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Research Article

Maize response to competition from Speargrass (*Imperata cylindrica* (L.) Raeuschel) regrowth from planted rhizomes II: Competitive Relationship-Relative Yield and Relative Yield Total.

ABSTRACT

Field study was conducted to evaluate the competitive effect of speargrass shoot regrowth from planted rhizomes on the growth and yield of subsequent maize crop. The competitive relationship study was laid out in a Randomized Complete Block Design with three replications. The study was conducted at the International Institute of Tropical Agriculture Ibadan, Nigeria, between September 2005 and September 2006. In this study maize and speargrass rhizomes were previously planted in eight monoculture densities (4, 8, 12, 16, 20, 32, 48 and 64 plants per plot and eight total densities in a mixture of 1:1 ratio of maize and speargrass (2:2-32:32) per plot in May 2005 and May 2006. .The maize-speargrass regrowth competition experiment was initiated in September 2005 and September 2006 respectively after the previous maize harvest. All plot that had maize or speargrass either as monoculture or in mixture with each other were slashed and subsequently replanted with maize maintaining the previous maize densities earlier planted; while all plot previously planted to speargrass either in monoculture or in mixture with maize were allow to regrow from the previously planted densities .

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Relative yields total (RYT) from the competition study indicated that maize and speargrass were competing for the same resources especially at 8:8 plants of both species in mixture, and there was mutual antagonism from severe competition for light, especially at high densities of both species (10:10-32:32 plants) in mixture. RYT of speargrass regrowth competition with maize was neither significantly higher nor lower than 2.0 for shoot competition (*P*=0.522); and was not significantly different (*P*=0.475) for rhizome competition among the various speargrass densities and proportions in competition with maize. Speargrass regrowth and maize interaction captured three resource competition scenarios of their association as follows: avoidance of competition, whereby individual species exploited the limiting resources separately (where, RYT > 2.0); both species competed fully or partial possibly at all densities in mixture since RYT values were not significantly higher or lower than 2.0; and both species may also have antagonized each other during their growth association (where, RYT <2.0)..

Speargrass is quite expensive to manage, and slashing, often employed by farmers probably encourages higher speargrass rhizome activity, resulting in a more intense competition with associated crops. Farmers should integrate a maize seeding rate that will compete favorably with speargrass shoot regrowth from rhizome by manipulating densities; especially after land preparation.

Key words**:** *Competition, Maize*, *Speargrass regrowth, Rhizome, Relative Yield, Relative Yield Total*

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1. INTRODUCTION

Maize is an important food staple for than 1 billion people in Sub-Saharan Africa, and a preferred crop of 900 million of world poor. In most developing countries it is grown in mixture with other crops or as sole crop [1]. Aggregated production especially in West Africa has shown an increase of about 73% between the 1980s and 2000s [2]. However, this increase is due to expansion in the area under cultivation while productivity per unit area still very low (0.5-1.0 ton/ha) due to several agro ecological factors including weeds infestation. Maize is sensitive to weed competition especially in the first 3 weeks after emergence [3]. Although maize is a vigorous and tall growing plant, it is susceptible to competition from weeds, with losses greater than 30% commonly reported [4]. Maize is a high- risk crop, mainly due to the varying climatic conditions as well as inadequate management practices. Researchers indicate that maize plants are very susceptible to weed competition and yield losses and are estimated at 35% to complete crop failure [5]. To obtain high crop yields weed control is very important because weed compete with maize for nutrients soil moisture and light. Therefore, information on competitive interaction between speargrass and maize will be useful for developing and implementing effective management programs. Speargrass *[Imperata cylindrica* (L.) Rauesch] is a rhizomatous, perennial grass weed, widely distributed throughout the tropics and in some warm areas of the temperate region [6]. It has become a major problem in the production of arable crops such as maize, soybean, and root and tuber crops in forest transition zone of West Africa [7, 8]. Most of the methods of control (hoe weeding, hand pulling and slashing) employed by rural farmers are not effective, because of its ability to infest, spread and colonize native vegetation [9, 10, 11, 12]. Yield loses attributed to speargrass infestation in maize has been reported to be between 40 and 80% [13, 14, 8, 15]. The competitive ability, density of speargrass and the competitive ability of the crop influence the effect of speargrass competition on crop yield. Most experiments conducted on speargrass have been to explore the relative aggressiveness of speargrass and certain crops [15] and few have been accomplished through the experimental manipulation of population crop density, proportion, or spatial arrangement [16]. However, none have critically looked at the interaction between speargrass shoot regrowth and

