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Analysis of Weed Management Options on Weed Infestation and Cane Yield of Sugarcane

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ABSTRACT

A field study was conducted in a sugarcane field in the southern Guinea savanna ecology of Nigeria to document the influence of weed management methods on the pattern of weed seedlings emergence and cane yield of sugarcane across 3 crop cycles. The experiment which had 6 weed management strategies (weedy check; pre- terbutylazine at 2.0 kg a.i/ ha + supplementary hand hoeing (SHH) at 4, 10 and 16 weeks after planting (WAP); post-ametryn at 3.0 kg a.i/ha + SHH at 10 & 16 WAP; post-dicamba at 0.5 kg a.i/ha + SHH at 10 and 16 WAP; pre-terbutylazine at 2.0 kg a.i/ha + post- 2, 4-D at 3.0 kg a.i/ ha; and monthly hand hoeing) was laid out in a randomized complete block design and replicated three times during 2014, 2015 and 2016 growing seasons. Weed seedlings emergence was monitored in 0.5m^2 quadrats continuously at 1, 2, 4, 6, 8 and 12 months after planting (MAP). The result shows that, the weed spectrum comprised 57-62% grasses, 23-29% broadleaves and 13% were sedges. *Dactyloctenium aegyptium* had 12.05% relative abundance, *Digitaria horizontalis* (10.84%), *Cynodon dactylon* (8.0%), and *Tephrosia linearis* (8.80%) *Eclipta alba* (7.50%), *Echinochloa obstusiflora* (7.17) were the top dominant weed species identified in plant and ratoon crops, respectively. Weed seedling emergence peaks occurred at 1 and 4 MAP across weed control options and crop cycles. Pre-terbutylazine at 2.0 kg a.i/ha + post 2, 4-D at 3.0 kg a.i/ ha was adjourned to minimized weeds emergence which translated into higher cane yields across crop cycles. This study concludes that pre-emergence application of terbutylazine at 2.0 kg a.i/ha + post-emergence of 2,4-D at 3.0 kg a.i/ ha prior to peak periods of weed emergence is the most stable and ideal weed

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management option for sugarcane estates in the southern Guinea savanna ecology of Nigeria.

Keywords: 2, 4-D, biplot analysis, cane yield, dicamba, ratoon crops, sugarcane, terbutylazine, weed emergence

INTRODUCTION

Sugarcane is mostly grown in the savanna regions of the Nigerian ecology which is characterized by erratic rainfall pattern. These changes in climate have an indirect influence on weed emergence which is also directly influence by land use, land intensification and crop management. The slow growth at the beginning of sugarcane life cycle couple with wide plant spacing provides weeds the opportunity to strive well in such ecology (Singh & Kumar, 2013) and this lowers the competitive ability of the crop thus reducing cane and sucrose yields (Chattha et al., 2007).

Weed emergence occurs in flushes and weed species exhibits different patterns of emergence and these have negative effect for site-specific weed management. The above weed characteristics limit the ability to predict weed emergence while management decisions could be less efficient, less reliable, and might be prone to agronomic and financial risk (Yirefu et al., 2013). Therefore a better understanding of sugarcane-weed interactions and identification of emergence pattern of dominant weed species with respect to sugarcane crop cycles will assist in making informed decisions, timely operations, and better management.

Knezevic et al. (2003) reported a significant yield increase due to the application of split and lowered doses of herbicides while Takim et al. (2017b) obtained a significant high maize grain yield with application of pre-Primextra [proprietary mixture of metolachlor (290 g/L) and atrazine (370 g/L)] and post-Guardforce (Nicosulfuron 40 g/L) due to low level of weed interference. Kandil and Kordy (2013) believed that combining herbicides with supplementary weeding control would efficiently eradicate stunting weeds. Olatunji et al. (2016) reemphasized that herbicides with one or two hand weeding ensured a broad spectrum for weed control over a longer period of time. Takim et al. (2017b) concluded that, although herbicides and supplementary weeding might lead to a reasonable high yield, but the method was tedious, time-consuming and not appropriate for large scale production especially a long duration crop like sugarcane. This study therefore was conducted to evaluate weed management options on the pattern of weed seedlings emergence and sugarcane yield across three cropping cycles.

