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A comparative analysis of the efficacies of six selected herbicides for effective control of spear grass (*Imperata cylindrical* Linn) in cassava production in Obudu, Northern Cross River State

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Abstract

A two-year, (2015 and 2016) field trial was conducted in Obudu Local Government Area of Cross River State to compare the efficacies of six (6) selected herbicides in controlling spear grass (*Imperata cylindrical* Linn) in cassava farm. The main treatments were the three cassava varieties: TMS 30572, TMS 50395 and NR 8082, while the sub treatments were six herbicides: Primextra, Igrancombi Gold, and Paracot as pre-emergence, Touchdown Forte Hi Tech, Galex and Fusilade Forte as post-emergence herbicides. The result showed that cassava establishment did not differ significantly among the cassava varieties, whereas herbicide type significantly ($p < 0.05$) affected cassava establishment. High plant establishment was recorded in plots treated with Paracot, followed by plots treated with Igrancombi compared to high mortality rate recorded in plots treated with primextra as pre-emergence application. The tuber yield did not differ significantly among the cassava varieties. However, on the basis of average for both years, the trend was as follows: TMS 30572 (2.81 t/ha^{-1}) > NR 8082 (2.75 t/ha^{-1}) > TMS 50395 (2.56 t/ha^{-1}). On the contrary, tuber yield differed significantly ($p < 0.05$) among herbicide types irrespective of the cassava variety, although no well-defined trend was established.

Keywords: Herbicide; Pre-emergence; Post-emergence; Cassava establishment; Weed control efficiency

1. Introduction

Cassava is a very important tuber crop that is produced in all tropical areas of the world, especially by the resource poor farmers. It is a popular energy food in most of the tropics where its production and yields are prolific. It has replaced yam and cocoyam as the number one carbohydrate staple and is said to provide up to 40% of all the calories consumed in Africa [1]. Apart from being a major staple food in the tropics, cassava is a prime source of industrial starch. Only recently, it has been introduced in the bakery industry in Nigeria as bread flour. Garri, one of the primary products of cassava is becoming more and more an essential commodity, as the price goes up on weekly basis. The chips (Cassava chips) or pellets are also becoming more important in World commerce as a relatively cheap energy feed for ruminants, Poultry and pigs. The leaves are eaten as vegetables in some parts of Africa. Even amongst animals, the goats relish them most. The price of Akpu has also gone up tremendously in recent times, around local communities in Vandeikya, Benue State, Obudu, Obanliku, Bekwarra, Ogoja and Boki in Cross River State. During the 2017 planting season, the sticks were in short supply in almost all cassava growing areas in Nigeria. In fact, the importance of cassava as a crop cannot be overemphasized.

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Cassava like any other crop, is susceptible to weed competition despite its high adaptation to adverse environmental conditions. The impact of the weed competition is most adversely felt by the crop during its first 30 to 120 days of planting [2]. In effect, it means that fields must be kept weed free during the early life of the crop.

The concept of weed originated mainly within the context of man's agricultural activities, his desires and ecological considerations [3]. The definition of weed has varied for some time now, depending on the effect's weeds are perceived to have on food production, recreational activities, and aesthetic values of humans. To the agriculturist, a weed is a plant growing where it is not desired [4]. To the ecologist, a weed may be a plant that grows spontaneously in a habitat that has been greatly modified by human activities [6]. Aldrich [5] offered a definition that combines both agricultural and ecological base. According to him, a weed is a plant that originated in a natural environment and in response to imposed or natural environment, evolved and will continue to do so, as an interference association with our crops and activities. Orkwor [7] defined a weed as an unwanted plant which succeed in its struggle for existence in competition with crops. Akabundu [3] summarized it all by saying that a plant is a weed either because it interferes with human activities and/or welfare, or because it occurs spontaneously in human disturbed habitat. However, whichever is the most acceptable definition of a weed, the fact remains that weeds are obstacles not only to man's agricultural development, but also interfere with his efficient use of the environment for food, fibre, shelter and recreational activities.