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maize densities and proportion with the aim of evaluating effects of densities and proportions of speargrass shoot regrowth on maize under the field environment or conditions.

.It is therefore the objective of this experiment to assess the competitive ability of maize against speargrass regrowth from manipulated maize densities

2. MATERIAL AND METHODS

2.1Description of study site

The experiment was conducted at the research farm of International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (7° 30'N, 3° 54'E), in the forest/savanna transition zone. The zone is characterized by an annual rainfall that averaged 1250 and 1500 with a bimodal distribution pattern which peaks in July and September. . Before monitoring the effect of speargrass regrowth on maize, the site was under speargrass fallow for four months The soil type at the experimental site was loamy sand (Alfisol) with a pH of 6.7 and organic matter of <2%, 0.13% N, 3.08 mg/kg P (available), 0.34K (cmol), and soil texture of 85% sand, 5% clay, and 9% silt. The average annual temperature is 26^oC and dominant soil type is Alfisol [17, 8]

2.2 Experimental procedure and design

The speargrass for this study was initially planted on the 25th of May 2005, and May 30th, 2006 in both addition and replacement series experiments [18] from sprouted rhizomes using a grid of 2 m by 2m with 64 quadrilles of 25 cm by 25 cm; and its competitive effect monitored on maize growth. This previous treatment consisted of three replicates of 16 established densities as monoculture, which included eight monocultures of maize and speargrass at the following densities (4, 8, 12, 16, 20, 32, 48, 64) and eight mixtures of maize: speargrass (2:2, 4:4, 6:6, 8:8, 10:10, 16:16, 24:24, 32:32) per plot of 2 m ×2 m. All the plots were slashed immediately after

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harvesting previous maize (approximately 4 months after planting the maize), and maize stover and speargrass shoots packed out of the plots on September 20, 2005 and September 25, 2006 respectively.. The same grid of 2 m × 2 m with 64 quadrilles of 25 × 25 cm was used to replant maize (cv. 'ACR 89-DMR-ESR-W') in all the plots, which included plots previously planted to sole maize and speargrass; and plots that had maize and speargrass in mixture on 13 September 25, ,2005 and September 30, in 2006 . The regrowth experiment was also conducted with three replicates in a randomized complete block design. Each replicate included the same 16 treatments: eight monocultures of maize (4:0, 8:0, 12:0, 16:0, 20:0, 32:0, 48:0, 64:0 per plot) replanted in the same plot they were planted earlier (May 25, 2005 and May 30, 2006), while speargrass monoculture plots were allowed to regrow from the previously planted densities(0:4, 0:8, 0:12, 0:16, 0:20, 0:32, 0:48, 0:64 per plot) in September 25, 2005 and September 30, 2006 For the eight mixtures of maize: speargrass, maize was also replanted into each plot that had the maize: speargrass mixture of various densities and proportions to simulate the treatment arrangement of the experiment earlier in the season. (2:2, 4:4, 6:6, 8:8, 10:10, 16:16, 24:24, 32:32 per plot).. Maize seedlings were thinned to one stand per hill one week after planting. All plots were kept free of other weeds that may interfere with competition between the target species by weekly hand pulling of weeds. Basal fertilizer was applied at a recommended rate of 45 kg ha^{-1} of N, P_20_5, and K_20 at 2 weeks after planting (WAP) on October 9, 2005 and October 14, 2006, while urea at 45 kg N ha^{-1} was applied at 6 WAP, on 30 October 2005 and October 30 2006. Both types of fertilizers were applied broadcast.