MATERIALS AND METHODS

Description of Study Area

The study was carried out during the 2014, 2015 and 2016 growing seasons at Josepdam Sugar Company Bacita, Nigeria. The site is located on longitude 9^o 05' N; latitude 4^o 57' E and 93.5 m above sea level. The average rainfall recorded during the study years was 1029.4 mm, bimodal rainfall distribution with peaks in June and September, the temperature range between minimum of 28°C and maximum of 34°C. The area is characterized by well drained sandy loam soil with good soil nutritional status.

Experimental Layout and Field Establishment

The experiment which had 6 weed management strategies (weedy check; pre-terbutylazine at 2.0 kg a.i/ha + supplementary hand hoeing (SHH) at 4, 10 and 16 weeks after planting (WAP); post-ametryn at 3.0 kg a.i/ha + SHH at 10 and 16 WAP; post-dicamba at 0.5 kg a.i/ha + SHH at 10 and 16 WAP; pre-terbutylazine at 2.0 kg a.i/ha + post- 2, 4-D at 3.0 kg a.i/ ha; and monthly hand hoeing) was laid out in a randomized complete block design and replicated three times during the plant crop in 2014, first ratoon crop in 2015 and second ratoon crop during the 2016 growing seasons. Ratoon is new sugarcane stand which develops from the underground subterranean buds on stubble of harvested plant cane. Such first regrowth is called first ratoon crop and subsequent regrowth after the harvest of first ratoon is a second ratoon crop and so on.

Allotted weed control treatments, field establishment and maintenance are as detailed in Takim and Suleiman (2017).

Data Collection

Quadrat measuring 0.2 5 m × 0.25 m, was placed at four random locations within each plot at 1, 2, 4, 6, 8 and 12MAP. The emerged weed seedlings were observed, counted, pulled for identification to species level with the aid of relevant weed handbooks like West African weeds by Akobundu et al. (2016). The weeds were separated into broadleaves, grasses and sedges. Weed fresh biomass was determined using a weighing balance and the dry biomass was obtained by subjecting the sampled weeds to oven drying. Data on cane yield was estimated at harvest (12MAP).

Analysis of Variance

The composition of the weed flora was analyzed by calculating the relative abundance (RA) of each species within each experimental field as in Fadayomi and Takim (2009). Crop cycle – weed control interaction for each weed species and morphological group was determined at $p \leq 0.05$ while significant interactions were further analyzed using a biplot software to identify dominant weed species, morphological group and ideal weed control strategy for sugarcane cultivation in the Nigerian savanna.

RESULTS AND DISCUSSION

A total of forty-three (43) weed species were encountered across the trial sites (Table 1) which comprised 63% annual weed species, 28% perennials and 9% were either annuals or perennials depending on the environmental variation. Grasses made up of 66.7% of the 43 weed species identified, 20.0% were sedges and 13.3% were broadleaved. Based on the level of importance, 15 weed species were identified as most prevalent species: *Dactyloctenium aegyptium* (9.61%); *Digitaria horizontalis* (9.36%); *Echinochloa stagnina* (6.87);

Cynodon dactylon (6.12%); *Chroris pilosa* (5.74%); *Ludwigia decurrens* (5.62%); *Paspalum scrobiculatum* (5.24%); *Cyperus iria* (4.87%); *Tridax procumbens* (4.39%); *Cyperus haspan* (3.62%); *Sida acuta* (3.62%); *Senna occidentalis* (3.37%); *Andropogon gayanus* (3.49%); *Rottbeollia cochinchinensis* (2.76%); and *Sorghum arundinaceum* (2.62%).

