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The use of Parkia *biglobosa* based products in the control of *Striga hermonthica* in maize (*Zea mays*. L.)

Magani I.E.[1]*, Ibrahim A.[2] and Avav. T.[1]

[1]Department of Crop and Environmental Protection, University of Agriculture, P.M.B 2373, Makurdi, Nigeria.
[2]Department of Agronomy, Nasarawa State University Keffi, Nasarawa State, Nigeria.

* Corresponding author e – mail: m.enochistifanus@yahoo.com

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ABSTRACT

Objective: To evaluate the effect of two Parkia (*Parkia biglobosa*) based products for the control of *Striga hermonthica* in the Nigeria Savanna.

Methodology and results: Three weed control treatments (post emergence POE) Triclopyr, 2, 4 – D, each at the rate of 0.36kg a.i/ha and a hoe weeded check at 3 and 6 weeks after sowing [WAS]) and seed coating (soaking for 20 minutes in Parkia fruit powder, Parkia seed powder and distilled water as control) were laid out in a split – plot design with three (3) replications using farmers' variety of maize (local); assigning weed control treatments and maize seed coating into main and sub – plots, respectively. The trials were carried out in two locations (Makurdi and Lafia). Generally, the number of maize plants infected with *Striga* was higher in Lafia than in Makurdi. Seed coating with Parkia based products resulted in significantly less plants infected with *Striga* when compared to soaking in distilled water. The POE of either Triclopyr or 2, 4 – D each at the rate of 0.36kg a.i/ha at 6 Weeks After Sowing delayed the emergence of *Striga* to 51 and 45 days after sowing (Days After Sowing), respectively. Treatments with Parkia based (fruit and seed powder) products significantly increased maize grain yield than the distilled water soaking; while the weed control treatments differed significantly in terms of maize grain yield, following the order: POE Triclopyr (2090kg/ha) > POE 2, 4 – D (1833 kg/ha) > hoe weeded check (1340kg/ha)

Conclusions and application of findings: The study results demonstrate the potentiality of using Parkia based products for the control of *S. hermonthica* followed by either Triclopyr or 2, 4 – D POE at 6 WAS. The Parkia trees are abundant within the savanna and thus their fruits can easily be procured. This implies that farmers could adopt this method and integrate it with other Striga management practices such as host plant resistance and cultural practices to enhance *Striga* control.

Key words: Biocontrol, *Striga hermonthica*, *Parkia biglobosa* based products, maize.

INTRODUCTION

Striga hermonthica (Del) Benth. is a parasitic weed that is endemic in the African Savannas where it parasitises many cultivated crops such as sorghum, rice, millet, maize, sugarcane as well as pasture and wild grasses (Weber *et al*., 1995). It is the dominant parasitic weed species in the

Nigerian Savanna, occurring in ecological zones extending from latitudes 7 – 14 ^{0}N. It is one of the major threats to cereal production and severe damage can cause total crop loss in farmers' fields particularly under low fertility conditions (Lagoke *et al*., 1991; Ogungbile *et al*., 1998; Marley *et al*., 2002; Kim *et al*., 2002).

Management approaches for control of *Striga* in Nigeria are generally based on cultural control strategies such as trap cropping, appropriate rates of fertilizer and suitable herbicide application, hand pulling and hoe weeding (Kuchinda *et al*., 2003), and host plant resistance (Lagoke *et al*., 2000; Marley *et al*., 2004); chemical (Ariga & Berner, 1993; Bagonneaud – Berthome *et al*., 1995) and biological control (Onu *et al*., 1996; Marley *et al*., 1999; Nekoum & Marley, 2002) . However, the use of plant products for the control of *S. hermonthica* is limited, though the effect of plant materials especially neem (*Azadiractha indica*) products have been reported to significantly control some organisms e.g. insects (Jackai *et al*., 1992; Gahukar, 2000; Abdulai *et al*., 2003), fungi (Kale & Holey, 1994; Devi & Prasad, 1996; Agbenin, 2002), and to some extent nematodes (Abdel – Razek & Gowen, 2002; Agbenin, 2002; Amadioha, 2002).