2.3 Data Collection

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In both years data were collected on total above ground biomass of both species by cutting at the soil surface, and below ground biomass of speargrass (rhizomes) on 27 December 2005 and on 30 December 2006, to evaluate relative yield and relative yield total of both species in mixture. An area of $2m^{-2}$ of was harvested from each plot for the determination of total above biomass of maize and speargrass. Speargrass rhizomes–were excavated by digging to the depth of 30-40 cm and manually separated from the soil for dry weight determination. Both maize and speargrass plant samples were oven dried in a Gallenkamp oven (OVE–300 Plus Series) at 80 ^{o}C until constant mass was recorded with a digital balance (XD–4K B042809, Denver Instrument Company, USA).

2.4 Data Analysis

All the data collected was analyzed by year. The completive relationship between maize and speargrass was calculated using the following indices of competition, relative yield (RY) and relative yield total (RYT). The relative yield total (RYT) is an index which measures the relative performance of mixtures compared with the corresponding monoculture [19, 20, 21, 22, 23]. The relative yield total (RYT) describes how the species in mixture share or utilize common limiting resources. Values of RYT approximating two (2.0) indicate that two species are in competition for the same limiting resources. Values of RYT > 2.0 means the species avoids competition and may somehow allow for over-yielding. Values of RYT < 2.0 imply mutual antagonism.–The relative yield total of (RYT) measured was based on the mean plant biomass yield of maize and speargrass. .The relative yield (RY) and relative yield total (RYT) were calculated as follows:

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Relative yield of maize (RYm): RYm =Yms/Ymm…… [1]

Relative yield of speargass (RYs): RYs = Ysm/ Yss …….... [2]

Relative yield total (RYT) RYT = RYm +RYs…… [3]

Where RYm, RYs, Yms, Ysm, Ymm and Yss are the relative yield of maize, speargrass, the mean yield/plant of maize and speargrass in mixture, the mean yield/plant of maize and speargrass in monoculture. However, competition effect of speargrass regrowth on maize was partitioned into the follow: (1) speargrass shoot competition with maize, (2) speargrass rhizome competition with maize and (3) the effect of whole plant of speargrass (shoot + rhizome). This was derived by mere calculation of the relative yield and relative yield total.

ANOVA was performed using the MIXED MODEL and general linear model (GLM) procedures in the Statistical Analysis Systems software (SAS) [24, 25]. In the mixed model procedure, years and replication were considered random effects in the model. Data were analyzed and presented by year. Least-square means of the individual treatment effects were separated using the contrast at P = 0.05 and standard error of the means in the LSMEANS output, and least significant difference (LSD) for relative yield (RY) and relative yield total (RYT).

3. RESULTS

3.1 Relative yield (RY) and relative yield total (RYT) of maize and speargrass regrowth in competition

In 2005, the relative yield of maize (RYm) in mixture with speargrass, except at 8:8 and 32:32 plant proportions in mixture with speargrass, was not significantly

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(P≥0.05) higher than 1.0 (Table 1). However, RYm at 4:4 (0.96) plant proportions was not significantly different from 1.0. Similarly, in 2006, except at 24:24 (maize: speargrass) proportions, RYm of all proportions in mixtures was not significantly different from the pure stand expectation (1.0). RYm at 6:6 plant proportions (0.99), though lower than 1.0, and was not significant (Table 1).

