

ISSN: 2695-2556 (Online)

ISSN: 2651-5679 (Print)

AKSU Journal of Agriculture and Food Sciences 8(3) 114-127

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Efficacy of Herbicides and Cassava Varieties on Weed Flora, Density, Biomass and Yield of Cassava (*Manihot esculenta* crantz) in Akwa Ibom State, Southeastern Nigeria

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Abstract

*A field experiment was conducted at the Akwa Ibom State University Teaching and Research Farm, Obio Akpa, Oruk Anam, Akwa Ibom State in the 2021 and 2022 cropping seasons, to evaluate the efficacy of herbicides and cassava varieties on weed flora, density, biomass and yield of cassava (*Manihot esculenta* Crantz) in Akwa Ibom State. The experiment was fitted into a split-split plot arrangement and a randomized complete block design, replicated three times was used. The main treatments were three cassava cultivars-TMS 980505, TME 419 and TMS-981632, sub treatments were four types of herbicides-pendimethalin, butachlor, diuron, and primextra. The sub-sub treatments were five rates of herbicide application- 0, 1.0, 2.0, 3.0 and 4.0 kg a.i/ha. Data collected on weed flora, density, biomass, height at first branching and yield of cassava were subjected to analysis of variance. Results showed that weed density and biomass were significantly ($p < 0.05$) affected in both cropping seasons. Weed density, biomass and tuber yield decreased with increase in rate of application of herbicides. TMS 980505 had the highest yield of 32.89t/ha and 33.26t/ha in 2021 and 2022 respectively and the highest branching ability, as well as the ability to suppress weeds as reflected in the lowest weed density and biomass associated with this variety. Similar results were recorded among the herbicide types. Primextra gave the highest root yield, lowest weed density and biomass. In addition, Primextra was able to control both grasses and broad leaf weeds compared to other herbicides. Efficacy of the herbicides on weeds increased with increase in rates of application. Based on the findings, primextra at 2.0 kg a.i/ha and cassava variety TMS 980505 is recommended for increased cassava production in the study area.*

Key words: Cassava, Herbicides, Weed density, Biomass, Rate of application

1.0 Introduction

Weeds constitute a major constraint to cassava cultivation in Nigeria and are also the most common pest of crops in the world especially in the tropics (Akinsoye, 1999). Weed infestation in field crops has such a serious magnitude that it requires a systematic and planned weed control programme. Cassava production can be influenced by many factors such as: variety of cassava, disease, insect pests and weed infestation (Anderson, 1992) just to mention a few.

Cassava is susceptible to weed interference during the first 10 to 16 weeks after planting because of slow canopy development for ground cover and weed suppression. Weed remains a serious problem which farmers have to contend with in crop production (Ayeni, 1991) because it can substantially reduce yield. Storage root yield reductions caused by uncontrolled weed interference in cassava ranges between 40% and total loss (Bamidele *et al.*, 2004; Udensi *et al.*, 2012; Forcella, 1990; Nyam, 2005; Alabi *et al.*, 2001; Oerke *et al.*, 1994 and Akobundu, 1987) due to weed density and type of weeds in a particular location (Fadoyomi, 1991). Most African farmers still use manual labor for weed control such as hoeing. This method of weed control is expensive and requires proper timing which farmers often do not fulfill due to competing household labor demands. Root yield reduction from such delays may range from 20 to 50% (Ekeleme, 2013).

Weeds are among the major crop pests in the humid and sub-humid tropics where adequate rainfall, humidity and temperature favours their growth. These reduce yield by competing with crops for light, soil moisture and nutrients. Weed competition reduces canopy development, tuberization and tuber numbers. Melifonwu (1994) indicated that early branching, vigorous cassava cultivars cover the ground quicker than the late, non-branching improved and traditional varieties.

Swanton *et al.* (2015) reported that weeds that emerge with or before the crop are by far the most competitive and results in greatest yield loss. Since weeds cause serious economic losses in crop production, its control is currently the cornerstone of increased cassava production in the tropics. Therefore, it requires a systematic and planned weed control project throughout Nigeria (Ogundola and Liasu, 2006).

Among the major weeds associated with cassava production are grasses such as *Andropogon spp*, *Imperata cylindrica*, *Panicum maximum*, *Pennisetum spp*, *Cyperus rotundus*, *Axonopus compresus*, *Cynodon dactylon* and broad leaved weeds such as *Aspilia africana*, *Chromolaena odorata*, *Commelina benghalensis*, *Euphorbia heterophylla*, *Mimosa invisa*, *Smilax kraussina* (IITA, 1990, 2003). In addition, Sharma and Dairo (1991) reported *Euphorbia hirta* L. as prevalent weed species in South-western Nigeria.

Weeds are difficult to control because of low herbicide options (Dexter, 1994; Paolini, *et al.*, 1999). Since the mid twentieth century, herbicides have been the primary means of weed management in developed countries. Prior to herbicides, extensive tillage and manual weeding were the primary means of weed management (Nelson and Bullock 2003). Herbicides are important and essential components of weed management in world agriculture. They have responded to the food production needs of all food sufficient countries of the world and are playing major roles in the tropics as the region has moved to surplus food production. IITA (2003) also indicated that the effective weed control approach in cassava is using half of the recommended dose of herbicide, plus good seed bed preparation,

planting cultivars with branching canopy and planting of 10,000 to 15,000 plants/ha. Jane-Frances *et al.*, (2013) reported effective weed control, superior growth and highest storage root yield of cassava with primextra at 2.0kg.a/ha.