Powder from the fruits of *P. biglobosa* that is used in the control of *S. hermonthica* has been reported to be beneficial to the soil agrochemical properties (Kambou *et al*., 1997). In a study of the inhibitory ability of different concentrations of Parkia fruit extracts on the germination of *S. hermonthica* seed in Burkina Faso using *in vitro* culture method (Lane *et al*., 1991), phytochemical analysis revealed the presence of steroids, triterpense, carotenoids, tannins and polyphenolic compounds in Parkia fruits. The derived polyphenolides, notably the tannins, are the active biological substances. According to Field and Lettinga (1989) tannins are the main secondary oxidates in Parkia and are toxic to animals especially in aquatic area (Mahadavan & Mulhukama, 1980). The tannins also possess antimicrobial properties (Scalbelt, 1991; Field & Lettinga, 1992). Kambou *et al*. (1997) reported germination inhibition of 97 – 100% and 92% of *Striga* seeds when untreated powder extract and decorted powder of Parkia were used, respectively. However, in Nigeria, evaluation of the effect of fruit and fruit peel powder of Parkia trees under field and green house condition in the Northern Guinea Savanna indicated less *Striga* emergence with 29.1 and 38.8%, respectively (Marley *et al*., 2004).

The present study focuses on assessment of the effects of two products from *P. biglobosa* for the control of *S. hermonthica* in the Nigerian Savanna.

MATERIALS AND METHODS

Collection and preparation of Parkia based products: Matured and dried Parkia fruits were collected from North Bank, Makurdi. The Parkia fruits were peeled; the fruit powder and seed were separated and allowed to dry under sunlight for about 14 days. Thereafter, they were separately ground into fine powder (<1mm) and stored dry until required.

Field evaluation: The field experiments were conducted in 2007/2008 wet seasons at the Teaching and Research Farm of the University of Agriculture, Makurdi (07^{0}14'N, 08^{0}37'E) and the Model Extension Village, Danka – Sarki, Lafia (08^{0}3'N, 07^{0}31'E) in the Southern Guinea Savanna agroecological zone of Nigeria. The two sites were naturally and heavily infested with *S. hermonthica*. The trials were established at Makurdi and Lafia on 28th May and 16th June 2008, respectively. The two sites of the trial were ploughed, harrowed and ridged at 0.75 m apart. Local maize variety was planted at 50 cm apart. Before planting, the maize seeds were soaked for a period of 20 minutes in the different concentrations of Parkia based products. Maize seeds were added to the slurry and mixed thoroughly in order to obtain bio-fortified maize at 400g/litre of the concentrations of Parkia fruit powder and the Parkia seed powder and another 1000 maize seeds that were soaked in one liter of water as the control.

The trials were planted in a split – plot design with three replications. The three weed control methods (post emergence (POE) Triclopyr, 2, 4 – D each at the rate of 0.36 kg a.i/ha and a hoe weeded check at 3 and 6 WAS) formed the main plot treatments while the maize

seed coating (soaking for 20 minutes in Parkia fruit powder, Parkia seed powder and distilled water as control) were the sub – plot treatments, respectively. The gross and net plot sizes were 9 and 4.5 m^2 (4 ridges and 2 ridges of 3m length each), respectively. Spot application of fertilizer was carried out at 120 kg N/ha, 60 kg P_2O_5/ha and 60 kg K_2O/ha to maize using 15 – 15 – 15 N – P – K compound fertilizer at 3 WAS and later top – dressed with urea at 6 WAS. The post – emergence herbicides (2, 4 – D and Triclopyr) were applied at 6 WAS at 20% *Striga* infestation using a knapsack sprayer (CP3) with spray volume of 250l/ha.

Observations made included number of maize plants infected, *Striga* shoot count per unit area, days to first *Striga* emergence, weight of 1000 grains and grain yield. The data collected were subjected to analysis of variance and means compared using Least Significant Difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Number of days to *Striga* emergence was not significantly affected by locations, seed coating and different weed control methods (Table 1). In respect to locations, Lafia had earlier emergence of *Striga* (41 DAS) than Makurdi (45 DAS). Soaking maize seeds in distilled water initiated early emergence (40 DAS) but was not statistically different from coating with Parkia seed powder. With the weed control treatments, post emergence application of either 2, 4 – D or Triclopyr at 0.36 kg a.i/ha each at 6 WAS delayed the emergence of *Striga* by 51 and 45 DAS, respectively.

Table 1: Effect of *Parkia biglobosa* and post emergence herbicides on number of maize plants infected, and the time of emergence on *Striga* at Makurdi and Lafia, 2008 wet season.