Similarly in 2005, except at 4:4 (0.84) and 2:2 (0.75) plant proportions; speargrass, relative yield of speargrass shoot (RYs) were significantly less than 1.0 for the plant proportions of 6:6 –32:32 in mixture (Table 1). The overall effect was a RYT that was lower than 2.0 at 6:6-32:32 plant proportions, but the values were not significantly different from 2.0 (Table 1). The RYT of all the different proportions of maize and speargrass in mixture did not differ significantly (P > 0.05), However, RYT at 2:2 (2.08) and 8:8 (2.56) plant proportions were higher than 2.0. RYT in 2006 at all proportions were not significantly different from pure stand expectation (2.0) (P>0.05), meaning that maize and speargrass are equal resource competitors. However, RYT was higher at plant or mixture proportions of 6:6 (3.24), 8:8 (2.53) and 24:24 (2.13), indicating that the competition effect was negligible (partial), or that at one time maize and speargrass were making different demands on the resources. The RYs at the 6:6 (1.32) plant proportion was significantly higher than RYs at plant proportions of 2:2 (0.63), 10:10 (0.55), 16:16 (0.36), 24:24 (0.42), and 32:32 (0.26) plant proportion in mixture. However, RYs at 6:6 was significantly higher than 1.0 (pure stand yield expectation). RYs was lowest at 32:32 (0.25) plant proportions (Table 1). Thus, at high densities of the species proportions in mixture (10:10-32:32) speargrass did not develop to its potentials; hence it did not contribute its expected share to the mixture yield. Hence, the RYT average of the years for the

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higher density proportion was lower than the expected total yield of 2.0. The RYT of all the mixtures when averaged over the years was neither significantly higher nor lower than 2.0 (*P*=0.5224). Thus, speargrass shoot competition with maize captures the three different interpretations of competition based on the RYT of the species in competition , which therefore means that speargrass shoot regrowth competition with maize can result as follows: (1) both maize and speargrass avoided competition, thus they exploited the resources differently, especially at 6:6 and 8:8 plant proportions (RYT > 2.0); (2) they also may have competed fully or partially at certain times of growing together possibly at all proportions in mixture, since RYT values calculated were not significantly higher or lower than 2.0; (3) both species may have also antagonized each other at certain periods of the association, especially at 10:10, 16:16, and 32:32 proportions (RYT <2.0).

TABLE.1. Relative yield and the relative yield total (RYT) of maize and speargrass shoot in response to competition from the speargrass shoot regrowth.

Mixture proportions		RY			RY		
Maize	Speargrass	Maize	Shoot	RYT	Maize	Shoot	RYT
No. per plot		2005	2005	2005	2006	2006	2006
2	2	1.33	0.75	2.08	1.30	0.52	1.82
4	4	0.96	0.84	1.80	1.39	0.50	1.89
6	6	1.12	0.40	1.52	0.99	2.24*	3.24
8	8	1.93	0.63	2.56	1.13	1.39	2.53
10	10	1.28	0.49	1.71	1.10	0.61	1.71
16	16	1.36	0.34	1.70	1.14	0.38	1.53

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24	24	1.53	0.27	1.80	1.56*	0.56	2.13
32	32	1.69	0.22	1.91	1.33	0.29	1.62
LSD for proportion		0.81	0.56	1.11	0.695	1.78	1.82

*, Significantly different from 1.0, at $P < 0.05$

LSD (P=0.05) for comparing 2005 RYT with 2.0= 0.722

LSD (P=0.05) for comparing 2006 RYT with 2.0= 1.266

LSD (P=0.05) for comparing years average RYT with 2.0= 0.697

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3.2 Relative yield (RYr) and relative yield total (RYT) of speargrass rhizome in competition with maize (belowground competition).

