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Effects of Organic Manure and Botanical Seed Treatment on Striga Hermonthica Control in Sorghum Bicolor

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Abstract

Sorghum (*Sorghum bicolor* L. Moench) is a staple food source in sub-Saharan Africa. It also constitutes a basic feed component in the livestock industry. Despite its socio-economic importance, sorghum yield is seriously threatened by *Striga hermonthica* infestation. The objective of this study was to determine the impacts of organic manure and *Parkia biglobosa* pulp powder powder on *Striga hermonthica* control in sorghum. The experiment was conducted in a screen house at the Teaching and Research Farm, Federal University of Technology, Minna, Nigeria. The research was a 2×4 factorial experiment in a completely randomised design with sixteen treatments in three replications. Treatments consisted of combinations of four levels of organic manure and *Parkia biglobosa* pulp powder powder each at 0, 40, 80, and 120g/bag. Data were collected on *Striga* emergence, *Striga* height, *Sorghum* plant height, and the number of leaves per plant. The data were subjected to analysis of variance at p=0.05. The results showed that *Striga* emergence did not vary significantly throughout the sampling periods. However, the treatment used inhibited the growth of *Striga*. Organic manure at the rate of 120 g /bag resulted in the highest number of *Sorghum* plant height, leaves and dry weight. The interaction effect of *Parkia* pulp powder powder and botanical seed treatment was significant ($p<0.05$) on *Striga* emergence, plant height and sorghum dry weight. The combination of the treatments suppressed more than 75 % of *Striga hermonthica* emergence. These findings revealed that organic farming can effectively be used to combat *Striga hermonthica* in sorghum.

Effets du Fumier Organique et du Traitement des Semences Botaniques sur le Contrôle de Striga Hermonthica Dans le Sorgho Bicolor

Résumé

Le sorgho (*Sorghum bicolor* L. Moench) est une source alimentaire de base en Afrique subsaharienne. Il constitue également un composant alimentaire de base dans l'industrie de l'élevage. Malgré son importance socio-économique, le rendement du sorgho est sérieusement menacé par l'infestation de *Striga hermonthica.* L'objectif de cette étude était de déterminer les impacts de la fumure organique et de la poudre de pulpe de *Parkia biglobosa* sur le contrôle de *Striga* hermonthica dans le sorgho. L'expérience a été menée dans une serre à la ferme d'enseignement et de recherche de l'Université fédérale de technologie de Minna, au Nigeria. La recherche était une expérience factorielle 2 × 4 dans une

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conception entièrement randomisée avec seize traitements en trois répétitions. Les traitements consistaient en des combinaisons de quatre niveaux de fumier organique et de poudre de pulpe de Parkia biglobosa chacun à 0, 40, 80 et 120 g/sac. Des données ont été recueillies sur l'émergence du *Striga*, la hauteur du *Striga,* la hauteur de la plante de sorgho et le nombre de feuilles par plante. Les données ont été soumises à une analyse de variance à p=0,05. Les résultats ont montré que l'émergence de *Striga* ne variait pas de manière significative tout au long des périodes d'échantillonnage. Cependant, le traitement utilisé a inhibé la croissance de *Striga*. Le fumier organique à raison de 120 g/sac a donné le plus grand nombre de hauteur de plante de sorgho, de feuilles et de poids sec. L'effet d'interaction de la poudre de pulpe de *Parkia* et du traitement des semences botaniques était significatif (p <0.05) sur l'émergence du *Striga*, la hauteur de la plante et le poids sec du sorgho. La combinaison des traitements a supprimé plus de 75 % de l'émergence de *Striga hermonthica*. Ces résultats ont révélé que l'agriculture biologique peut être utilisée efficacement pour lutter contre *Striga hermonthica* dans le sorgho.