One of the predominant weeds that drastically reduce the yield of cassava tubers in the tropics is 'spear grass' or 'sword grass' (*Imperata cylindrica*). The plant is a devastating weed of cassava and other tuber crops such as yam and sweet potato [3]. It is said to cause 40 to 45% losses of the total cultivated cassava tubers in West Africa [8]. Spear grass is a very stubborn weed, and persist in the soil even during dry season. The weed is prolific and regenerates easily through its underground rhizomes and is very difficult to control manually. The weed damaged cassava tubers and other root crops by piercing through the tubers with its racemes which are dense, tight, cylindrical and spikelike, thereby damaging the tubers and reducing the product quality, yield and market value, hence rendering them unacceptable for human consumption. Also, by piercing through the cassava tubers, the spear grass creates openings for fungal and bacterial diseases to infest the tubers (Alvarez and Molina, 2000). Moreso, the weed competes favourably with cassava for light, water and nutrients much more than most other weeds.

There are many methods of controlling weeds in cassava cultivation, these are cultural, manual, mechanical and chemical. However, this paper is concerned with chemical method of weed control. Chemical method of weed control is the practice of killing weed plants by spraying them with chemicals called herbicides [3]. Chemical method commands certain characteristics which make the method most popular, despite the general public agitations that the herbicides are hazardous to human health and the environment. The method is said to be effective against all forms of weeds. It is also less drudgery, labour demand is lower, it is faster, weeds can be selectively killed, if need be, and the ability to completely eliminate weeds right from the seeds, thereby preventing them from sprouting. These attributes of chemical weed control, make the method popular and dependable even amongst small scale farmers up till today. Adigun and Lagoke [10] have an observation which is in line with this view, according to them, chemical weed control remains the most effective alternative to the time consuming, expensive, and energy sapping method involved in manual weeding. Akobundu [3] also observed that the problem of scarcity and high cost of labour involved in manual weeding often associated with large hectares of land, is eliminated when chemical method of weed control is applied.

Many research works are on-going by scientists the world over, on how best to cut down on the use of agrochemicals including herbicides in agricultural production, due to their hazards to the environment and toxicity to humans. However, chemical weed control remains the best option for now and in the future (Adigun and Lagoke, 1994). The benefits of chemical weed control over other methods cannot be over emphasized. Their mode of action is immediate, and it is seldom to find an alternative means of control that will produce the same result. They can increase the yield and quality of crops bringing stability in the agricultural sector. Both subsistence and commercial farmers find chemical weed control easier, available at all times and more result oriented than any other means of weed control available to them.

1.1. Justification of the research work

Farmers now find chemical weed control more preferable to other means. However, there is hardly any farming community you go during farming season that you will not find young men carrying knapsack sprayers on their backs, either returning or going to the farm to spray herbicides. This means that, chemical weed control is becoming more and more popular even amongst peasant farmers. Spear grass is a predominant weed in almost all cassava growing areas of northern Cross River State, which have a spill over of the guinea savanna climate stretching from the southern part of Benue State. The control of spear grass manually, is a very difficult task, characterized by drudgery, time wasting and not yielding results of effectively controlling the weed. Therefore, chemical weed control remains the best option for

dealing with the weed (Spear grass). However, recent research has it that, some weeds including spear grass (*Imperata cylindrica*) are becoming resilient by developing resistant to most herbicides due to genetic mutation and effects of climate change [11]. This is similar to many insect species which have long developed resistance to many organo-chlorine and organo-phosphate insecticides in the changing climatic conditions [12].

Instances abound where sufficient quantities of herbicides were applied in cassava plots to kill weeds, all other weeds died but spear grass only partially died. After some days, shoots started springing up from the rhizomes of the spear grass, and within two weeks of the application, the whole farm was covered with the spear grass, thereby devastating the cassava farm as if no herbicide was initially applied. In addition, a whole lot of herbicides were poured into the environment thereby resulting in health hazards to humans and environmental degradation. Sometimes, the farmer is tempted to repeat the spraying with another herbicide hoping to get results, but may not. For this reason, it has become imperative to experiment with some selected pre and post-emergence herbicides to establish a herbicide or herbicides that have the efficacy to eradicate the noxious weeds such as spear grass (*Imperata cylindrica*) even as the weed (s) display resistance to the herbicide (s) due to genetic changes resulting from climate change.

When an herbicide has been established to have the efficacy to completely eradicate spear grass, it will be recommended to farmers by extension agents and this will lead to improvement in the quality of cassava tubers and also increase in the yield of the crop. If the indiscriminate manner of applying herbicides is minimized, loss of cassava yield, wastage of funds and environmental degradation arising from introduction of too much quantities and so many herbicides into the environment will be avoided.