Table 1
Relative abundance of weed species encountered on sugarcane ecology in Bacita, Nigeria

FAMILY	Weed species	MG	Relative Abundance (%)		
			PC	1RC	2RC
Amaranthaceae	*Amaranthus spinosus* Linn.	B	0.00	0.00	0.56
	Celosia Isertii C.C.Townsend	B	0.00	0.00	1.89
	Celosia leptostachya Benth.	B	0.00	0.00	1.61
Asteraceae	*Conyza sumatrensis* (Retz.) Walker	B	0.00	0.00	0.08
	Eclipta alba (L.) Hassk	B	1.23	2.93	4.39
	Malanthera scandens (Schum. & Thonn.)	B	0.28	0.00	0.00
	Tridax procumbens Linn.	B	3.68	4.29	5.27
	Vernonia cinerea (Linn.) Less.	B	0.42	0.00	0.31
	Vernonia perrottetti Sch. Bip.	B	0.28	0.98	5.73
Caesalpinioideae	*Anthonotha macrophylla* P. Beauv.	B	0.21	0.00	0.21
	Chamaecrista minosolides (L.) Greene	B	0.00	1.29	0.19
	Senna occidentalis (L.) Link	B	3.27	2.85	0.00
Cleomaceae	*Cleome viscosa* L.	B	2.34	3.07	3.10
Combretaceae	*Combretum zenkeri* Engl. & Diels	B	0.14	1.06	3.15
Commelinaceae	*Commelina benghalensis* L.	B	0.00	1.01	1.34
	Commelina diffusa Burm. f.	B	0.59	0.24	0.00
Convolvulaceae	*Evolvulus alsinoides* (Linn.) Linn.	B	2.08	2.76	5.55
	Ipomoea eriocarpa R. Br.	B	0.00	0.00	0.06
Cyperaceae	*Cyperus esculentus* Linn.	S	0.00	0.96	0.00
	Cyperus haspan Linn.	S	3.92	2.36	3.29
	Cyperus iria Linn.	S	4.53	4.70	5.89
	Cyperus rotundus Linn.	S	1.95	1.66	1.63
	Fimbristylis littoralis Gaudet	S	0.91	1.91	3.55
Euphorbiaceae	*Euphorbia hyssopifolia* Linn.	B	0.98	0.73	0.65
Laminaceae	*Solenostemon monostrochyus* (P. Beauv.) Brig	B	1.02	1.00	1.42
Malvaceae	*Malvastrum coromandelianum* (Linn.) Garcke	B	0.49	0.00	1.27
	Sida acuta Burn. f.	B	3.20	4.46	0.26
Onagraceae	*Lugwigia abyssinica* A. Rich	B	1.46	1.75	1.61
	Lugwigia decurrens Walt.	B	5.62	4.21	0.00
Papilionoideae	*Indigofera hirsuta* Linn.	B	0.49	1.22	4.50
	Trephrosia linearis (Willd.) Pers.	B	1.79	1.05	0.00
Poaceae	*Andropogon gayanus* Kunth	G	4.02	1.38	1.74
	Andropogon tectorum Schum. & Thonn.	G	0.53	1.59	2.03
	Brachiaria falcifera (Trin.) stapf	G	1.40	6.75	0.00

Table 1 *(continue)*

FAMILY	Weed species	MG	Relative Abundance (%)		
			PC	1RC	2RC
Poaceae	*Chloris pilosa* Schumach	G	6.07	6.29	0.00
	Cynodon dactylon (Linn.) Pers.	G	5.50	3.18	3.60
	Dactyloctenium aegyptium (Linn.) P. Beauv.	G	9.75	5.02	5.16
	Digitaria horizontalis Willd.	G	8.74	5.19	6.34
	Echinochloa obstusiflora Stapf	G	1.60	1.35	3.00
	Echinochloa stagnina (Retz.) P. Beauv.	G	5.95	5.55	0.00
	Oryza barthii A. Chev.	G	1.27	2.87	0.03
	Panicum laxum Sw.	G	1.75	1.79	0.00
	Pannicum repens Linn.	G	0.24	0.13	0.00
	Paspalum conjugatum Berg.	G	0.38	0.00	0.00
	Paspalum scrobiculatum Linn.	G	5.27	5.83	5.00
	Rottbellia cochinchinensis (Lour.) Clayton	G	2.01	1.43	4.82
	Setaria pumila (Poir.) Roem & Schult.	G	0.24	1.04	0.00
	Sorghum arundinaceum (Desv.) Stapf.	G	2.77	2.68	2.48
Rubiaceae	*Mitracorpus villosus*(Sw.) DC.	B	0.37	0.00	1.18
Solanaceae	*Physalis angulate* Linn.	B	0.68	0.90	2.74
Sterculiaceae	*Melochia corchorifolia* Linn.	B	0.02	0.00	0.00
Tiliaceae	*Corchorus tridens* Linn.	B	0.55	0.56	4.37