Barberi *et al.*, (1997), reported that crop production practices such as weed control influences weed communities in agricultural systems. The abundance or scarcity of certain weed species in a given crop is determined largely by the degree of competition offered by that crop. Elements of climate may have profound effects on structure and composition of weeds. Weed species diversity and density have increased over the last century despite the use of highly effective herbicides; this is because current crop pest management systems lead to the presence of highly adapted weed species that exploit a given set of cultural chemical and environmental conditions (Cousens and Mortimer, 1995; Ghersa and Roush; 1993 and Wyse, 1994).

Melinda *et al.* (1998) reported that herbicides and cultivation that regulate weed seed production had more influence on seed distribution in the 0-5cm layer of the soil and concluded that weed control practices can prevent increased number of weed seeds in the soil which can lead to high density. Lutman and Miller (2007) indicated that weed occurrence and density varies significantly within a farm or a field. Weeds surviving herbicide treatment have the same competitiveness and provide the same yield loss as untreated weeds (Swinton and King, 1994). Christensen (1994) showed that reduced herbicide doses applied in competitive crops often are non-lethal and reduce the weed competitiveness and weed dry matter production significantly. Jane-Frances *et al.* (2021a) showed that growth and yield attributes of cassava cultivars reduced as the rate of application of herbicides was increased. Christensen *et al.* (2003) showed that the optimization of the dosage to the local weed species composition and densities every year reduced herbicide usage 45-65% without reducing the crop yield or increasing the density of the weed population.

Chikoye *et al.* (2004) indicated lower weed dry matter and weed species in the treatments involving primextra herbicide. Species composition and density of weed communities of agricultural land varies greatly and are closely linked to cropping history (Buhler, 1999). Composition is influenced by farming practices (Buhler *et al.*, 1994) and varies from field to fields and among area within fields. Buhler *et al.* (1994) indicated that weed species emerging from soil seed bank was as a result of weed seed production and germination and resulting weed populations are composed of many species while a few dominant species generally comprise 70-90% of the total seed bank. These dominant species are the primary pest because they are resistant to control measures and adapted to the cropping system (Buhler, 1999) thereby competing with crops. Buhler (1999) also indicated that weed seed densities can be greatly reduced by preventing the plants from producing seed through appropriate control measures. Primextra complimented with hoe weeding has resulted in low weed density (Olorunmaiye and Olorunmaiye, 2009). This integration reduced weed population and biomass satisfactorily and enhanced tuber yield.

Herbicide use could proffer more profitable option to other methods of weed control in the production of cassava and protect crops from adverse early weed competition which can avert economic losses. Hence this study was undertaken to assess the efficacy of herbicides and cassava varieties on weed flora, density, biomass and yield of cassava.

2.0 Materials and Methods

The study was conducted at the Akwa Ibom State University Teaching and Research Farm, Obio Akpa, Oruk Anam, Akwa Ibom State, Nigeria in April, 2021 and April, 2022 cropping seasons. The location of the experimental site lies between latitude 5.03⁰N and longitude 7.93⁰ E and 196m above sea level within the equatorial rainforest belt with average minimum temperature of 23⁰C and maximum 31.7⁰C, average monthly relative humidity 51- 89%, monthly sunshine of 3.14 hours and average rainfall 2473mm /annum (Akwa Ibom State Statistical Year Book, 2013).

The location has a tropical climate masked by two distinct seasons namely; dry season (November – March) and the wet season (April – October). The wet season is usually interrupted by a short dry weather in August which is often known as ‘August break’ (Peters et al., 1989). The site in both cropping seasons was fallowed for one cropping season. The land was under two years fallow after fluted pumpkin and maize was harvested, prior to the studies. Weed species found within the plot were identified before land preparation respectively by throwing a 1m x1m quadrat randomly at six different locations and counting the number of weeds within the quadrat. The identified weed samples were classified as grasses, broadleaves and sedges. The population of each class was estimated as the mean of six samples. The vegetation for 2021 cropping season was mainly broadleaves (68.22%), grasses (21.17%) and sedges (10.61%) and in 2022 cropping season, broadleaves (59.33%), grasses (29.21%) and sedges (11.46%).

