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RESEARCH ARTICLE

ALLELOPATHIC POTENTIAL OF *Parkia biglobosa* PLANT EXTRACTS ON *Striga hermonthica* (DEL.) BENTH CONTROL IN HYBRID MAIZE (*Zea mays* L.)

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Abstract

Phytochemical potentials of *Parkia* extracts was evaluated on hybrid variety and local maize cultivars to determine their efficacy on the control of *Striga hermonthica* (DEL). The experiment was carried out in both the laboratory and later evaluated in a 2 x 2 x 3 factorial experiment in a randomized complete block design (RCBD) with three replications. The results obtained revealed that *Parkia* fruit extracts had a greater inhibitory effect on *Striga* emergence count but not significantly different from that of seed powder extracts. There was also significant varietal differences (P>0.001) to *Striga* infection, farmer's local was more strongly affected than the hybrid Across 97TZL. This result also suggested that both *Parkia* fruit and seed powder extracts have phytotoxic effects on the control of *S. hermonthica*. The hybrid Across 97TZL supported low *Striga* emergence and low infection to *Striga* damage than the farmer's local. This revealed that the hybrid is more resistant to *Striga* infection than the farmer's local. There was significant interaction between inoculation and variety on maize shoot and *Striga* shoot dry weight.
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Introduction

The root obligate hemi-parasitic weed, *Striga hermonthica* (Del.) Benth, is a major biotic constraint to food production in the Nigerian Savannas because their hosts are subsistence on economically important C4 crops most especially sorghum, maize, pearl millet, sugar cane and upland rice and are grown in areas marginal for agriculture production due to land intensification of cereal based monocropping. Yield losses associated with *Striga* damage are often significant, ranging from 40 to 100% even under good management (Lagoke *et al.*, 1991), which result in little or no food at all for millions of subsistence farmers and consequently aggravate hunger and poverty. This is inconsistent with the pursuit of attainment of the Millennium Development Goal one (MDG 1); which is the eradication of extreme poverty and hunger by half by the year 2015.

Several control measures against *Striga* have been practiced ranging from host plant resistance (Lagoke *et al*., 2000; Marley *et al*., 2004); chemical (Ariga and Berner, 1993; and biological control (Onu *et al*., 1996; Marley *et al*., 1999; Nekoum and Marley, 2002), but so far none has given consistent, effective and economically feasible results when used alone (Eplee *et al.*, 1991).

Modern agriculture has been greatly relying on chemical use as a labor-saving tool for weed control and high yields. The intensive and repeated application of agrochemicals produces a wide range of toxic side-effects that pose a potential hazard to the environment. Recently, due to environmental considerations, many herbicides have been criticized as being chemical pollutants (Meksawat and Pornprom, 2010).Therefore, there is a need to develop natural herbicides that are not toxic to the environment. The development of herbicides from naturally occurring plant chemicals is one method that has the potential to reduce detrimental environmental impacts and harmful effects on human health especially in organic agriculture.

Some plant parts including leaves (Kumari and Kohli, 1987), roots (Horsley, 1977), pollen (Cruz-Ortega *et al*. 1988), trichomes (Bansal, 1990), bark (Kohli, 1990), as well as seeds and fruits (Friedman *et al*. 1982) have allelopathic potential. Kohli *et al*. (1998) suggested that a great number of plants, including crops, trees and weeds, have alleopathic potential. Recently, there have been reports of the inhibitory activity of the powder extracts from *Parkia* fruit and fruit peel powder on germination and seedling growth of *S. hermonthica* on sorghum (Marley *et al.*, 2004). Phytochemical analysis reported by (Lane *et al.*, 1991) also revealed the presence of steroids, triterpene, carotenoids, tannins and polyphenolic compounds in *Parkia* pods. These secondary metabolites are suspected to be the allelochemicals that have effects on *Striga* seeds germination. However, its role in allelopathy is not fully understood. Therefore, the objective of the study is to determine the allelopathic potential of *Parkia* fruit and seed powder extracts on the germinability of *Striga hermonthica*as it affects maize plant growth.