MG =Morphological group, PC=Plant crop, 1RC= First Ratoon crop, 2RC =Second Ratoon crop, B= Broadleaves, G= Grasses, S= Sedges

The results from this study agreed with Takim and Amodu (2013) who reported that broadleaves had higher diversity in species on the sugarcane fields but members of the Poaceae dominated the sugarcane weed community Takim et al. (2014). There is a gradual shift from the natural vegetation with predominant annual grasses and broadleaves to perennial weed species in the ratoon cycles. This call for the use of broad spectrum herbicides or mixture of herbicides during the plant crop while a schedule herbicide rotations plan across the ratoon cycles to avoid a decrease responses of weed species to herbicide as a result of its continuous application.

The pattern of weed emergence indicates that weed seedlings emerged throughout the trial period (Figure 1). The peak of weed 'seedling' emergence was at 1 and 4MAP then declined gradually to the lowest emergence at 8MAP and suddenly increased. This implies that, weed control should be targeted during the peak periods of weed seedlings emergence (Takim & Fadayomi, 2013).

Figure 2 is a polygon view biplot showing which weed control strategy had a better efficacy and at which cropping cycle. Guilly et al. (2017) defined the small circle on the polygon as the average-environmental axis (AEA) and the arrow

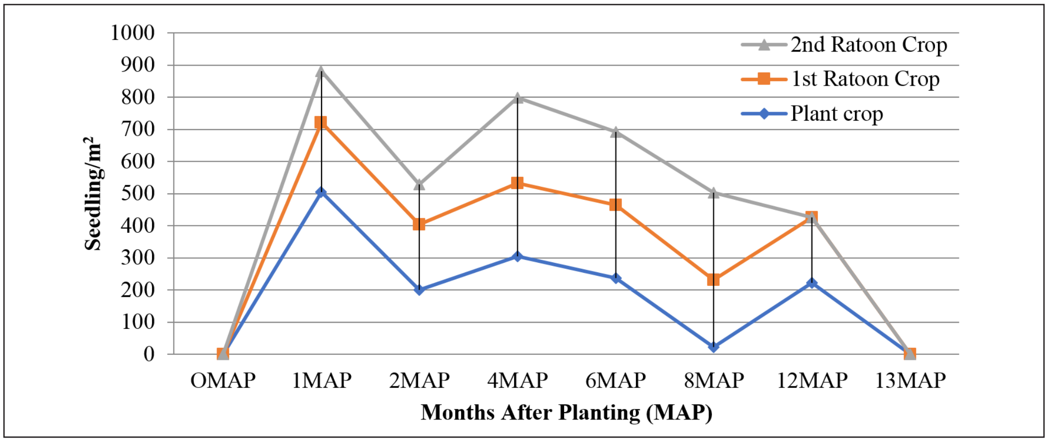

Figure 1. Pattern of weed seedling emergence in a sugarcane ecology

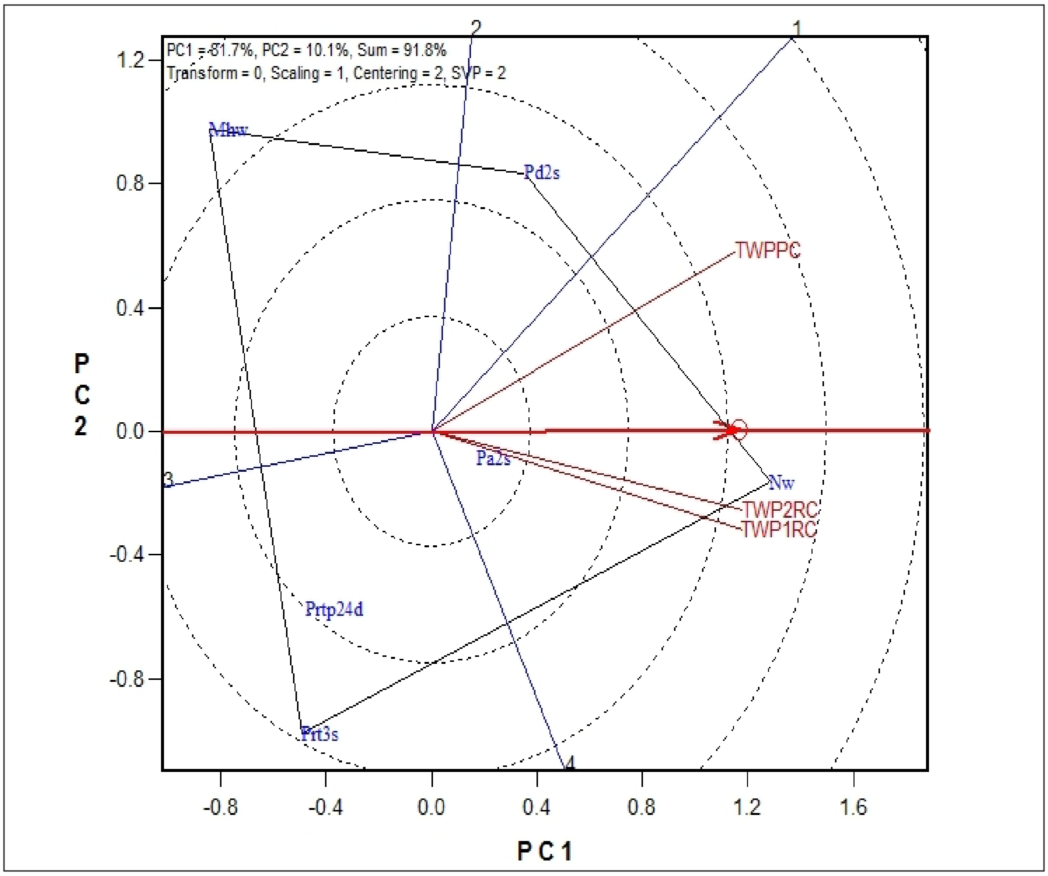

Figure 2. The polygon view of biplot showing which weed control strategy won in which sugarcane cropping cycle TWPPC = total weed population at plant crop, TWP1RC = total weed population at first ratoon crop, TWP2RC = total weed population at second ratoon crop, Pd2s = post dicamba + 2 hoeing, Pa2s = post-ametryn + 2 hoeing, Prtp24d = pre-terbutylazine and 2, 4-D, Prt3s = pre-terbutylazine + 3 hoeing, Mhw = monthly hand handing, Nw = no weeding (weeding check)

pointing to it indicated the direction of the AEA and weed control option. The line ranks the weed control strategy according to their mean efficacy that it approximates the contribution of each method to the cropping cycle. No Weeding (Nw) is the most stable weed control option while post-Ametryn and 2 supplementary hand hoeing (Pa2s) the most unstable weed control option. The monthly hand weeding (MHW) and pre-terbutylazine + post 2, 4-D (Prtp24d) plots had less weed population compared to no weeding plots across the crop cycles. The crop cycles also differed weed population while plant crop (TWPPC) had high weed population but unstable, first ratoon crop (TWP1RC) and second ratoon crop (TWP2RC) had high but stable weed population across the growing seasons.