2. Material and methods

The experiment was conducted in Obudu in the northern part of Cross River State, between March 2015 to March 2017. Obudu experiences two climatic conditions in two different parts of the Local Government. The southern part is the rain forest zone while the northern part lies towards the Guinea Savanna zone that stretches out from the southern part of Benue State of Nigeria. This Guinea Savanna zone which is grassland in nature, was the study area for this research. The climate here is generally characterized by a long-wet season which starts in mid-March and last till October, and a long dry season from November till mid-March, accompanied by the harmattan which is cool and misty in the morning hours and disappearing as the sun rises in the day.

The experimental design used was the Randomized Complete Block Design (RCD) with a split plot arrangement and replicated three times. The entire experiential plot measured 45 m x 15 m. Each main plot measured 15.5 m x 10.5 m while each subplot measured 2.5 m x 1.8 m. Both main and sub-plots were separated from each other by 1m path, whereas replicates were separated from each other by a 2 m path. The fields were prepared manually beginning from weeding of the 3-year fallow plot on the 16th and 17th of March 2015. The predominant weeds in the fields were spear grass (*Imperata cylindrica*). Other weeds such as *Aspiliaafricana*, *Urenalobata* and *Acalypha ciliate* were also sparingly growing in the fields. The main treatments were the three cassava varieties; TMS 30572, TMS 50395 and NR 8082 while the sub-plots or sub-treatments were the herbicides used namely; Primextra (290 g S-metolachlor + 370 g atrazine per litre), IgranCombi Gold 450 EC (250 g S – Metolachlor + 200 g terbutryn per litre) and Paracot (Paraquate dichloride 276 g/litre) as pre-emergence. Touchdown forte Hi Tech (500 g/litre glyphosate acid), Galex (Metobromuron and Metolachlor) and Fusilade Forte 150 EC (150 g Fluazifop-p-buty1) as post-emergence, while the manually weeded and no herbicide applied was the control. Cassava cuttings of 25 cm each were planted on ridges of 2.4 m x 1.8 m at a planting distance of 90 cm apart within rows and 100 cm between rows, giving a plant population of 10,000 stands per hectare. Application of pre-emergence herbicides was done a day before planting and repeated 16 weeks after the first application while application of post-emergence herbicides was done 2 weeks after planting and repeated 16 weeks after the initial application. Means of the readings were calculated and recorded. The spraying was at equal rate of 2 kg ai/ha for all the herbicides. The spraying was done with a knapsack sprayer at a pray volume of 250 litres/ha using a deflector nozzle at a pressure of 2.1kg/cm², and walking speed of 1 metre per second.

2.1. Data Collection and Analysis

Percentage establishment of the cassava varieties was determined by counting the number of germinated stands and expressed as a percentage of total number of cuttings planted per sub-plot at two weeks after planting (2WAP). Visual ratings were taken for herbicide toxicity (injury) levels on the crop plants and their control using the method of Smith and Khodayari [13]. Ratings were done as follows: Toxicity (injury) in which less than 10% of the crop was killed (mortality rate) was insignificant, (ii) toxicity (injury) was slight where 10-29% of the crop was killed, (iii) Toxicity (injury) level of 30-70% was regarded as moderate, while (iv) Toxicity (injury) level of 70-100% was considered as severe. In assessing herbicide weed control efficiency, a scale was used, thus if less than 10% of weeds emerged after

spray, then the rating was regarded as very good. (ii) if 10 – 49% of weeds emerged, the rating was regarded as good, (iii) if 50 – 79% of weeds emerged, it was fair, while if 80 – 100% of weeds emerged, the rating was considered poor. Both toxicity (injury) levels of the herbicides on the crop and control level were determined at 6 weeks after application of both pre-and post-emergence at both years.

Tuber yield was obtained from each plot by weighing in kg and later expressed in tonnes per hectare (t/ha), data collected were subjected to analysis of variance using Genstat Statistical Software (version 13), and significant means were compared using least significant difference (LSD) at 5% level of probability. Tuber yields were determined when the mean of the two seasons were pooled together and the average calculated.