MATERIALS AND METHODS

Collection and Preparation Parkia based products

Matured locust bean pods (*Parkia*) that were grown in fields in North Bank, Makurdi, guinea savanna zone of Nigeria, were harvested and separated into fruits and seeds. These plant portions were cut, decorticated, dried at 40^{o}C for 1 week, and ground into a powder using electric blender in order to pass through a (<1mm) sieve screen mesh. These powders were stored dry in plastic bottles at ambient temperature until it was required. Two water-soluble extracts of *Parkia* pulp and seed powder were obtained. The water soluble extracts were prepared by dissolving 400 mg of each extract powder in 100 mL of distilled water, stirred to form slurry at 25^{o}C for 24 hours.

Preparation *S. hermonthica* seeds

S. hermonthica seed collected in 2007 were cleaned to remove chaff by passing them through a 250 μm sieve. The *Striga* seed were then mixed with sand that have been sieved through a 250 μm screen at a ratio of 1:39 by weight to obtain approximately 3000 germinable seed per gram of sand to seed mixture as described by Berner *et al.*, (1996) to form the stock. Each experimental pot (19cm wide x 22cm high) was filled with soil (5kg/pot) obtained from a field belonging to the Experimental Farm of the College of Agriculture, Yandev that had no history of *Striga* infestation. The soil was air dried, and then one gram of the sand/seed mixture as per the different seed concentrations (5 and 10 c.c/pot) required was placed in each pot and thoroughly mixed with soil before maize seeds were placed in the hole and saturated with tap water before planting was done. Planting was done on the 22nd of July, 2008 and was terminated 77 days after sowing (DAS). Compound fertilizer 15:15:15 (N:P:K) and urea were applied 21 and 42 DAS respectively at the recommended rate of 1.38g/pot. The inoculums of *Parkia* pulp extract and *Parkia* seed extract each were mixed thoroughly with the *Striga* sand seed mixture and each of the *Parkia* infested pots and uninfested control were preconditioned for 7 days. The temperature in the green house was maintained at 25 to 30^{o}C. Maize seeds (Across 97 TZL and farmers' local) were sown two each in the planting holes. The plants were maintained by regular watering as necessary for optimal maize development.

The treatments were arranged as a 2 x 2 x 3 factorial experiment in a randomized complete block design (RCBD) with three replications. All the data were subjected to analysis of variance (ANOVA). The treatment means were separated by using Fisher's Protected Least Significant Difference (LSD) test at P = 0.05.

RESULTS AND DISCUSSION

Number of days to *Striga* emergence was delayed significantly by the powder extracts of *Parkia* from 1-2 weeks after the first *Striga* emergence (Table 1). Maximum inhibition was observed in the *Parkia* fruit treated pots (57 DAS) when compared to 50 and 43 DAS in the *Parkia* seed and distilled water treated pots respectively. These results suggest that *Parkia* extracts can inhibit *Striga* emergence better with *Parkia* fruit powder extracts than seed powder extracts and the control. Magani *et al.*, (2009) revealed similar reports in the field experiment where 1 week delayed in Striga emergence was recorded between the *Parkia* fruit and the control.

There was no significant effect of maize varieties (P=0.002) and *Striga* seed concentration (P=0.374) on number of days to *Striga* emergence. The relatively mild effects of *S. hermonthica* on Across 97 TZL when compared to farmers' local can be explained, at least to some extent by a delay in the onset of germination it is well documented that differences in production of germination stimulants exist between cultivars. (Hess *et al.,* 1992; Reda *et al.,*1994).

In general, the *Parkia* fruit extracts had a greater inhibitory effect on *Striga* emergence count but it was not significantly different from that of the seed powder extracts and the control except at 40 DAS (figure 1). Our findings of the allelopathic effects of *Parkia* are consistent with similar effects reported for other plant species. For instance, *Parkia biglobosa* (Marley *et al.,* 2004), *Rottboellia cochinchinensis* (Meksawat and pornprom, 2010) and *Dicranopteris linearis* (Chong and Ismail, 2006) release allelochemicals that have been found to suppress the growth of other plant species. These results suggest that *Parkia* fruit and seed powder extracts have phytotoxic activity because of the direct release of a possible toxic substance(s) from the living plant parts and the indirect release of a toxic substance(s) after degradation of the extracts due to decomposition by microorganisms in the soil. There is overwhelming evidence that plant phenolic play a major role in Allelopathy (Chong and Ismail, 2006). Lane *et al.,* (1991) reported that Phytochemical analysis of *Parkia* pods revealed the presence of plant phenolic compounds. Several studies have suggested that the effects of allelochemicals on the target plants last a short time after application. Their decomposition in the environment seems faster than organic chemicals (Dayan *et al*. 1999). However, in terms of weed control, the weed can emerge after the applied allelochemicals have either decomposed or their concentration has decreased.