Treatments	Number of days to Striga emergence	Number of maize plants infected with Striga		
Treatments		9 WAS	12 WAS	Harvest
Makurdi	45[a]	2.48[b]	2.96[b]	3.41
Lafia	41[b]	2.85[a]	3.48[a]	3.93
LSD	7.43	1.42	0.97	0.42
Seed Coating				
Parkia Fruit powder	46[b]	1.89[b]	2.39[b]	2.33
Parkia Seed powder	43[ab]	2.50[b]	2.94[b]	3.06
Distilled water	40[b]	3.61[a]	4.33[a]	5.66
LSD	4.46	0.63	0.78	0.55
Weed Control				
POE Triclopyr (0.36kga.i/ha)	51[a]	1.56[b]	2.06[b]	2.33
POE 2, 4 – D (0.36kga.i/ha)	45[a]	2.11[b]	2.50[b]	3.06
Hoe weeded (check) at 6WAS	33[b]	4.33[a]	5.11[a]	5.61
LSD	8.00	0.80	0.67	0.55
Interaction(s)				
Loc x Wc	NS	NS	NS	NS
Loc x Sc	NS	NS	NS	NS
Sc x Wc	NS	NS	NS	*
Loc x Sc x Wc	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letters are not significantly different at 5% level suing LSD. POE = Post – emergence; WAS = Weeks after sowing.

In the trials, locations, seed coating and weed control methods differed significantly with respect to the number of plants infected at 9 and 12 WAS (Table 1). Generally, the number of plants infected with *Striga* was highest in Lafia than in Makurdi. This may be attributed to high *Striga* seed bank density in Lafia than in Makurdi. At 9 and 12 WAS, seed coating with Parkia based products (fruit or seed) resulted in significantly lower number of maize plants infected with *Striga* when compared to the use of distilled water. The data in this report supports farmers practice in Nigeria where they use neem and Parkia products for *Striga* control, among other practices such as the use of brine (NaCl) solution (Gworgwor *et al*., 2002). Our results also

support Kambou *et al*. (1997) whereby different concentrations of Parkia pod extracts were used to inhibit the germination of *S. hermonthica* seed in Burkina Faso. Based on phytochemical analysis Lane *et al.* (1991) reported the presence of sterols, triterpenes, carotenoids, tannins and polyphenolic compounds in Parkia pods. The derived polyphenolics, notably the tannins, are reported to be the active biological substance.

Post emergence (POE) application of either Triclopyr or 2, 4 – D at the rate of 0.36kg a.i/ha each resulted in less plants infected than the hoe – weeded check (Table 1). However, at harvest, there was no significant difference between the different treatments in respect to the number of plants infected with *Striga*. However, the trend indicates more plants infected with *Striga* in Lafia, with distilled and hoe weeded check as with location, seed coating and weed control methods, respectively. The use of hormonal type of herbicides such as 2, 4 – D, Triclopyr POE has been reported to significantly reduce the number of emerged Striga (Lagoke *et al*., 1993). Triclopyr kills the target weed by mimicking the plant growth hormone auxin (indole acetic acid). The exact mode of action of triclopyr has not been fully described, but it is believed to inhibit cell division and growth.

Table 2: Effect of *Parkia biglobosa* and post – emergence herbicides on *Striga* shoot count, weight of 1000 grains and grain yield at Makurdi and Lafia, 2008 wet season.

Treatments	Striga shoot count			Weight of 1000 grains (g)	Grain yield (Kg/ha)
Location	9WAS	12WAS	Harvest		
Makurdi	3.22^{b}	8.78	11.56	288.5^{a}	1790
Lafia	4.04^{a}	7.52	13.48	284.4^{b}	1719
LSD	0.70	1.62	3.26	22.14	6030
Seed Coating					
Parkia Fruit Powder	1.89	6.06^{b}	8.83^{c}	294.4^{a}	2167^{a}
Parkia Seed Powder	2.67	7.50^{b}	11.44^{b}	285.6^{ab}	1957^{a}
Distilled Water	6.33	10.89^{a}	17.38^{a}	279.4^{b}	1138^{b}
LSD	1.35	1.49	1.04	9.64	208.30
Weed Control					
POE Triclopyr (0.36kga.i/ha)	1.69^{b}	3.33^{c}	7.11^{c}	293.9^{a}	2090^{a}
POE 2, 4 – D (0.36kga.i/ha)	2.67^{b}	7.00^{b}	9.89^{b}	285.6^{b}	1833^{b}
Hoe Weeded (check at 6WAS	6.61^{a}	14.11^{a}	20.56^{a}	280.0^{b}	1340^{c}
LSD	1.17	2.08	2.13	8.83	161.9
Interaction(s)					
Loc x Wc	NS	NS	*	NS	NS
Loc x Sc	NS	*	NS	NS	NS
Sc x Wc	NS	NS	*	NS	NS
Loc x Sc x Wc	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letters are not significantly different at 5% level using LSD. POE = Post – emergence; WAS = Weeks after sowing.