RYT in 2005 relative to speargrass rhizome (RYr) competition was not significantly (P=0.4752) different among various speargrass densities and proportions in competition with maize (Table 2). In both years, RYT except at 8:8 was lower than 2.0, as well as not significantly different from 2.0. indicating that there may have been an antagonistic effect between maize and speargrass rhizomes at these proportions, and may also have competed for the available growth resources at one stage (Table 2). RYT for rhizome in 2006 was also not significantly different with the various densities and proportions (P>0.05) due to rhizome competition. In 2006, at plant proportions of 10:10, 16:16, and 24:24, RYT was lower than 2.0, but was not significantly different from 2.0, while at 2:2(2.09), 4:4 (2.07), 32:32 (2.03), and 8:8(2.01) RYT were approximately 2.0, indicating that maize and speargrass rhizomes at these proportions in mixture were fully competing for the same resources (Table 2). The RYT result in 2006 seems to suggest that competition with maize was greater with rhizomes (cutting across four densities and proportions) than with shoots at the same density. The averaged RYT of the mixture proportions for the period of study was not different (P>0.05). The years' average RYT at 8:8 (2.27), 6:6 (2.16), and 2:2 (2.04) were slightly higher than 2.0, while at 4:4 (1.95), 32:32 (1.94) and 24:24 (1.83) proportions RYT values were less than or approximately 2.0, while at 16:16 (1.68) and 10:10 (1.6) mixtures, values were not significantly lower than 2.0.

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TABLE 2. Relative yield and the relative yield total (RYT) of maize and speargrass rhizome in response to below ground competition from rhizome in replacement proportion.

Mixture proportions		RY			RY		
Maize	Speargrass	Maize	Rhizome	RYT	Maize	Rhizome	RYT
No. per plot		2005	2005	2005	2006	2006	2006
2	2	1.33	0.66	1.99	1.30	0.78	2.08
4	4	0.96	0.85	1.81	1.39	0.67	2.07
6	6	1.12	0.33	1.46	0.99	1.87	2.86
8	8	1.93	0.59	2.52	1.13	0.88	2.01
10	10	1.28	0.41	1.63	1.10	0.48	1.58
16	16	1.36	0.37	1.73	1.14	0.48	1.63
24	24	1.53	0.26	1.79	1.56	0.31	1.87
32	32	1.69	0.16	1.84	1.33	0.70	2.03
LSD for plant proportion		**0.81**	**0.50**	**1.01**	**0.695**	**1.56**	**1.76**

LSD (P=0.05) for comparing 2005 RYT with 2.0= 0.658

LSD (P=0.05) for comparing 2006 RYT with 2.0=1.16

LSD (P=0.05) for comparing years average RYT with 2.0=0.623

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3.3 Relative yield and relative yield total of speargrass plant (shoot + rhizome) in competition with maize in replacement proportion

In 2005, RYT was ≥ 2.0 only at 2.2 and 8:8 plant proportions, meaning that it was only at these proportions that speargrass reached its growth potentials and hence contributed to the total yield (Table 3). However, the RYT value was not significantly different from 2.0, indicating that speargrass competed at these proportions or densities with maize. However, at 32:32, 4:4, 16:16, 10:10, RYT ≥ 1.50 ≤ 1.88, and at 6:6, RYT was 1.49. These values were not significantly different from 2.0, and can be interpreted as follows: (1) since RYT was lower than 2.0, there may have been an antagonistic effect between maize and speargrass regrowth at a certain period of their growth association, (2) at another stage of their interaction in the mixture, both may have competed for the same resource, hence RYT was not significantly lower or different from 2.0. In 2006, the RY of speargrass at 6:6 (1.89) and 8:8 (1.23) plant proportions in mixture with speargrass grew to its potential and thus contributed significantly to the mixture yield (Table 3). The result indicated that maize and speargrass may have exploited the resources differently at 6:6 mixtures, and may have competed at 8:8 mixtures, since RYT was not significantly different from 2.0. At the rest of the species proportion in mixture, RYT was not significantly lower than 2.0, meaning that they may have been an equal competitive effect between maize and speargrass, as well as the antagonistic effect between them, The RYT of the proportions over the years was not different from each other, and

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hence was not different from 2.0 (P>0.05), indicating that speargrass competed with maize equally.