The dominant weed species found prior to land preparation in 2021 cropping season were; *Panicum maximum* Jacq, *Aspilia africanum* L, *Ageratum conyzoides* L, *Commelina benghalis* L, *Mitracarpus villosus* (Sw.) DC, *Euphorbia hirta* L, *Axonopus compressus* (L) Pegs, *Pueraria phaseoloides* (Roxb.) Benth, *Commelina erecta* L, *Kyllinga erecta* Schum, *Chromolaena odorata* R.M King and Robinson, *Acalypha ciliata* Forssk, *Ipomea involucrata* P. Beauv., *Sida acuta* Burm. F, *Cyperus rotundus* L, *Paspalum orbiculare* G. Forst while weeds found in 2022 cropping season were; *Axonopus compressus* L, *Cyperus rotundus* L, *Ageratum conyzoides* L, *Euphorbia hirta* L, *Panicum maximum* Jacq, *Kyllinga erecta* Schum, *Chromolaena odorat* R.M King and Robinson, *Pueraria phaseoloides* (Roxb.) Benth, *Celosia laxa* Schum and Thonn., *Tridax procumbens* L, *Cassia hirsuta* L, *Commelina erecta* L, *Mariscus flabelliformis* Vahl, *Oldenlandia corymbosa* L, *Boerhavia diffusa* L.

Composite soil samples were randomly collected at six different locations from the site before land preparation at the depths of 0 – 15cm and 15-30cm in both seasons using soil auger. The samples collected soil samples were bulked, bagged, labelled and analyzed for physical and chemical composition of the soil. Land preparation at the experimental site was done by slashing and stumping of woody shrubs. Then the land was ploughed with a tractor for favorable establishment of roots and for development of tubers. Harrowing was carried out three days after ploughing in order to break bigger particles of soil into smaller particles. This was followed by ridging at 1m apart with foot paths of 1.5m around the plots and in between the main treatments in 2021 and 2022 cropping seasons, respectively.

The design used for the experiment was a Randomized Complete Block Design with split – split plot arrangement and replicated three times for 2021 and repeated in 2022 cropping season. The main treatments were three cassava cultivars viz: TMS 980505, TMS 981632, TME 419. The sub treatments were types of herbicide viz: Pendimethalin, Butachlor, Diuron and Primextra (Atrazine + metolachlor), while the sub- sub treatments were rates of application viz: 0, 1.0, 2.0, 3.0, 4.0 kg a.i/ha for each herbicide. The herbicides were diluted

in water solvent at respective rates of applications and applied as pre-emergent. Main plot size was 20 x 16m, sub-plot size was 20 x 4m, while the sub-sub plot size was 4 x 4m. The total plot size was 60 x 48m = 2,880m² for 2021 and 2022 cropping seasons respectively.

The three cassava cultivars stem cutting were planted after land preparation at 1 x 1m spacing using inclined position at an angle of 60° and the buds pointing upward. Four types of herbicides; Pendimethalin, Butachlor, Diuron and Primextra were applied after planting at 1.0, 2.0, 3.0, 4.0 kg a.i/ha using four different knapsack sprayers and each calibrated to give a spray volume of 250 liters/ha using a deflector nozzle at a pressure of 2.1kg/cm and walking speed of 1m meter per second. One hundred kilograms of compound fertilizer (NPKMg 12:12:17+2) fertilizer was applied to the crops at two months after planting (2 MAP) using ring method.

Data were observed on number of branches, tuber yield and also on weed flora, weed density and weed biomass at 3, 6 and 9 MAP using a quadrat of 1 x 1m randomly placed in each treatment. All data collected were subjected to analysis of variance (ANOVA) using GenStat Statistical Software (Version 13) and significant means were compared using Least Significant Difference (LSD) at 5% probability.

3.0 Results and Discussion

The soil physical and chemical properties of the experimental site before planting for 2021 and 2022 indicated that the soil was sandy loam and slightly acidic with high organic matter content, low in total nitrogen and high contents of available phosphorous (Table 3.1).

The effect of cultivars, herbicide and rates of application significantly influenced tuber yield in 2021 and 2022. Primextra at 2.0 kg a.i/ha had the highest tuber yield of 32.89t/ha in 2021 and 33.26t/ha in 2022 planting season (Figures 3.1 and 3.2) and the lowest weed density and biomass in 2021 and 2022 planting seasons (Figures 3.3, 3.4, 3.5 and 3.6). This is in consonance with Enyong *et al*, (2013) who reported effective weed control, superior growth and highest storage root yield of cassava with primextra at 2.0kg a.i/ha. However, Diuron produced the lowest yield similar to no herbicide application. This may be as a consequence of the selective nature of the herbicide on weeds. This result agrees with Swinton and King (1994) that weeds surviving an herbicide treatment have the same competitiveness and provide the yield loss as untreated plot. The unweeded (no herbicide) plot gave the lowest tuber yield in both cropping seasons, respectively when compared with other treatments. The highest weed density, biomass and lowest tuber yield observed in the control plot showed that weed control is a critical factor for optimum yield in cassava. The reduction in yield is on account of unrestricted weed infestation in the cassava plot. This is similar to the report of Dan *et al* (2016) that greater weeds density and biomass were obtained in weedy check with lowest yield of cassava due to intense weed competition.