Mot clé :
Agriculture biologique, Fumure organique, Poudre de pulpe de Parkia et lutte contre le Striga hermonthica

Introduction

The primary centre of origin and diversity for sorghum are believed to be in sub-Saharan Africa extending from the extreme East to West Africa (Tarekegne, 2014) Sorghum is an indigenous crop of Ethiopia where a tremendous amount of variability exists in-country (Adugna, 2007). It has a diversity of both domesticated and wild relatives which revealed Ethiopia as the centre of origin and diversity (Mekibeb, 2009). The United States is the world's largest producer of sorghum followed by Mexico, Nigeria, Sudan and India, Ethiopia is the third-largest producer of sorghum and one of the major sorghum growing countries in Africa next to Sudan and Nigeria (FAO, 2019). The crop is the fifth most important grain crop globally after maize, wheat, rice, and barley (FAO, 2015). It is the main staple food crop for more than 500 million people in Africa, Asia and Latin America particularly in semi-arid tropical regions where drought is the major limitation to food production. According to FAO (2017), Africa is the world's regional leader in the total production of sorghum. *Striga* species of the Orobanchaceae family are obligate root parasites that infest staple crops in sub-Saharan Africa, the Middle East, and parts of Asia (Parker, 2012). The *Striga*, particularly *S. hermonthica* has become a major threat to food security, exacerbating hunger, and poverty in many African countries (Khan *et al*., 2014). *Striga* is affecting the lives of more than 300 million people in Africa and causing enormous yield losses with a value ranging from US$7 - 10 billion annually (Rodenburg *et al*., 2010). Ejeta (2007) estimated that *Striga* affected 100 million hectares in cereal fields in Africa. Globally, nearly one million hectares of sorghum fields have been reported to be infested with *Striga*, resulting in yield losses ranging from 20 to 80 % (Hearne 2009).

Several control practices have been recommended for reducing *Striga* infestation. These include the use of resistant varieties, cultural practices, and chemical control methods (Hearne 2009). Research on the identification of control measures for *Striga hermonthica* in Africa has been conducted for the last seven decades and is still ongoing. Various control methods (e.g. land preparation, hand-pulling, hoe-weeding, trap cropping) have been tried out singly or in combination over the years with no conclusive and consistent results for the peasant farmers. This could partly be attributed to the huge amounts of seeds that accumulate over time in the seed bank (Oswald, 2004). Other methods are crop rotation, and injection of ethylene gas (Radi, 2007). The use of natural products could also inhibit the germination of *Striga* seeds to deplete the *Striga* seed bank in the soil (Yonli *et al*., 2010). Debrah *et al*. (1998) reported that *Striga* abundance is favoured by continuous cropping and low soil fertility, and hence does not do well on soils with high organic matter content. Organic manure is a complex mixture of living, dead and decomposed materials which include naturally occurring organic materials (e.g. cow dung, compost and guano). Most of the organic manure is derived from decomposing plant tissue. Organic manure contains three primary macronutrients: nitrogen (N), phosphorus (P), and potassium (K) and three secondary macronutrients: calcium (Ca), sulphur (S) and magnesium (Mg). N-fertilizer has been reported to delay *Striga* emergence, promote high sorghum yield and reduces *Striga* damage in the guinea savannah ecological zones (Sule *et al*., 2008). *Parkia biglobosa* pulp powder from the tree has been discovered to have pesticide effects in several studies. For instance, screenhouse evaluation of *Parkia biglobosa* and *Azadirachta indica* (neem tree) has been reported to be effective in inhibiting *Striga hermonthica* seed germination and subsequently reduce *Striga* emergence (Marley *et al*., 2004; Syngeta, 2004). Therefore, this study investigated the effects of organic manure and botanical seed treatment on *Striga hermonthica* control in sorghum farmland.

Materials and Methods

Study Location

The experiment was conducted under the screenhouse conditions at the Federal University of Technology, Minna, Niger State, northern Nigeria, between June and October 2013. The Federal University of Technology Minna is located on latitude 90 37'N and longitude 6 32'E with an annual mean rainfall of 1300 mm and a mean monthly minimum and maximum temperature distribution value of 22.7 °C and 34.2 °C, respectively.

Treatments and Experimental Design

The treatments comprised four levels (0, 40, 80 and 120 g) of organic manure and four levels (0, 40, 80 and 120 g) of *Parkia* pulp powder combined factorially to give sixteen treatment combinations. The treatments were arranged in a Completely Randomised Design (CRD) with three replications.