There is significant varietals differences (P<0.001) to *Striga* infection (figure 2). It was evident that farmers' local was more strongly affected than Across 97 TZL at 56, 63, 70 and 77 DAS. However, at 40 and 48 DAS, there was no difference in *Striga* emergence count in respect with the two cultivars. Probably, this difference may be partly as a result of delayed attachment of the parasite on Across 97 TZL plants or partly, the relatively, high level of tolerance of the host which determine the amount of resources potentially available for the parasite. For farmers' local variety, the initial growth and development of *Striga* plants were relatively high, indicating a more compatible host; this host plant was strongly affected by the parasite. Observed difference between variety in early attachments and their expected influence on the final growth reduction on the plant are a strong indication that control practices based on a delay in first attachments could contribute to a reduction in the *S. hermonthica* problem (Van delft, 1997).

The *Striga* emergence counts were not significantly affected by seed concentration (figure 3). In the low infested pots, *Striga* emergence count was on the average 37% lower than in the high (10cc) seed concentration throughout the period of observation. In this study, the *Striga* seed concentration resulted to intraspecific competition of the emerged *Striga* evident by smaller *Striga* shoots that emerged in pots. Webb and Smith (1996) observed this phenomenon between seedbank density and *Striga* emergence.

Percentage germination of maize at 10 DAS are presented for both varieties. A non-significant effect (P=0.516) of *Parkia* extract on % germination of maize were observed (Table 1). Inoculation with *Parkia* fruit powder extract resulted in higher number of maize seed germination. However, percentage germination of Across 97 TZL did not differed significantly from that of the farmers' local variety (P=0.134) resulting in percentage germination of 98.6% and 92.80% respectively. Moreover, *Striga* seed infestation at low (5cc) concentration did not differed significantly from that of the high (10cc) seed concentration (P=0.715).

Except for *Striga* seed concentration, the maize shoot and *Striga* shoot dry weight were significantly different in respect to inoculation of the *Parkia* powder extracts and maize varieties (Table 1). In general, the maize shoot dry weight was greater in the *Parkia* fruit extract as compared to *Parkia* seed powder extract and the control. For *Striga* shoot dry weight, an increase in maize shoot dry weight was accompanied by a decrease in *Striga* dry weight. The parasite causes a reduction in leaf photosynthetic rate and changes in plant architecture (Watling and Press, 2001). This suggest a partitioning of biomass into the leaf component of the host relative to the biomass accumulated by the *Striga* as a result of the inhibitory effects of allelochemicals present in *Parkia* pods. Across 97 TZL supported low *Striga* emergence and low infection to Striga damage than the farmers' local variety. This variety was classified as resistant in earlier studies (Kuchinda *et al.,* 2003; Haussmann *et al.,* 2001). However, there was no differences in respond to high (10cc) and low (5cc) *Striga* concentration. This may be related to persistence levels of the *Striga* seeds in the presence of the host.

There was significant interaction between inoculation and variety on maize shoot and *Striga* shoot dry weight. This indicates that the plant did not respond to the same treatment. The highest maize shoot dry weight was obtained with *Parkia* fruit powder extract on Across 97 TZL which significantly differed from other treatments except *Parkia* fruit extracts on farmers' local variety (Table 2). However, the highest *Striga* shoot dry weight was obtained with the distilled water control treatment on farmers' local variety.

Except for *Striga* seed concentration, the shoot growth of maize plants was significantly different for inoculation and variety. In general, the mean maize shoot length in the *Parkia* fruit infested pots was longer than the

Parkia seed powder extract. The shortest was observed with the distilled water control (Table 1). This suggest a inhibitory effect of allelochemicals present in the *Parkia* fruit powder extract as a result of the partitioning of biomass into the leaf component that favours the accumulation of photosynthates.