Across cassava cultivars, results also showed TMS 980505 with the least weed biomass (Figures 3.9 and 3.10). The superior performance maybe an expression of inherent characteristics and the beneficial effect of the combined treatments in the study. The integration of TMS 980505 and primextra at 2.0 kg a.i/ha had the highest tuber yield, lowest weed density and biomass in 2021 and 2022 than other herbicides treated plots. This may also be due to the ability of primextra herbicide to control weeds like grasses and broadleaves and the inherent branching ability of TMS 980505 which may have encourage weed suppression thus minimizing competition and interference its growth and yield. This weed suppression

mechanism may be due to the branching ability of cassava cultivar (TMS 980505) to smother and shade out germinated weed seedlings from full light intensity thereby retarding photosynthetic activities, weed growth, hence reducing weed density and biomass compared to TMS 981632 and TME 419 cultivars. This agrees with the report of Forcella (1990) that the reduction of weeds in a given crop to some extent is determined by the degree of competition offered by that crop. Similar finding was reported by Chikoye *et al* (2004) that lower weed dry matter and weed species were obtained in the treatments involving herbicides. TME 419 cultivar recorded lowest number of branches and yield. The lower yield may be attributed to the lowest number of branches recorded in the cultivar and thus was unable to smother weeds at a certain growth stage thus leading to weed competition. However, yield of all cultivars reduced as the rate of application was increased. This agrees with Jane-Frances *et al*, (2021a) that tuber yield of cassava decreased with increase in herbicides rates of application

Weed density and weed biomass decreased as the rate of application was increased (Figures 3.3, 3.4, 3.5 and 3.6). Thus the ability of the herbicides to kill or suppress weeds increases as the rate of application increases. The control plot of no herbicide treatment indicated preponderance of broad leaves, grasses and sedges.

Primextra treatment showed the least weed species dominance (10-29%) in both 2021 and 2022 cropping seasons (Table 3.2). This agrees with Olorunmaiye and Olorunmaiye (2009) who indicated low weed density with the use of primextra. This was followed by Butachlor (*Cyperus rotundus*, *Panicum maximum*, *Euphorbia hirta* and *Kyllinga erecta*) at 30-59%. Pendimethalin had high infestation of grasses (*Mariscus alternifolius*, *Axonopus compressus* and *Panicum maximum*) at 30-59% (Table 3.2). Diuron recorded high species of broadleaves (*Ageratum conyzoides*, *Oldelandia corymbosa*, *Euphorbia hirta*, *Chromolaena odorata*, *Phyllanthus amarus*, *Panicum maximum*), in both cropping seasons, While the highest was recorded in no herbicide treatment at 60-100 %.

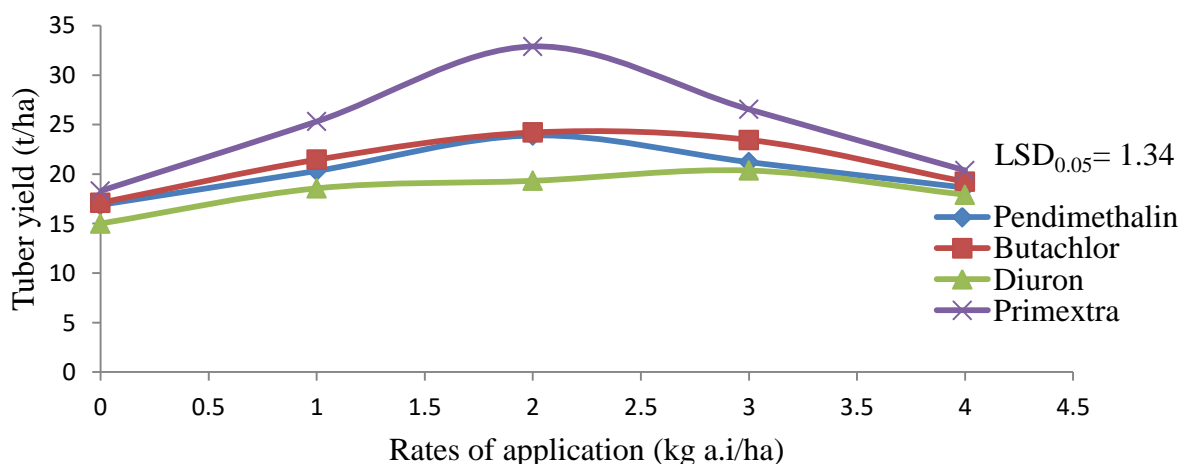


Figure 3.1: Tuber yield (t/ha) of cassava as affected by interaction of types and rates of herbicide in 2021 cropping season

Table 3.1: Soil physico-chemical properties of the experimental site before planting

	2021		2022	
	Soil depth (cm)			
Soil physical properties	0-15cm	15-30cm	0-15cm	15-30cm
Sand %	82.30	78.50	80.50	78.60
Silt %	3.20	5.20	5.14	6.08
Clay %	14.50	16.30	14.36	15.32
Soil chemical properties				
pH (H ₂ O)	5.70	5.80	5.87	5.70
EC (dsm)	0.09	0.04	0.07	0.05
Organic matter (%)	3.74	3.44	3.92	3.34
Total N (%)	0.16	0.08	0.14	0.09
Available P (mg/kg)	84.19	71.49	70.30	68.26
Ca (cmol/kg)	4.00	3.10	4.89	5.52
Mg (cmol/kg)	1.70	1.40	1.93	1.65
Na (cmol/kg)	0.05	0.06	0.06	0.04
K (cmol/kg)	0.10	0.09	0.14	0.11
Ea (cmol/kg)	1.76	1.92	1.87	1.99
ECEC (cmol/kg)	7.61	6.57	7.93	7.20
EAL (cmol/kg)	1.09	1.20	1.10	1.18
Base saturation (%)	77.87	70.78	84.16	81.43