3. Results

3.1. Physico-chemical properties of the soil at the experimental site

Table 1 Physical and chemical properties of the soil at the experimental sites before planting;

SN	Soil Properties	2015		2016	
		Soil depth			
		0-15	5-30	0-15	15-30
1	Soil pH (H ₂ O)	5.52	5.22	5.62	5.25
2	Organic matter (%)	2.65	2.25	5.60	5.32
3	Total Nitrogen (%)	0.23	0.21	0.20	0.19
4	Available P (mg/kg)	1.56.33	142.21	165.60	152.22
5	Exchangeable cations				
	Ca (meg/100g)	4.62	3.20	6.60	6.20
	Mg (meg/100g)	2.20	2.21	2.46	2.44
	Na (meg/100g)	0.06	0.06	0.04	0.04
	K (meg/100g)	0.22	0.20	1.05	0.05
6	Exchangeable acidity				
	A1 (Cmo1/kg)	0.62	0.51	0.56	0.46
	H (Cmo1/kg)	0.42	0.41	0.43	0.12
	ECEC (Cmo1/kg)	8.32	6.56	10.32	9.42
7	Particle size distribution (%)				
	Sand	89.60	88.60	88.60	88.60
	Silt	5.52	5.67	5.50	6.22
	Clay	4.80	4.76	4.86	4.88
	Soil texture	Sandy Loam			

3.2. Plant establishment, crop mortality rating and weed control efficiency

Cassava percentage establishment at 2 weeks after planting (WAP) did not differ significantly among cassava varieties (Table 2). However, herbicide type significantly affected ($p < 0.05$) cassava establishment. This means that, the type of herbicide applied affected the percentage establishment and the mortality rate of the crop. This was demonstrated by the high percentage establishment of crop in the plots treated with paracot and Igrancombi as compared to the high mortality rate in plots treated with primextra for pre-emergence application. The interaction effects between the

herbicide type and the cassava varieties were also significant ($p < 0.05$) with the trend showing that Paracot and Igrancombi favoured cassava establishment.

Table 2 Effects of Selected Herbicides on Percentage Establishment of some Cassava Varieties at 2 weeks after planting

Cassava variety	Herbicide	2015	2016	Mean
TMS30572	Control	90.52	91.45	90.98
	Paracot	93.76	95.73	94.75
	Primextra	51.02	47.26	49.14
	Igrancombi	90.60	91.06	90.83
	Mean	81.50	81.40	81.43
TMS 50395	Control	87.52	87.61	87.56
	Paracot	92.62	92.33	92.51
	Primextra	50.10	48.20	49.15
	Igrancombi	90.04	91.22	90.63
	Mean	80.07	79.84	79.96
NR8082	Control	90.63	94.43	92.53
	Paracot	97.62	94.55	90.10
	Primextra	42.65	45.62	44.14
	Igrancombi	92.64	93.65	93.10
	Mean	80.88	82.40	81.46
LSD (p=0.05)				
Variety		NS		NS
Herbicide		5.75		4.63
Variety and Herbicide		26.40		16.20

NS = Not significant

Percentage crop establishment for paracot treated plots was highest in all the plots irrespective of the cassava variety. Paracot was closely followed by Igrancombi (250 g S- Metolachlor + 200 g terbutryn per litre) treated plots. Significant differences were observed in the injury (mortality) rating of the herbicide type (Table 3). Primextra was most lethal to cassava compared to other herbicides irrespective of the cassava variety. Weed control efficiency rating differed significantly among the herbicides. It was also observed that Paracot was the most efficient in controlling the weeds followed by Igrancombi (Table 4) whereas Primextra was the least effective herbicide in controlling the spear grass.

Table 3 Injury Rating (%) of Selected Herbicides (Pre-emergence) on some Cassava Varieties at two weeks after Planting/Application

Treatments	2015	2016	Mean
Control	1.02	0.81	0.92
Paracot	4.62	5.12	4.87
Primextra	74.21	68.23	71.22
Igrancombi	6.22	5.24	5.73
Mean	21.52	19.85	20.68
LSD (p<0.05)	5.22		4.92

There were no significant differences in the mortality rate among the cassava varieties as well as for weed control efficiency rating and interaction effects.