There was significant interaction between seed coating and weed control methods at harvest on the number of plants infected with *Striga* (Table 3). Soaking seeds in distilled water either with hoe weeded check or post emergence application of 2, 4 – D at the rate of 0.36kg a.i/ha resulted into significantly higher number of plants infected. This was followed by either using distilled water and POE of Triclopyr at 6 WAS or Parkia seed powder and hoe weeded check. The use of Parkia fruit powder either with POE of Triclopyr or 2, 4 – D at the rate of 0.36kg a.i/ha each gave the least number of plants infected with *Striga* but this was not statically different from using Parkia seed powder and applying Triclopyr at the rate of 0.36kg a.i/ha at 6 WAS. This study suggested that the efficacy of Parkia – based products could be enhanced through synergism with synthetic herbicides applied at rates below those recommended by the manufacturer (Boyette, 2008).

There were significant differences in *Striga* shoot count at 9, 12 WAS and harvest in respect of locations, seed coating and weed control methods (Table 2). At 9 WAS Lafia had significantly higher *Striga* shoot count than Makurdi. Seed coating did not significantly affect *Striga* shoot count, but the seeds

soaked in distilled water had more *Striga* shoot count. Results from this study showed that Parkia based products possess a strong allelopathic potential and exhibit strong inhibition on *Striga* germination. A number of allelochemicals that were identified in dodder (*Cuscuta* spp) plant, including terpenes, phenols, phenolic acids, long – chain fatty acids, and lactose are similar to those in Parkia based products (Tran *et al*. 2008). These chemicals have been previously reported to inhibit plant growth. Terpenes are known to exhibit strong herbicidal activities (Singh *et al*., 2002; Agelini *et al*., 2003; Nishida *et al*., 2005) while coumaran was reported as a highly effective volatile insecticidal compound (Scharf *et al*., 2006). One of the major secondary metabolites of plants are phenolic compounds that act as allelochemicals that inhibit growth of other organisms in the plant's vicinity. The phenolic acids contained in Parkia were earlier reported to strongly suppress growth of plants (Patterson, 1981; Elzaawely *et al*., 2005).

Table 3: Interaction effect of seed treatment and weed control on number of plants infected at Harvest, 2008 wet season.

Weed Control	Seed coating		
	P. Fruit powder	P. Seed powder	Distilled Water
POE Triclopyr (0.36kga.i/ha) [a]	2.00[cd]	2.17[cd]	4.00[b]
POE 2, 4 – D (0.36kga.i/ha)[a]	2.17[cd]	2.83[c]	6.00[a]
Hoe weeded (check) [b]	2.83[c]	4.17[b]	6.83[a]
LSD		0.98	

[a] = 6 weeks after sowing; [b] = 3 and 6 weeks after sowing; Means in a column of any set of treatments followed by different letters are not significantly different at 5% level using LSD. POE = Post emergence; WAS = Weeks after sowing.

Table 4: Interaction effect of location and seed treatment on Striga shoot count at 12 WAS, 2008 wet season.

Seed Coating	Location	
	Makurdi	Lafia
P. fruit powder	2.56[e]	4.11[de]
P. seed powder	7.67[c]	6.33[cd]
Distilled water	16.11[a]	12.11[b]
LSD (P<0.05)	2.51	

Means in a column of any set of treatments followed by different letters are not significantly different at 5% level using LSD.

The fatty acids are documented as common plant growth inhibitors (Tsuzuki *et al*., 1987; Khanh *et al*., 2006) and it has been suggested that these allelochemicals are responsible for the strong inhibitory activities of Parkia based products against the emergence and subsequent growth of *Striga*. To date, several reports have shown that secondary metabolites from hosts stimulate the below ground growth of parasitic plants that attach to their roots (Bouwmmeester *et al*., 2003) and that host-derived substances also induce haustorial development by these parasitic plants (Yoder, 2001).

At 12 WAS and at harvest, location was not significantly different in respect of *Striga* shoot count (Table 2). However, under the same period of observation, seeds soaked in distilled water recorded higher *Striga* shoot count than those treated with Parkia based products. This is attributable to the suppressive ability of the allelochemicals contained in Parkia based products (Lane *et al*. 1991; Kambou *et al*., 1997). In the weed control treatments, the POE of Triclopyr or 2, 4 – D at the rate of 0.36kg a.i/ha resulted in significantly fewer shoot count than the hoe weeded check.