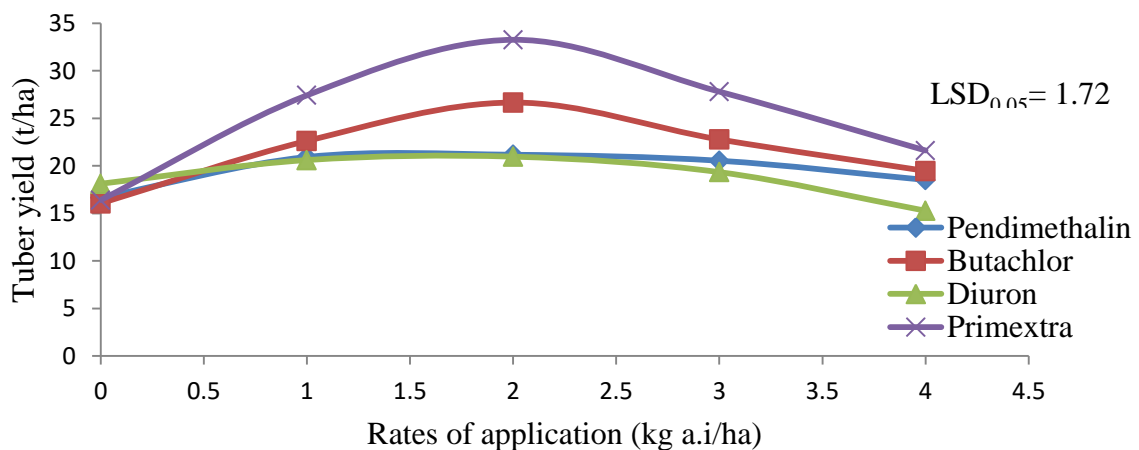


Figure 3.2: Tuber yield (t/ha) of cassava as affected by interaction of types and rates of herbicide in 2022 cropping season.

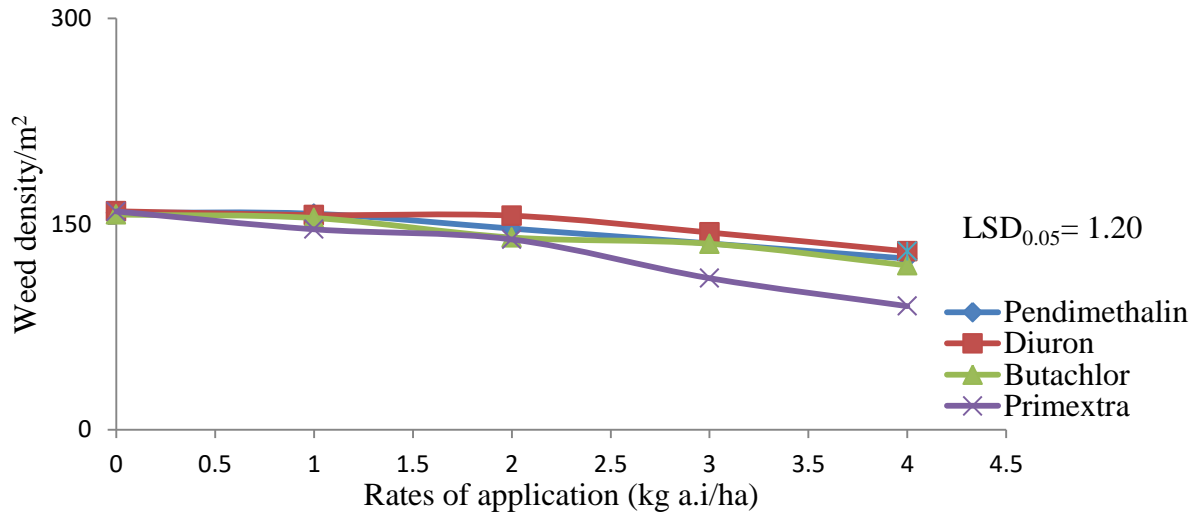


Figure 3:3 Effect of interaction of types and rates of herbicide on weed density / m^2 at six months after planting in 2021 cropping season.