Table 4 Spear grass control efficiency ratings (%) of selected Herbicides applied Pre-emergence

Treatments	2015	2016	Mean
Control	82.23	77.36	79.80
Paracot	100.00	98.72	99.36
Primextra	62.52	70.21	66.36
Igrancombi	86.22	85.83	86.03
Mean	82.74	83.03	82.88
LSD (p<0.05)	6.11		5.96

Table 5 Injury Rating (%) of selected Herbicides (Post-emergence) on cassava varieties at four weeks after planting/Application

Treatments	2015	2016	Mean
Control	1.05	1.02	1.04
Touchdown Forte	68.25	70.22	69.24
Galex	3.67	4.53	4.10
Fusilade Forte	2.52	3.04	2.78
Mean	18.87	19.71	19.29
LSD (p<0.05)	5.38		4.26

Table 6 Spear grass control efficiency ratings (%) of selected Herbicides applied post-emergence

Treatments	2015	2016	Mean
Control	78.33	72.12	75.23
Touchdown Forte	65.20	68.64	66.92
Galex	86.32	88.21	87.26
Fusilade Forte	100.00	99.62	99.81
Mean	82.46	82.15	82.31
LSD (p<0.05)	6.10	5.82	

Significant differences were observed in the injury rating of the herbicide type (Table 5). Touchdown Forte was the most lethal to the cassava compared to other post-emergence herbicides the herbicide types. It was observed from the experiment that Fusilade Forte was the most efficient in controlling the spear grass at post-emergence application, followed by Galex (Table 6). Touchdown Forte was the least. There were no significant differences ($p>0.05$) among the cassava varieties and the weed control efficiency rating as well as the interaction effect.

Tuber yield did not differ significantly ($p<0.05$) among the cassava varieties (Tables 7 and 8). However, on the basis of average for both years, the trend was in the following order: TMS 30572 (2.81 t/ha⁻¹) > NR 8082 (2.75 t/ha⁻¹) > TMS 50395 (2.56 t/ha⁻¹). In contrast, tuber yield differed significantly ($p<0.05$) among herbicide types irrespective of the cassava variety, though no clear trend was exhibited. Average for both years indicated that Paracot (3.47, 2.75 and 3.25)

t/ha⁻¹ promoted tuber yield in TMS 30572, TMS 50395 and NR 8082 respectively. Followed by Igrancombi (3.12, 2.34 and 3.18) t/ha⁻¹ for TMS 30572, TMS 50395 and NR 8082 respectively, then the control (2.56, 2.98 and 2.35) t/ha⁻¹ in TMS 30572, TMS 50395 and NR 8082 respectively in pre-emergence application (Table 7).

Table 7 Effects of Selected Herbicides applied Pre-emergence on the yield of Cassava Varieties

Cassava variety	Herbicide	Tuber yield (t/ha)		Mean
		2015	2016	
TMS30572	Control	3.52	2.60	2.56
	Paracot	3.62	3.32	3.47
	Primextra	1.95	2.20	2.10
	Igrancombi	3.22	3.02	3.12
	Mean	2.83	2.78	2.81
TMS 50395	Control	2.94	3.02	2.98
	Paracot	2.93	2.56	2.75
	Primextra	2.22	2.15	2.20
	Igrancombi	2.26	2.41	2.34
	Mean	2.58	2.54	2.56
NR8082	Control	2.46	2.25	2.35
	Paracot	1.95	2.20	2.10
	Primextra	2.22	2.21	2.22
	Igrancombi	3.14	3.22	3.18
	Mean	2.76	2.73	2.75
LSD (p=0.05)				
Variety		NS	NS	
Herbicide		3.40	3.51	
Variety and Herbicide		3.31	3.45	

Table 8 Effects of Selected Herbicides applied Post-emergence on the tuber yield of Cassava Varieties

Cassava variety	Herbicide	Tuber yield (t/ha)		Mean
		2015	2016	
TMS30572	Control	2.66	2.68	2.67
	Fusilade Forte	3.72	3.62	3.67
	Galex	3.32	3.16	3.24
	Glyphosate	1.98	2.03	2.01
	Mean	2.92	2.87	2.89
TMS 50395	Control	2.60	2.51	2.55
	Fusilade Forte	2.63	2.51	2.57

	Galex	2.24	2.58	2.41
	Glyphosate	1.96	2.03	1.99
	Mean	2.42	2.55	2.50
NR8082	Control	2.52	2.36	2.44
	Fusilade Forte	3.26	2.89	3.10
	Galex	3.11	2.88	2.99
	Glyphosate	2.27	2.42	2.35
	Mean	2.79	2.77	2.78
LSD (p=0.05)				
Variety		NS	NS	
Herbicide		3.42	3.62	
Variety and Herbicide		3.35	3.48	