. **TABLE 3. Relative yield and the relative yield total (RYT) of maize and speargrass biomass (shoot + rhizome) in competition with maize in replacement proportion**

Mixture proportions		RY			RY		
		Maize	Total biomass	RYT	Maize	Total biomass	RYT
Maize	Speargrass						
No. per plot		2005	2005	2005	2006	2006	2006
2	2	1.33	0.71	2.04	1.30	0.62	1.92
4	4	0.96	0.84	1.81	1.39	0.56	1.96
6	6	1.12	0.37	1.49	0.99	1.89*	2.89*
8	8	1.93	0.61	2.54	1.13	1.23	2.36
10	10	1.28	0.44	1.67	1.10	0.57	1.67
16	16	1.36	0.35	1.71	1.14	0.42	1.56
24	24	1.53	0.27	1.80	1.56	0.36	1.92
32	32	1.69	0.20	1.88	1.33	0.44	1.77
LSD		0.81	0.52	1.06	0.695	1.06	1.183

LSD (P=0.05) for comparing 2005 RYT with 2.0= 0.693

LSD (P=0.05) for comparing 2006 RYT with 2.0=0.813

LSD (P=0.05) for comparing years average RYT with 2.0=0.515
*, Significantly different from 1.0, *P* <0.05

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3.4 Relative yield and relative yield total of maize and speargrass biomass (shoot + rhizome) in competition with maize in addition proportion

At all densities in addition proportions with speargrass in both years, maize grew to its potential, hence RY was ≥1.0 at all proportions (P>0.05), (Table 4). The relative yield (RY) of speargrass plant in competition with maize was less than 1.0 in both years (Table 4) hence speargrass did not grow to reach its potential, it therefore did not contribute its expected share to the mixture yield. Therefore, the relative yield total (RYT) of both plants in competition, except at 8:8 (RYT maize–speargrass =1.77± 0.14, in 2005 and 1.88 ± 0.17, in 2006) was significantly (P≤0.05) less than the total pure stand yield expectation of both species (2.0) in both years (Table 4). Combined analysis of both years indicates that speargrass competed equally with maize only at 8:8 maize: speargrass proportion in mixture, hence RYT was not different from 2.0 at this proportion (P>0.05), while at 4:4, 16:16, and 32:32 species proportions, RYT was significantly (P<0.05) different from 2.0 (Table 4).

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Table 4. Relative yield and the relative yield total (RYT) of maize and speargrass biomass in competition in addition proportion

Mixture Proportion		Relative yield (RY) of maize and speargrass				Relative yield total (RYT)		
		2005		2006				Combined
Maize	Speargrss	Maize	Speargrass	Maize	Speargrass	2005	2006	
4 :	4	0.97	0.40***[1]	0.92	0.39**	1.37**	1.32**	1.34**
8 :	8	1.20	0.57**	1.19	0.69a	1.77	1.88	1.82
16 :	16	1.27	0.23***	0.78	0.27**	1.50**	1.05**	1.27**
32 :	32	0.84	0.14***	0.72	0.26**	0.98b**	0.98**	0.98**
[2]LSD (P=0.05)		0.69	0.34	0.48	0.66	0.71	0.84	0.43
[3]LSD (P=0.05)		0.44	0.22	0.30	0.39	0.42	0.53	0.30

[1] *, **, *** significantly different from 1.0 for RY or 2.0 for RYT $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$ respectively

[2]LSD for comparing densities and proportion of mixture

[3]LSD for comparing densities in competition with expected mixture yield (2.0)

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4. DISCUSSION

The effect of competition from speargrass regrowth affected the growth and development of both species in pure or mixed cultures. However, maize also responded to density effect. However, data on the RY of both maize and speargrass indicate that an increase in the relative yield of maize resulted in a decrease in the relative yield of speargrass. But this effect on speargrass was lower or not significant at previously lower density proportions of maize: speargrass. RYT values of speargrass when grown with maize at the various proportions were either lower or not significantly different from 2.0; meaning that both species antagonized each other at one stage of their growth, and also may have competed at another stage. This confirms the results of previous replacement series experiments where, maize and speargrass growing in mixture were crowding for the same resources (competing for the same resources) and are mutually exclusive [19]. RYT lower than 2.0 indicate an antagonistic effect between maize and speargrass. The observed antagonistic effect between maize and speargrass is attributable to severe competition for light, which is evident by the intensity of competition at high maize densities. These results are in agreement with similar studies that report on nutsedge competition with maize and tomato [26]. Since maize and speargrass have similar growth habits and life cycles, the two species may have been competing for the same resources and the success of speargrass in this case may be dependent on the extent of rhizome regrowth and interference. Species exhibiting similar growth forms and life cycles may compete more for specific resources at similar times of their growing seasons, thus intensifying interference