Figure 3 showed that PC (plant crop) and 1RC (first ratoon crop) had high weeds population as compared to 2RC (second ratoon crop) while grasses were relatively high during PC and 1RC, broadleaves dominated 2RC. The line with the small circle defined by the average efficacy across the cycles and thus it expressed the weed control method contribution to cane yield. Ideal method should have high project towards the arrowed line and near zero projection (Yan, 2001). Pre-terbutylazine + post-2, 4-D was the most stable weed

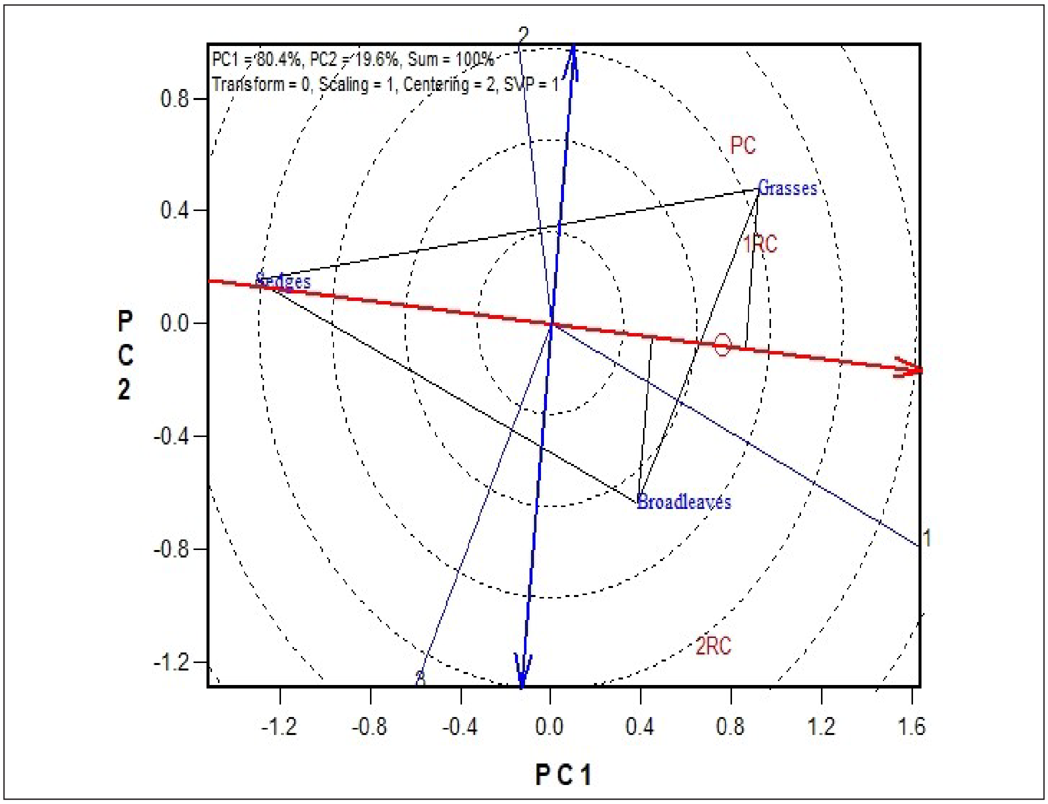

Figure 3. The polygon view of biplot showing which morphological group won in which sugarcane cropping cycle PC = plant crop, 1RC=first ratoon crop, 2RC = second ratoon crop

control method and it was most ideal for plant crop cycle (Figure 4). Other ideal methods but unstable are post-dicamba + 2 supplementary hoe weeding (pd2s) and monthly hoeing. Figure 4 also showed that cane yield of plant crop (CYPC) was more representative and stable while cane yields of other cycles were unstable (Olaoye et al., 2017).