Fusillade Forte (3.67, 2.57 and 3.10) t/ha⁻¹ promoted tuber yield in TMS 30572, TMS 50395 and NR 8082 respectively. Followed by Galex (3.24, 2.41 and 2.99) t/ha⁻¹ in TMS 30572, TMS 50395 and NR 8082 respectively. Then the control, 2.67 t/ha⁻¹ in TMS 30572, 2.55 t/ha⁻¹ in TMS 50395 and 2.44 t/ha⁻¹ in NR 8082 for post-emergence application (Table 8). The interaction effects between the cassava varieties and the herbicide types on tuber yield was significant ($p < 0.05$) with Paracot and Igrancombi highly favoured for pre-emergence application and Fusillade Forte and Galex highly favoured for post-emergence application.

4. Discussion

The significant difference in the percentage establishment and mortality rate among herbicide types was an indication that some herbicides were toxic to the plants at the early stage of growth of the crops. Although, Akobundu (1987) reported that most pre-emergence herbicides are less toxic to plants at lower rates of 2.0 kg or 3.0 kg ai/ha. Cassava percentage establishment was lower in plots where primextra was applied than in plots treated with other pre-emergence herbicides. This was confirmed by the high mortality rate of the cassava varieties that received primextra treatment. Primextra is a combination of atrazine and S-metolachlor, therefore the toxicity of Primextra might have been the action of atrazine present in it. Akobundu [3] reported that proper timing of herbicides application and adequate knowledge of which herbicides to use in a given weed situation are very important in crop production. Therefore, this primextra toxicity effect is likely to be reduced if planting of cassava is done not earlier than 48 hours after application as pre-emergence, so as to reduce the high mortality rate of crops due to herbicide toxicity (injury).

Tuber yield of cassava differed significantly among the herbicide types applied and also in the level of interaction between the cassava varieties and the herbicide types. It is obvious that there was a tremendous effect of the types of herbicide applied on the yield of cassava tubers. The highest yield was obtained in plots treated with Paracot (Paraquate Dichloride) followed by plots treated with Igrancombi (250g S - metolachlor + 200 g terbutryn) for pre-emergence application, while the highest yield of cassava tubers was obtained in plots treated with Fusilade Forte (150g Fluazifop -p- butyl) and followed by plots treated with Galex (Metobromuron + Metolachlor) for post emergence application. The efficient control of the spear grass here by Paraquate Dichloride and Igran combi confirms the report of Adigun and Lagoke [10], that most pre-emergence herbicides are very effective against noxious weeds. Similarly, Gharizadeh, Lorzadeh and Ariannia [3] reported the efficacy of Fluazifop - p - butyl against stubborn weeds in cereal crops. Keramatiet *al.* [13] also reported the effective control of stubborn weeds such as spear grass by Galex in legume crops.

Therefore, it was observed that the use of appropriate and the recommended herbicides in controlling stubborn weeds such as spear grass and other weeds in cassava cultivation, will drastically increase the yield of the crop. It was also observed from the experiment that applying Fusilade Forte and Galex at 2 or 3 kg ai/ha as post-emergence application, kept the cassava farm perpetually clean of the spear grass and other weed throughout the crop growing season thereby enhancing an increase in the yield of the crop.

5. Conclusion

Based on the findings, it is concluded that using Fusilade Forte is the most effective herbicide in controlling spear grass in cassava under sole cropping as post-emergence application. However, Galex could be used in the post-emergence application if Fusilade Forte is unavailable as the two herbicides gave 90% and 100% effective control of the spear grass respectively.

In the event that application should be done pre-emergence, then Paracot (Paraquate Dichloride) is the most effective in controlling spear grass in cassava sole cropping. Where Paracot is unavailable, then Igrancombi could be used as the two herbicides gave 95% and 100% effective spear grass control respectively under pre-emergence application. They also recorded very low injury levels to crops due to phytotoxicity effect, Glyphosate and Primextra are highly toxic to cassava plants especially at the early stage of the crop. If they are to be used in controlling weeds in cassava sole cropping, then application should be done pre-planting and not less than two days after application, so that the toxicity effect of the chemicals can be reduced through evaporation.

Compliance with ethical standards

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Disclosure of conflict of interest

We are satisfied with the level of involvement and participation of all the authors towards the completion of the work.

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