There were significant interactions between location x seed coating at 12 WAS, location x weed control methods and seed coating x weed control methods at harvest on *Striga* shoot count (Table 4, 5 and 6). At 9 WAS, seeds soaked in distilled water and planted at Makurdi had significantly higher *Striga* count than all other treatments. This was followed by distilled water treatment at Lafia while the lowest was obtained in Makurdi with treatment of Parkia fruit powder (Table 4). Hoe weeded check in Lafia recorded the highest *Striga* count and followed in that order by the check in Makurdi. The lowest was recorded by POE of Triclopyr at the two locations (Table 5). In the interaction effects

of seed coating and weed control method on *Striga* count at harvest revealed that the use of either Parkia based products with POE of Triclopyr at 0.36kg a.i/ha recorded the least (Table 6). Lane *et al.* (1991) had earlier identified the presence of triterpenes, carotenoids, tannins and polyphenolic compounds in parkia pods. Their chemical structures are very stable due to their aromatic substances. Germination inhibition of 97 – 100% and 92% *Striga* was achieved using the untreated powder extract and decorted powder of Parkia, respectively (Kambou *et al.* 1997). The evaluation of fruit peel powder of Parkia trees under field and green house condition in the Northern Guinea Savanna resulted in reduced *Striga* emergence with 29.1 and 38.8%, respectively (Marley *et al.* 2004).

Table 5: Interaction effect of location and weed control on Striga count at harvest 2008 set season.

Weed Control	Location	
	Makurdi	Lafia
POE Triclopyr (0.36kga.i/ha)	8.67^{de}	9.00^{de}
POE 2, 4 D – (0.36kga.i/ha)	10.67^{cd}	12.22^{c}
Hoe weeded check (3 and 6 WAS)	15.33^{b}	19.22^{a}
LSD (P<0.05)	2.51	

Means in a column of any set of treatments followed by different letters are not significantly different at 5% level using LSD. POE = Post emergence; WAS= Weeks after sowing.

Table 6: Interaction effects of seed treatment and weed control on Striga count at harvest 2008 wet season.

Weed control	Seed coating		
	P. Fruit powder	P. Seed powder	Distilled Water
POE Triclopyr (0.36kga.i/ha) ^{a}	5.00^{fg}	6.67^{efg}	14.83^{c}
POE 2, 4 – D (0.36kga.i/ha) ^{a}	6.83^{ef}	9.17^{de}	18.33^{b}
Hoe weeded (check) ^{b}	9.50^{d}	13.83^{c}	28.50^{a}
LSD	3.12		

^{a} = 6 weeks after sowing; ^{b} = 3 and 6 weeks after sowing; Means in a column of any set of treatments followed by different letters are not significantly different at 5% level using LSD. POE = Post emergence; WAS = Weeks after sowing.

Location, seed coating and weed control methods differed significantly with respect to weight of 1000 grains (Table 2). Makurdi location had significantly heavier grains than Lafia, similar to earlier reports by Lagoke *et al.* (1993). Among the seed coating treatments, Parkia fruit powder produced significantly heavier grains, but this was not statistically different from those treated with Parkia seed powder. The seeds treated with distilled water had the least weight of 1000 grains. In the weed control treatments, POE of 2, 4 – D at the rate of 0.36kg a.i/ha and hoe weeded check resulted in the least significant 1000 grains weight while the heaviest was with treatment that received POE Triclopyr at the rate of 0.36kg a.i/ha.

Locations had no significant effect on grain yield (Table 2). However, the better yield of (1790 kg/ha) was obtained in Makurdi than that of Lafia (1719 kg/ha). The high *Striga* infestation recorded at Lafia over Makurdi may be responsible for the low maize grain yield. Treatments with Parkia based products (fruit and seed powder) significantly increased grain yield than soaking in distilled water (Table 2). The ability to suppress parasites by the allelochemicals contained in the Parkia products might have been responsible for better performance of the maize plants and thus increased grain yield. The weed control methods differed significantly in terms of grain yield, following the order: POE Triclopyr > POE 2, 4 – D > hoe weeded check (2090kg/ha > 1833kg/ha > 1340kg/ha), respectively. This study confirms earlier reports whereby 2, 4 – D, Triclopyr applied POE significantly reduced the number of emerged Striga and subsequently increased grain yields of sorghum and maize (Lagoke *et al*., 1993).

CONCLUSION

Parkia trees are abundant within the savanna and thus their fruits can easily be produced. The Parkia fruit powder and fruit peel are by – products obtained after processing the Parkia beans (seeds), and thus can also be easily procured. Therefore, farmers could adopt this method and continue this practice by integrating Parkia

use with other Striga management practices (Emechebe *et al*., 1991) such as host plant resistance and cultural practices. However, the mechanism by which these plant products successfully control *Striga* needs to be further investigated.

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