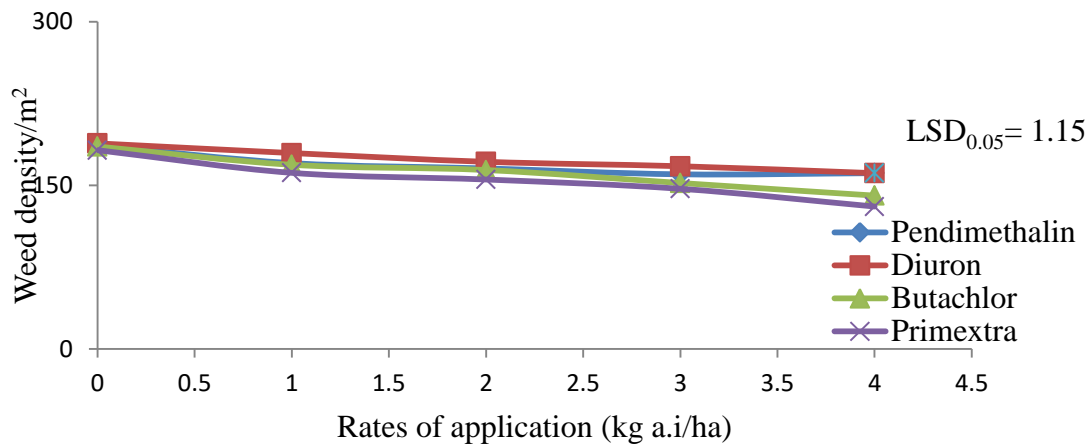


Figure 3.4: Effect of interaction of types and rates of herbicide on weed density / m^2 at six months after planting in 2022 cropping season.

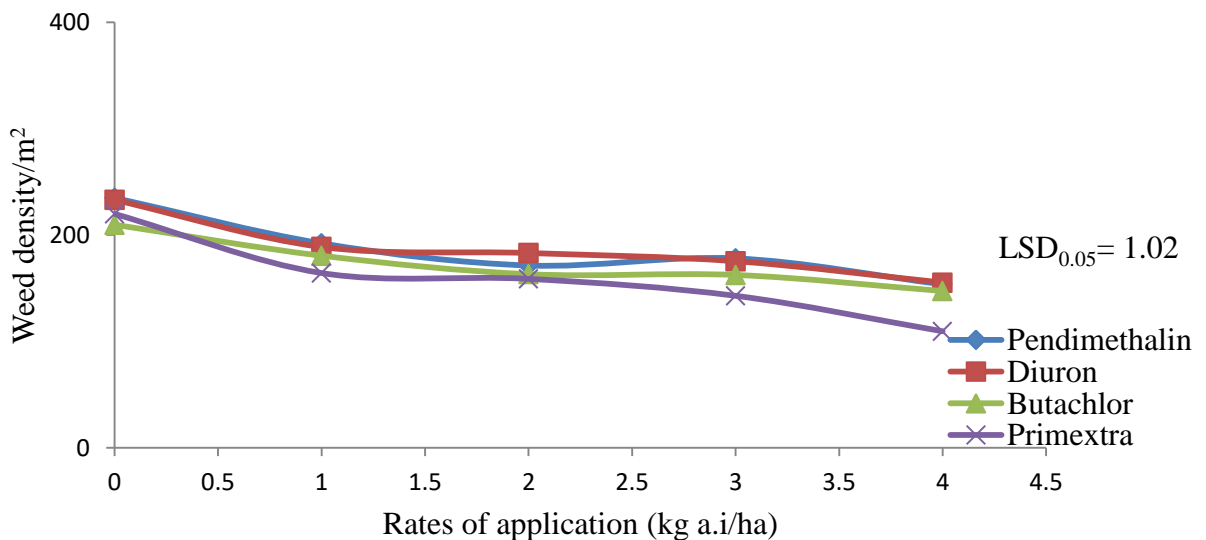


Figure 3.5: Effect of interaction of types and rates of herbicide on weed density / m^2 at nine months after planting in 2021 cropping season.

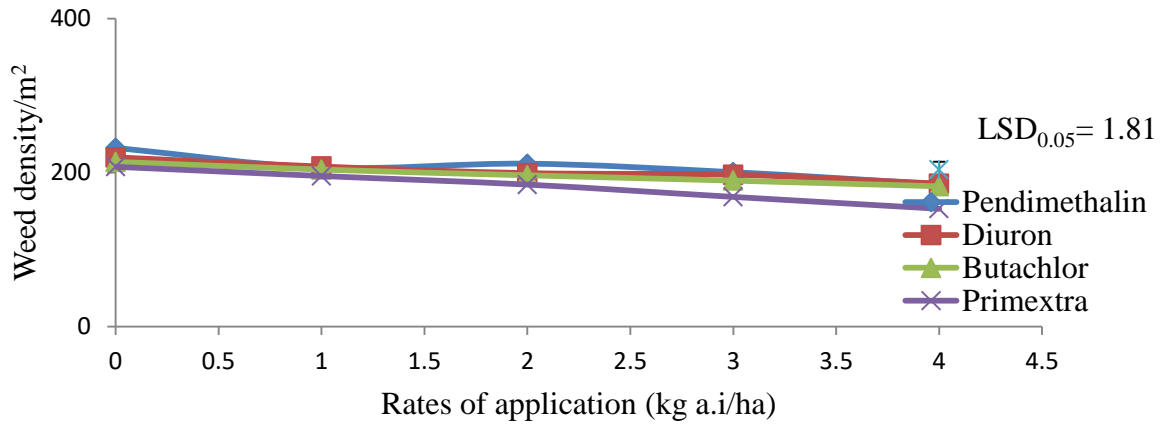


Figure 3.6: Effect of interaction of types and rates of herbicide on weed density/m² at nine months after planting in 2022 cropping season.