Source of *Striga* Seed, *Striga*-resistant Sorghum seed, Cattle dung and *Parkia* Pulp powder

Parkia fruits were collected from Bosso town in Minna and pounded in a mortar. Sorghum-resistant sorghum seeds were obtained from a reputable Agrochemical Seed Store in Minna. Dry cattle dung was collected from the Federal University of Technology, Animal Production Department Research Farm Minna. The pulp powder was then sieved with a 2-mm sieve. *Striga* seeds were obtained from National Cereal Research Institute (NCRI) Badeggi, Bida, Niger State.

Sowing and crop Management

Plastic pots were filled with 5 kg of heat-sterilized topsoil mixed with cattle dung. Planting was done on 29th June 2013 with sorghum seeds treated with *Parkia* pulp powder. Four seeds were sown per bag and later infested with 15 g *Striga hermonthica* seeds. The sorghum seedlings were thinned to two plants per bag two weeks after sowing. The plants were irrigated at three-day intervals to provide adequate moisture for plant growth and *Striga* emergence.

Data Collection and Analysis

Data were collected on *Striga* emergence and height at 4 and 12 weeks after sowing (WAS). sorghum plant height and the number of leaves per plant at 4, 6, and 8. The data collected were subjected to analysis of variance (ANOVA) using the computer software SPSS. Means were separated using Duncan's Multiple Range Test (DMRT) at p=0.05.

Results and Discussion

Effects of organic manure and *Parkia* pulp powder on *Striga* emergence and plant height

The effect of organic manure and botanical seed treatment resulted in significant ($p<0.05$) differences in *Striga* emergence (Table 1). *Striga* emergence varied between 0.3 and 3 shoots at 4 WAS. The combined application of 120 g organic manure and 120 g *Parkia* pulp powder enhanced the lowest *Striga* shoot emergence, whereas the highest *Striga* emergence was observed when in the absence of organic manure and *Parkia* pulp powder. Interestingly, a combination of 120 g organic manure and 40 g *Parkia* pulp powder, as well as the use of 120 g organic manure and 80 g *Parkia* pulp powder also resulted in low *Striga* emergence (0.7 shoots). At 12 WAS, a slightly similar trend was encountered, as the use of 120 g organic manure and 120 g *Parkia* pulp powder resulted in the lowest (2.3 shoots) *Striga* emergence. However, the highest *Striga* emergence of 4 shoots per pot was encountered in the absence of organic manure and *Parkia* pulp powder, as well in the application of *Parkia* pulp powder alone at 40 g, 80 and 120 g (Table 1). The lowest *Striga* emergence observed when 120 g organic manure was combined with 120 g *Parkia* pulp powder could be attributed to the high level of nitrogen from the applied organic manure, which eventually reduce *Striga* attack by increasing crop tolerance. This is consistent with the findings of Kureh *et al*. (2008) who reported that N-fertilizer delayed *Striga* emergence and promoted high *Sorghum* yield.

Effects of organic manure and *Parkia* pulp powder on *Striga* plant height

At 4 WAS, the pots without organic manure and *Parkia pulp powder* (0 g organic manure + 0 g *Parkia* pulp powder), and those treated with 0 g organic manure + 40 g *Parkia* pulp powder produced the tallest *Striga* plant height of 7.3 cm each (Table 1). Although a combination of 120 g of organic manure and 80 g of *Parkia* pulp powder resulted in the shortest *Striga* plant height (2.3 cm), the value (2.7 cm)obtained was not significantly ($p>0.05$) different when 120 g of organic manure was combined with 120 g of *Parkia* pulp powder. However, at 12 WAS, the overriding efficacy of combined application of 120 g organic manure and 120 g *Parkia* pulp powder was evident as the pots so treated had the shortest *Striga* plant height (7.7 cm). This was followed by the mean height (8.3 cm) occasioned by the combined application of 120 g organic manure and 40 g *Parkia* pulp powder, as well mean plant height (8.3 cm). when 120 g of organic manure was combined with 80 g *Parkia* pulp powder. On the other hand, the use of 40 g *Parkia* pulp powder alone resulted in the highest *Striga* plant height (14.3 cm) (Table 1). These observations clearly revealed the effectiveness of a high rate of organic manure and *Parkia* pulp powder for *Striga* control. Again, the desirable performance of both treatments was due to the synergy between the inhibitory effect of high nitrogen rate and the detrimental impact of *Parkia* pulp powder on *Striga* growth (Table 1). Again, the excellent performance of a combined application of a high rate of organic manure with *Parkia* pulp powder was due to the improved soil nutrient and unfavourable germination and growth environment for the *Striga* plants.