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between them [20]. Previous studies on the nature of crop weed competition have shown that belowground (roots or rhizomes) competition has a greater effect on the relative performance of species than does above ground (shoot) competition [27, 28, 29, 30,]. Though the RYT values were not statistically different from 2.0, they suggest that speargrass was incapable of realizing its potential yield due to the shading effect of maize on speargrass especially at the high maize densities. Although speargrass was established from presprouted rhizomes, maize grew taller and developed a closed canopy faster than speargrass. This may have induced shade over speargrass, and reduce PAR available to speargrass,which therefore reduced speargrass competitive ability against maize However, rhizomes competitive ability with maize in this study was possible at all densities in mixed proportions, especially being higher at low density proportions. This result suggest that greater rhizome competition may be wieghted by the fact that the ecological survival of speargrass is depended much on the activity and viability of the rhizomes.. The under ground rhizome reserves of speargrass have been reported to contribute significantly in its competitive ability in crops [31,32]. Speargrass would require more time to develop significant quantities of rhizome reserve under closed maize canopy to be able to out compete maize in a 1:1 mixed proportion.The following mechanisms probably account for the pattern of interference observed in this study (1) mutual antagonism might be occurring through competition for resources (especially light), (2) not all the resources were available to speargrass and (3) low and inconsistent light availability under the maize canopy.The result from this study does not completely agree with reports of previous studies conducted on speargrass infested field, which identified speargrass as being more

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competitive than maize [33,34]. The observed differeces in the competitive ability of maize and speargrass from previous reports may be attributed to differential densities and proportion of the species in competition, as well as canopy relationship of the species. This is moreso as the density of maize may have been fixed across all level of speargrass infestation, and also under varied management strategies. However, under varied densities the result is likely to differ, due to species canopy relationships and densities. Though, maize was more competitive than speargrass in 1:1mixture in this study, there was also an indication that speargrass competed with maize, and this can be more intense depending on the density and proportion in competition, and duration of infestation. However, previous reports have shown that response of relative yield to mixed ratio depends on total density of the species in proportion [35,36].

5. CONCLUSION

The outcome of this study fits into the various interpretations of weed crop competition, based on the relative yield total (RYT). The competitive interaction between maize and speargrass indicate that both compete for the same resources, but there was also a mutual antagonism in which neither maize nor speargrass contributed its expected share to the yield of the mixture. The antagonistic effect observed was attributable to canopy relationship and perhaps competition for light resources. Their competitive interaction and ability depends on the proximity, the regrowth stage, and the canopy relationship during growth association. The greater competitiveness of speargrass regrowth, as we observed, may be apparent only under conditions of relatively high speargrass infestation and long duration of competition. Speargrass competition can be intensified if disturbance due to

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slashing encouraged shoot regrowth from rhizomes, because rhizome competition was found to have a greater effect on the relative performance of speargrass. Thus speargrass densities of 8-16 plant m^{-2} in mixture with maize had the greatest rhizome biomass due to vigorous regrowth. Slashing, often employed by farmers probably encourages higher speargrass rhizome activity, resulting in a more intense competition with associated crops. Speargrass is quite expensive to manage if effective control is required, farmers should try to use or integrate a maize seeding rate that will give the optimum population that will reduce the effect of speargrass shoot regrowth from rhizome after land preparation. Such maize population density will maximize the relative competitive ability of maize and minimizes the effect of speargrass.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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