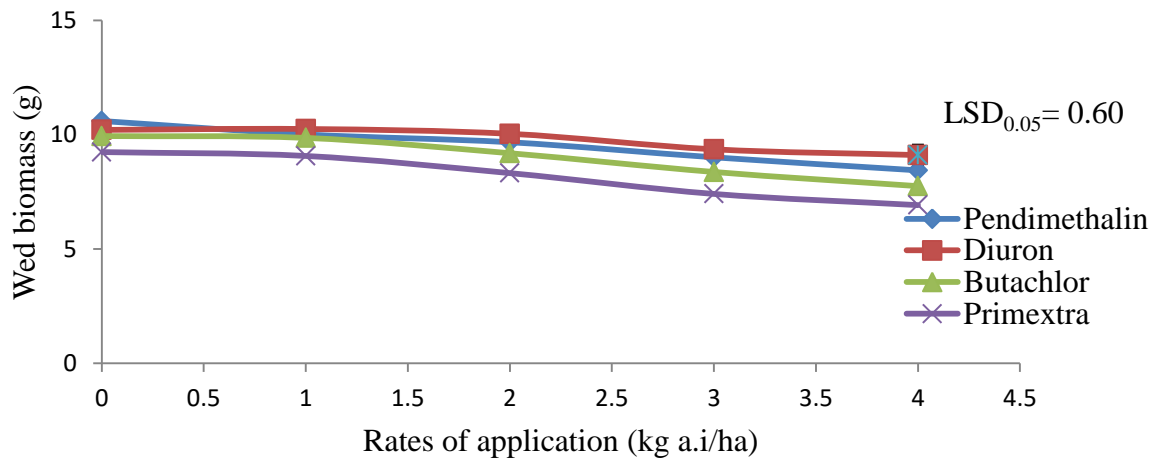


Figure 3.7: Effect of interaction of types and rates of herbicides on weed biomass (g) at nine months after planting in 2021 cropping season.

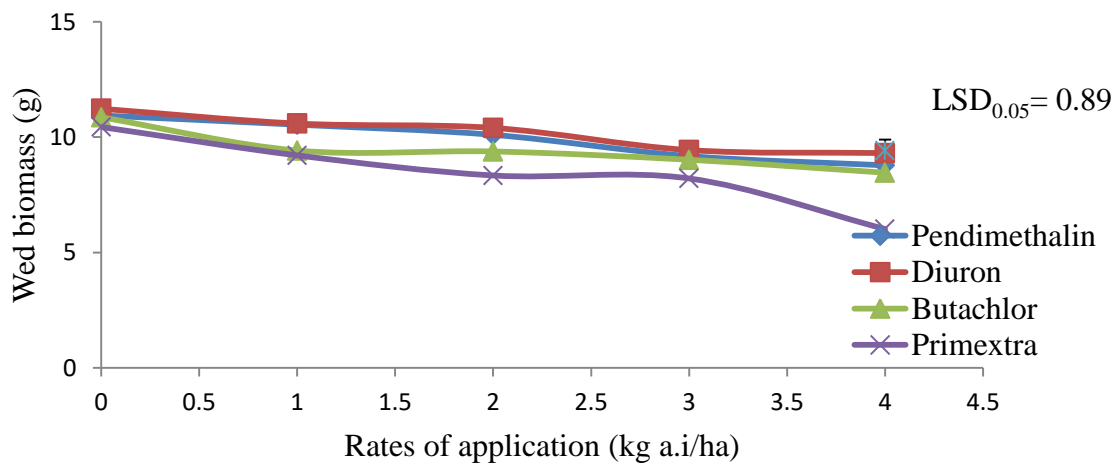


Figure 3.8: Effect of interaction of types and rates of herbicides on weed biomass (g) at nine months after planting in 2022 cropping season.

Table 3.2: Weed species dominance and level of infestation as influenced by types of herbicides in 2021 and 2022 cropping seasons

Herbicides	Dominant weed species at 9 MAP	Level of infestation	
		2021	2022
No herbicide	<i>Panicum maximum</i>	+++	+++
	<i>Aspilia africanum</i>	++	++
	<i>Ageratum conyzoides</i>	+++	++
	<i>Commelina benghalis</i>	++	++
	<i>Mitrocarpus vilosus</i>	++	++
	<i>Euphorbia hirta</i>	+++	+++
	<i>Axonopus compressus</i>	+++	+++
	<i>Commelina erecta</i>	+++	++
	<i>Chromolaena odorata</i>	+++	+++
	<i>Acalypha ciliate</i>	+++	++
	<i>Ipomoea involucrate</i>	++	++
	<i>Sida acuta</i>	+++	++
	<i>Celosia laxa</i>	+++	+++
	<i>Tridax procumbens</i>	++	+++
	<i>Cassia hirsute</i>	++	+++
	<i>Mariscus alternifolius</i>	+++	+++
	<i>Oldelandia corymbosa</i>	+++	+++
	<i>Boerhavia diffusa</i>	++	+++
	<i>Paspalum orbiculare</i>	+++	+++
	<i>Pueraria phaseoloides</i>	++	+++
Diuron	<i>Kyllinga erecta</i>	+++	+++
	<i>Cyperus rotundus</i>	+++	+++
	<i>Phyllanthus amarus</i>	+++	+++
	<i>Ageratum conyzoides</i>	+++	+++
	<i>Oldelandia corymbosa</i>	+++	++
	<i>Euphorbia hirta</i>	++	+++
Pendimethalin	<i>Chromolaena odorata</i>	++	++
	<i>Phyllanthus amarus</i>	+++	++
	<i>Panicum maximum</i>	++	++
	<i>Panicum maximum</i>	+++	+++
Butachlor	<i>Axonopus compressus</i>	++	+++
	<i>Mariscus alternifolius</i>	++	++
	<i>Ageratum conyzoides</i>	++	++
Primextra	<i>Cyperus rotundus</i>	+	++
	<i>Panicum maximum</i>	++	++
	<i>Euphorbia hirta</i>	++	++
	<i>Kyllinga erecta</i>	++	++
Primextra	<i>Commelina diffusa</i>	+	+
	<i>Cyperus rotundus</i>	+	+
	<i>Kyllinga erecta</i>	+	+

