade cassava variety had significantly higher weed density (79.12 m²) and biomass (21.32g) than Ampong variety which may be attributed to its late branching nature. The highest weed density (173.75m²) and biomass (58.85g) was recorded from the no weeded plots. This agrees with the result of Uddin et al. (2009) that the density of most weed species increased under weedy check compared to densities obtained from all other treatments. These results are also in accordance with the findings of Javaid et al. (2009), who reported higher weed density and coverage in weedy check treatment. Terbulor + 2 hoe weeding treatment had lowest weed density (17.88m²) and biomass (3.10g). Similar results was reported by Mahadi et al. (2007). Apart from weed-free and Butachlor + 2 hoe weeding, the weed density and biomass in the other treatments were not significantly different (Table 3).

Conclusions

From the result of this study, it can be concluded that relatively large numbers of broadleaved weed species were found across both cassava varieties than grasses and sedges in the study area. The most abundant and dominant weed species found in this study were C. rotundus, S. anthelma and P. maximum. The descriptive analysis showed that the lowest relative frequency, density, abundance and importance value index parameters were observed in I. involucrata, S. acuta, R. cochinchinensis, and T. triangulare species across a variety. Significant reduction in weed density and biomass was observed in Terbulor supplemented with 2 hoe weeding.

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Conflict of interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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