The polygons are divided into several sectors and some of these sectors have weed management options within them suggesting the possibility of different mega-environments (Yan & Rajcan, 2002) existing for the crop cycles of sugarcane (Mattos et al., 2013). Figure 4 shows three mega-environments which included: PrTP2, 4-D, Hoeing and Pd2s as a mega-environment with CYPC, CY1RC and CY2RC. The PC was the best performing crop cycle and PrTP2, 4-D as the most ideal weed management option. Second mega environment had Weedy with no crop cycle and the third mega-environment had two weed management options (Prt3s and Pa2s). However, this mega-environment pattern needs verification through other multi-environment trials for this target region (Takim et al., 2017a). Regarding this pattern, PrTP2, 4-D was the most favourable weed management option having high efficacy across the crop cycles.

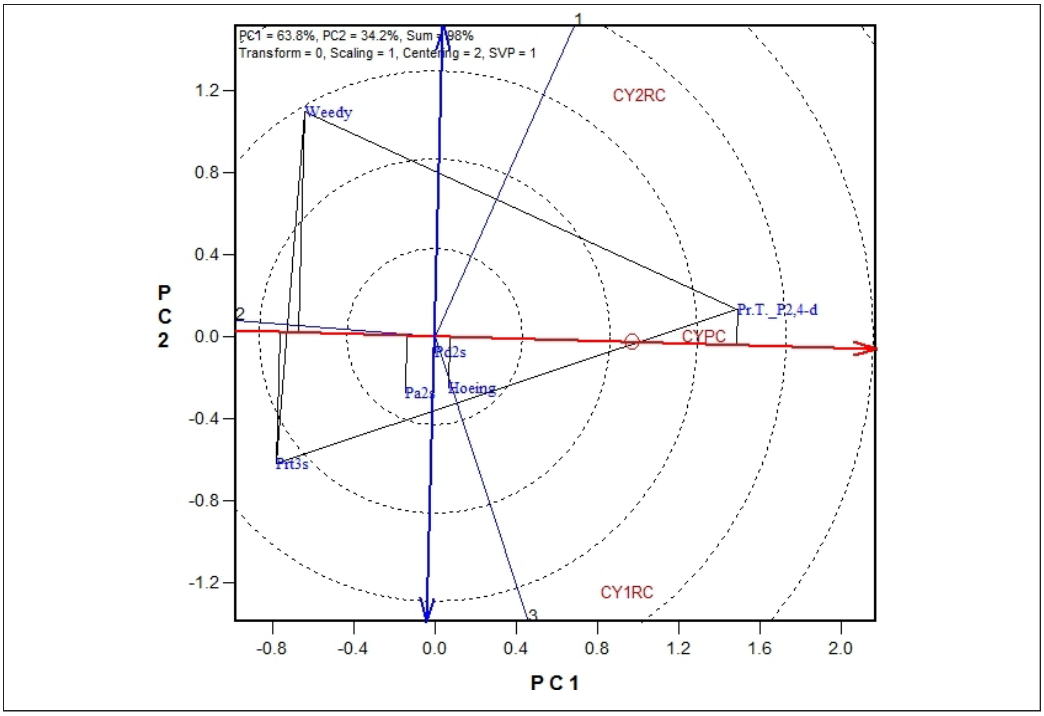

Figure 4. The polygon view of biplot showing which weed control strategy won in sugarcane yield across cropping cycle

CYPC = cane yield of plant crop, CY1RC = cane yield of first ratoon crop, CY2RC = cane yield of second ratoon crop, Pd2s = post dicamba + 2 hoeing, Pa2s = post-ametryn + 2 hoeing, Prtp24d = pre-terbutylazine + 2, 4-D, Prt3s = pre-terbutylazine + 3 hoeing

CONCLUSION

The study concluded that sugarcane ecology was dominated with grasses while broadleaved species were high in diversity; weed control should be targeted at 1 and 4 months after planting; and pre-terbutylazine at 2.0 kg a.i/ha + post-2, 4-D at 3.0 kg a.i/ ha was adjourned to minimized emergence of weed seedlings across crop cycles. This study therefore recommends that pre-emergence application of terbutylazine at 2.0 kg a.i/ha and post-emergence of 2,4-D at 3.0 kg a.i/ ha prior to weeds peak periods could be the appropriate weed control option to the advantage of sugarcane in the southern Guinea savanna of Nigeria.

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