Effects of Organic manure and *Parkia* pulp powder on *Sorghum* plant height

The applied treatments resulted in significant height differences among the *Sorghum* plants at the various times of assessment. At 4 WAS, a combination of 120 g organic manure and 40 g *Parkia* pulp powder as well as combined application of 120 g organic manure and 120 g *Parkia* pulp powder resulted in the tallest plants (29.7 cm) (Table 2). Nevertheless, the mean height observed was statistically similar to the height recorded 29.3 cm when only 120 g organic manure was applied, and when 120 g organic manure was combined with 80 g *Parkia* pulp powder. Conversely, the plants without organic manure and *Parkia* pulp powder treatments produced the shortest plants (20 cm). In spite of this, the mean height observed was comparable to the mean height of the plants in which only *Parkia* pulp powder was used either at 40 g (20.7 cm), 80 g (20.3 cm), and 120 g (20.3 cm). Although a combination of 120 g organic manure and 80 g *Parkia* pulp powder produced the tallest (53.3 cm) plants at 6 WAS, the mean height observed was not significantly different from the plants treated either with 120 g organic manure alone (53 cm), a combination of 120 g organic manure and 40 g *Parkia* pulp powder (52.7 cm), or 120 g organic manure and 120 g *Parkia* pulp powder (52.7 cm). On the other hand, the shortest (40.3 cm) height was observed in the absence of organic manure and *Parkia* pulp powder, just as in the use of 120 g *Parkia* pulp powder alone. Next were the plants in which only *Parkia* pulp powder was applied either at 40 or 80 g, resulting in a mean height of 41 cm each. At 8 WAS, the trend in *Sorghum* plant height was as observed at 6 WAS (Table 2). These findings are in tandem with the observations reported in Kureh *et al*. (2002).

Effects of organic manure and *Parkia* pulp powder on *Sorghum* dry matter

The result showed that organic manure and seed treatment with *Parkia* pulp powder exerted significant differences in the dry matter of *Sorghum* (Table 2). The highest (5 g/plant) sorghum dry matter was recorded when 120 g organic manure was combined with 120 g *Parkia* pulp powder which was at par with 120 g of organic manure combined with 40 g *Parkia* pulp powder but statistically similar to the dry matter obtained (4.8 g/plant) when 120 g of organic manure was combined with 80 g *Parkia* pulp powder. The highest sorghum dry matter observed could be attributed to the level of nitrogen which helped in delaying *Striga* emergence and reducing attack on the plant hence promoting *Sorghum* yield and reduction in *Striga* damage. This finding is in agreement with Kurch *et al*. (2002) who reported that nitrogen fertilizer delayed *Striga* emergence, promoted high *Sorghum* and maize yield as well as reduced *Striga* damage in the guinea savannah ecological zones.

Table 1: Effect of organic manure and *Parkia* pulp powder on *Striga* emergence and plant height

Treatment	***Striga* emergence (no.)**		***Striga* plant height (cm)**	
	4 WAS	**12 WAS**	**4 WAS**	**12 WAS**
0 g organic manure + 0 g *Parkia* pulp powder	3.0^{a}	4.0^{a}	7.3^{a}	13.0^{a}
0 g organic manure + 40 g *Parkia* pulp powder	2.7^{a}	4.0^{a}	7.3^{a}	14.3^{a}
0 g organic manure + 80 g *Parkia* pulp powder	2.3^{b}	4.0^{a}	5.7^{b}	11.7^{b}
0 g organic manure + 120 g *Parkia* pulp powder	2.0^{b}	4.0^{a}	5.7^{b}	11.3^{b}
40 g organic manure + 0 g *Parkia* pulp powder	2.0^{b}	3.7^{a}	5.7^{b}	10.7^{b}
40 g organic manure + 40 g *Parkia* pulp powder	2.0^{b}	3.7^{a}	4.7^{c}	11.0^{b}
40 g organic manure + 80 g *Parkia* pulp powder	2.0^{b}	4.0^{a}	5.0^{c}	10.3^{c}
40 g organic manure + 120 g *Parkia* pulp powder	1.7^{b}	3.3^{b}	5.0c	11.0^{b}
80 g organic manure + 0 g *Parkia* pulp powder	1.7^{b}	3.0^{b}	4.7c	11.0^{b}
80 g organic manure + 40 g *Parkia* pulp powder	2.0^{b}	2.7^{b}	4.0^{d}	9.0^{d}
80 g organic manure + 80 g *Parkia* pulp powder	2.0^{b}	3.0^{b}	4.0^{d}	9.3^{d}
80 g organic manure + 120 g *Parkia* pulp powder	1.3^{c}	2.7^{b}	3.7^{d}	9.3^{d}
120 g organic manure + 0 g *Parkia* pulp powder	1.0^{c}	2.7^{b}	3.0^{e}	9.0^{d}
120 g organic manure + 40 g *Parkia* pulp powder	0.7^{b}	2.7^{b}	3.0^{e}	8.3^{e}
120 g organic manure + 80 g *Parkia* pulp powder	0.7^{b}	2.7^{b}	2.3^{f}	8.3^{e}
120 g organic manure + 120 g *Parkia* pulp powder	0.3^{c}	2.3^{c}	2.7^{e}	7.7^{e}
±SEM	0.1	0.1	0.2	0.2