The inference of our study suggests that maize seeds can be shielded from parasitism through the critical initial period as a result of the allelopathic potential of the *Parkia* extracts leading to significant yield increases complemented by reductions in *S. hermonthica* reproduction. We conclude that *Parkia* fruit and seed might be used as a powder extracts material in *S. hermonthica* control to reduce dependence on herbicides. However, more experiments are needed to determine if the efficacy of *Parkia* could be enhanced, as well as to analyze the active allelochemicals inside *Parkia* plants. This would be a promising start in producing bio-herbicides for *S. hermonthica* control.

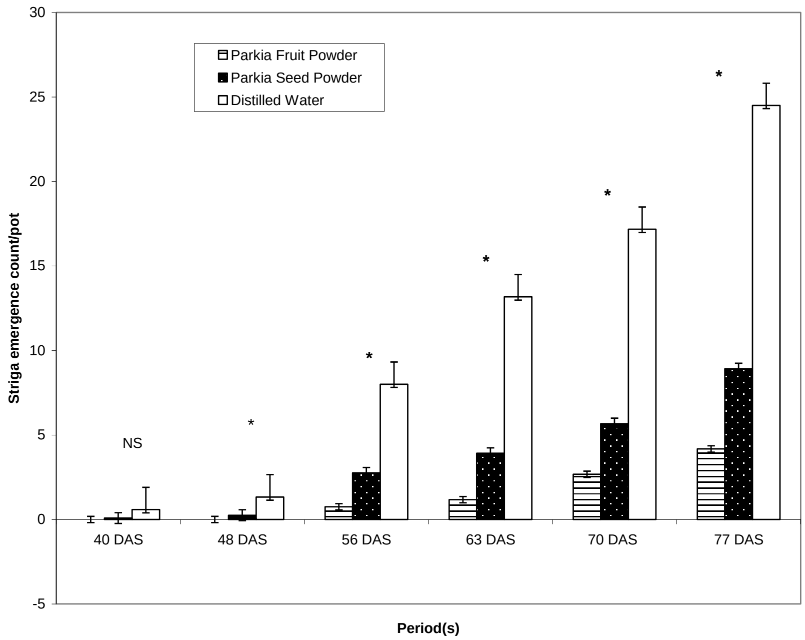

Fig. 1: Effect of *Parkia* powder extracts on *Striga* emergence count. * indicate significant differences according to the t-test at P < 0.05. The vertical lines at the top of the columns show standard error of the means. NS, not significantly different.

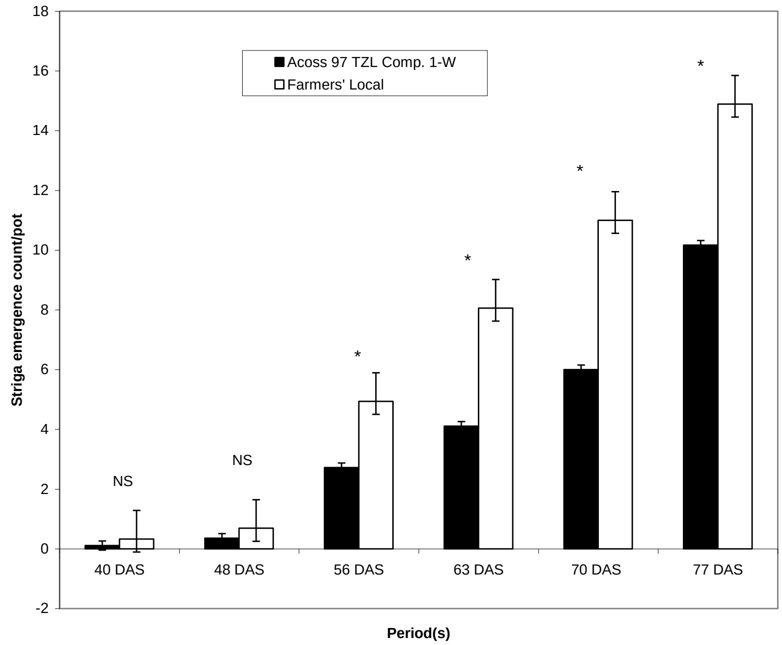

Fig. 2: Effect of variety on *Striga* emergence count. * indicate significant differences according to the t-test at P < 0.05. The vertical lines at the top of the columns show standard error of the means. NS, not significantly different.