Key: +++ High infestation (60-100% occurrence); ++ Moderate infestation (30-59% occurrence); + Low infestation (10-29% occurrence)

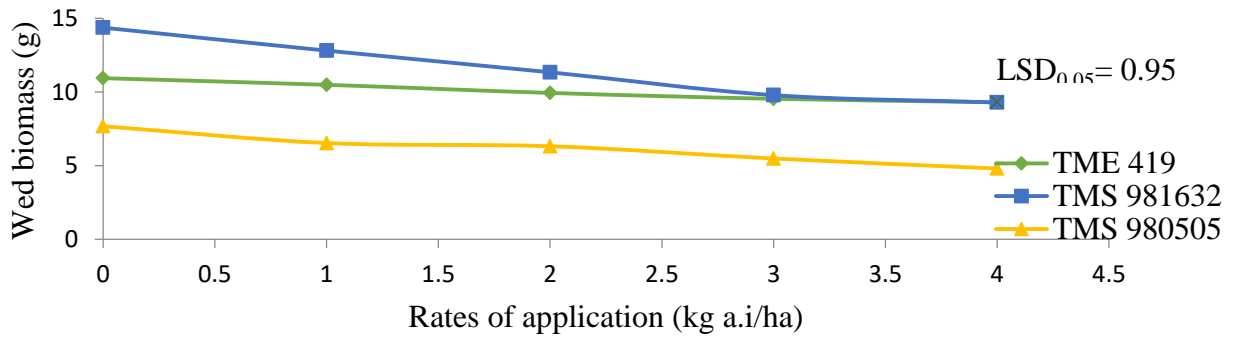


Figure 3.9: Weed biomass (g) as influenced by interaction of cultivars and rates of application of herbicide on at nine months after planting in 2021 cropping season.

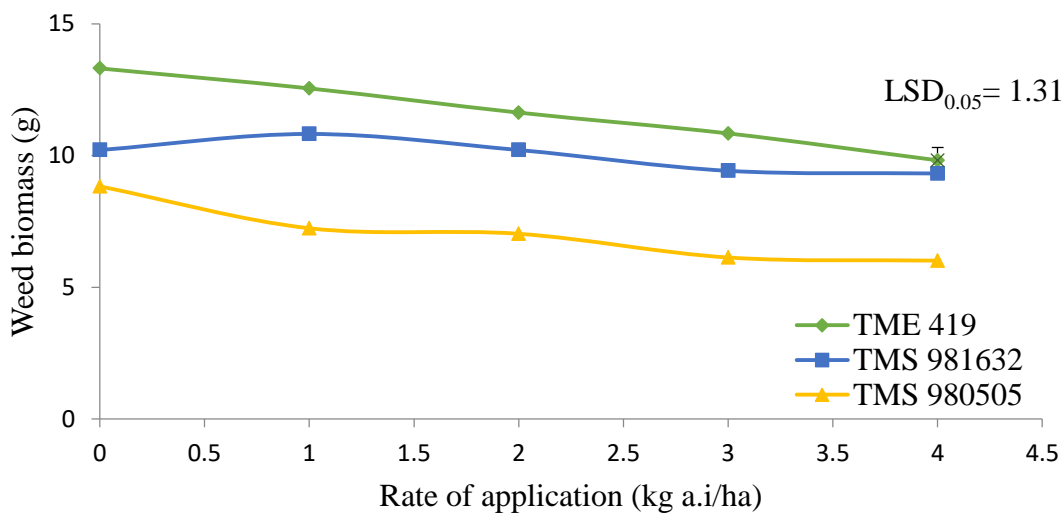


Figure 3.10: Weed biomass (g) as influenced by interaction of cultivars and rates of application of herbicide at nine months after planting in 2022 cropping season.

4.0 Conclusion

Weed control is a critical factor and a cornerstone for increased cassava production worldwide cassava cultivar TMS 980505 and primextra at 2.0 kg a.i./ha had the highest tuber yield, lowest weed flora, density and biomass among the treatments. Therefore, it can be concluded that the integration of cassava cultivar TMS 980505 with primextra herbicide at 2.0 kg a.i./ha is favorable for weed control in cassava in the study area.

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