Means not followed by the same letter within the column differ significantly ($p<0.05$) by Duncan's Multiple Range Test (DMRT); WAS =Weeks after Sowing

Table 2: Effect of organic manure and *Parkia* pulp powder on *Sorghum* plant height and dry matter

Treatment	*Sorghum* plant height (cm)			*Sorghum* dry matter (g)
	4 WAS	6 WAS	8 WAS	
0 g organic manure + 0 g *Parkia* pulp powder	20.0[d]	40.3[c]	89.3[c]	2.1[c]
0 g organic manure + 40 g *Parkia* pulp powder	20.7[d]	41.0[c]	90.3[c]	2.1[c]
0 g organic manure + 80 g *Parkia* pulp powder	20.3[d]	41.0[c]	89.0[c]	2.0[c]
0 g organic manure + 120 g *Parkia* pulp powder	20.3[d]	40.3[c]	89.0[c]	2.2[c]
40 g organic manure + 0 g *Parkia* pulp powder	22.7[c]	45.3[b]	91.7[b]	2.9[b]
40 g organic manure + 40 g *Parkia* pulp powder	23.3[c]	44.7[b]	91.3[b]	2.8[b]
40 g organic manure + 80 g *Parkia* pulp powder	23.3[c]	44.7[b]	91.3[b]	3.0[b]
40 g organic manure + 120 g *Parkia* pulp powder	23.7[c]	45.3[b]	94.3[b]	3.0[b]
80 g organic manure + 0 g *Parkia* pulp powder	26.7[b]	49.7[b]	100.1[a]	4.0[b]
80 g organic manure + 40 g *Parkia* pulp powder	27.0 [b]	50.0[b]	99.3[ab]	4.0[b]
80 g organic manure + 80 g *Parkia* pulp powder	27.0 [b]	49.3[b]	99.3[ab]	3.9[b]
80 g organic manure + 120 g *Parkia* pulp powder	27.7 [b]	49.7[b]	98.7[b]	4.0[b]
120 g organic manure + 0 g *Parkia* pulp powder	29.3[a]	53.0[a]	101.3[a]	4.6[b]
120 g organic manure + 40 g *Parkia* pulp powder	29.7[a]	52.7[a]	102.0[a]	5.0[a]
120 g organic manure + 80 g *Parkia* pulp powder	29.3[a]	53.3[a]	103.0[a]	4.8[a]
120 g organic manure + 120 g *Parkia* pulp powder	29.7[a]	52.7[a]	100.0[a]	5.0[a]
±SEM	0.5	0.7	0.8	0.1

Means not followed by the same letter within the column differ significantly (p<0.05) by Duncan's Multiple Range Test (DMRT); WAS =Weeks after Sowing

Conclusion

Based on the results obtained from the experiment, the best control measure of *S. hermonthica* is the use of a combination of 120 g organic manure and 120 g Parkia pulp powder and resistant sorghum variety. Therefore, farmers in *Striga* affected areas are urged to use organic manure and *Parkia* pulp powder in addition to *Striga* resistant *Sorghum* variety.

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