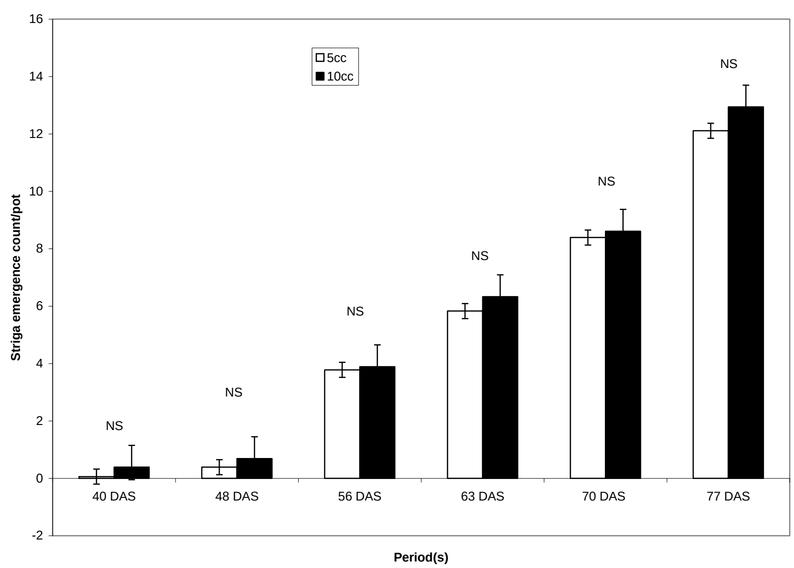

Fig. 3: Effect of *Striga* seed concentration on *Striga* emergence count. * indicate significant differences according to the t-test at P < 0.05. The vertical lines at the top of the columns show standard error of the means. NS, not significantly different.

Table 1: Phytotoxic Effect of *Parkia* Powder Extracts on *S. hermonthica* and Maize Growth

Treatment	First *Striga* emergence (DAS)	% Germination	Maize plant height at 77 DAS (cm)	Maize shoot dry weight (g/plant)	*Striga* shoot dry weight (g/plant)
Inoculation					
Parkia fruit powder	56a	98.8	90.27a	56.08a	2.11c
Parkia seed powder	50b	94.6	81.36b	51.93b	3.65b
Distilled water	43c	93.8	57.26c	38.64c	9.21a
F-test	*	NS	*	*	*
P-value	< .001	0.51	< .001	< .001	< .001
Variety					
Across 97 TZL	53	98.6	79.97	52.75a	3.83b
Farmer's local	47	92.8	72.63	45.01b	6.15a
F-test	NS	NS	*	*	*
P-value	0.002	0.134	< .001	< .001	< .001
***Striga* seed concentration**					
5 cc	51	96.4	78.82	49.97	4.71
10 cc	49	95.00	73.78	47.79	5.27
F-test	NS	NS	NS	NS	NS
P-value	0.374	0.715	0.007	0.030	0.109
Contrast(s)					
Inoculation x Variety	NS	NS	NS	*	*
Variety x *Striga* concentration	NS	NS	NS	NS	NS
Inoculation x Striga concentration	NS	NS	NS	NS	NS
Inoculation x Variety x *Striga* concentration	NS	NS	NS	NS	NS
Means	50	95.7	76.30	48.88	4.99
Coefficient of variation (%)	10.7	11.8	6.70	5.70	20.30
Standard error	5.326	11.25	5.074	2.811	1.012

*Significantly different at 5%. Means in the same column followed by the same letters are not significantly different by Fisher's Protected Least Significance Difference test at P=0.05, NS, Not significantly different.

Table 2. Interaction effect of inoculation x variety on Maize shoot dry weight and Striga shoot dry weight at 77 DAS.

Inoculation	Variety		Variety	
	Across 97 TZL	Farmer's local	Across 97 TZL	Farmers' local
	Maize shoot dry weight (g)		*Striga* shoot dry weight (g)	
Parkia fruit powder extract	56.92a	55.23ab	1.37e	2.86d
Parkia seed powder extract	53.55bc	50.33cd	3.20cd	4.10c
Distilled water	47.78d	29.50e	6.92b	11.50a
$LSD_{0.05}$	3.37		1.21	

Means in the same column followed by the same letters are not significantly different by Fisher's Protected Least Significant Difference test at P = 0.05.

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