Research Journal of Agronomy 3 (2): 18-24, 2009
ISSN: 1815-9354

Fusarium oxysporum Potential to Control *Striga hermonthica* in Maize (*Zea mays* L.) in the Savanna

[1]A. Ibrahim, [2]E.I. Magani and [2]T. Avav
[1]Department of Agronomy, Nasarawa State University Keffi, Nasarawa State, Nigeria
[2]Department of Crop and Environmental Protection, University of Agriculture,
P.M.B. 2373, Makurdi, Nigeria

Abstract: Field trials were conducted in 2007/2008 wet season at the Teaching and Research Farm of University of Agriculture, Makurdi (7°14'N, 8°37'E) and the model extension village, Danka-Sarki, Lafia (8°3'N and 7°31'E) in the Southern Guinea Savanna of Nigeria, to evaluate the efficacy of a granular mycoherbicide formulation of *Fusarium* sp. for the control of *Striga hermonthica* in maize. Two maize varieties (Farmers' local and Across 97 TZL Comp 1-W) and four treatments, *F. oxysporum* followed by (fb) 2, 4-D; *F. oxysporum* fb Supplementary Hoe Weeding (SHW); *F. oxysporum* fb triclopyr and a control (No *F. oxysporum*, but hoe weeded) were laid in a split-plot design with three replications. The two maize varieties formed the main plot treatments while, the *Striga* control methods were the sub-plots treatments (2 g of mycoherbicide applied pre-sowing in each planting hole). Generally, number of maize plants infected and *Striga* shoot count, was highest with Hoe Weeded check throughout the period of observations. The farmers' variety recorded higher plants infected and *Striga* shoot count than CV Across 97 TZL Comp 1-W throughout the period of observation in this trial, while, higher *Striga* infestation was observed in Makurdi than in Lafia. The use of *F. oxysporum* fb either Post Emergence (POE) triclopyr or 2, 4-D each at 0.36 kg a.i ha^{-1} resulted in significantly lower *Striga* infestation consequently higher maize grain yield than those fb SHW or Hoe Weeded check.

Key words: Biocontrol, *Striga hermonthica*, *Fusarium oxysporum*, mycoherbicide, maize

INTRODUCTION

The parasitic weed *Striga hermonthica* (Del.) Benth has become one of the most severe constraints to cereal production in many parts of sub-Sahara Africa (Lagoke *et al*., 1991). Intensification of traditional cereal-based systems has reduced the fallow period that used to keep *Striga* pressure at tolerable levels and has increased the area under continuous cereal cropping. This has allowed *Striga* to become a ubiquitous weed, causing over 50% yield losses in cereals and affecting the livelihood of millions of mostly resource-poor farmers in Sub-Saharan Africa (Pieterse and Verkleij, 1991).

Several decades of research on *Striga* control technologies have resulted in the identification of a range of technologies. The use of *Striga* tolerant varieties of maize (*Zea mays*), sorghum (*Sorghum bicolor*) and millet (*Pennisetum glaucum*) can be an effective way of reducing *Striga* damage (Parker and Riches, 1993; Kling *et al*., 2000). However, given the variation observed in the tolerance of maize varieties to different *Striga* strains, the weed may show a rapid evolutionary adaptation to *Striga* tolerant cereal varieties in the future. The use of leguminous trap crops that stimulate the suicidal germination of *Striga* is another technology to control *Striga*. Trap crops include varieties of groundnut (*Arachis hypogae*), soyabean (*Glycine max*) cowpea (*Vigna unguiculata*) and sesame (*Sesamum indicum*) (Hess and Dodo, 2003). The application of nitrogen fertilizer to cereals on soils with low fertility reduces crop damage caused by *Striga*, but no clear relationship between nitrogen application and *Striga* suppression has been established by Parker and Riches (1993). Others have investigated the use of chemical (Ariga and Berner, 1993; Bagonneaud-Berthome *et al*., 1995) and biological control (Onu *et al*., 1996; Marley *et al*., 1999; Nekoum and Marley, 2002). The potential of using fungi for biological control of *Striga* was proposed by Musselman (1983) and has since generated research. Adeoti (1993) and Weber *et al*. (1995) have shown that *Fusarium equiseti*, *Cercospora*, *Fusarium*, *Phoma*, *Alternaria* and *Macrophomia* sp. are associated with *Striga*.

The potential of *Fusarium oxysporum* grown in grain sorghum as a biocontrol agent for the control of

Corresponding Author: E.I. Magani, Department of Crop and Environmental Protection, University of Agriculture, P.M.B. 2373, Makurdi, Nigeria

Striga hermonthica has been reported by Kroschel *et al.* (1996), Abbasher *et al.* (1998), Marley *et al.* (1999) and Marley and Shebayan (2005). Isolates of *Fusarium oxysporum* from *Striga hermonthica* have been shown to infect on *Striga* sp. and other no other crops or vegetables (Abbasher *et al.*, 1998; Elzein, 2003; Marley and Shebayan, 2005). Therefore, the principal objective of this study was to evaluate the efficacy of granular mycoherbicide formulation under a field condition.

MATERIALS AND METHODS

Preparation of pathogenic fungi (mycoherbicide): Biological control using *F. oxysporum* (isolate PSM 197) as mycoherbicide (Marley *et al.*, 1999; Marley and Shebayan, 2005). The biocontrrol agent, *F. oxysporum* was produced on gritted (whole grain broken into smaller pieces) maize grains in the laboratory as described by Marley *et al.* (1999). *Fusarium oxysporum* (isolate PSM 197) was isolated from *S. hermonthica* stems and single spore isolates made into stock cultures. They were maintained on Potato Dextrose Agar (PDA) amended with streptomycin (Difco) and stored in the refrigerator at 4°C. Starter cultures were made when required. Mass production of inoculum was made on gritted maize grain. Gritted grain (500 g) was placed in 1-L flat-bottomed flasks each containing 250 mL of sterile distilled water. Flasks were shaken to ensure that the substrate was properly moistened and excess water was poured off prior to autoclaving for 1 h at 121°C (103.5 kPa). After cooling, each flask was inoculated with three agar plugs (5 mm diameter) of the isolate and then incubated at 28°C for 7 days. During the incubation period, each flask was shaken daily to allow for full colonization of the grains by the pathogen. Colonized grains were harvested 14 days after inoculation and stored in refrigerator at 4°C for use when required as the mycoherbicide.

Field evaluation: The field experiments were conducted in 2007/2008 wet seasons at the teaching and research farm of the University of Agriculture, Makurdi (7°14'N, 8°37'E) and the model extension village, Danka-Sarki, Lafia (8°3'N and 7°31'E) in the Southern Guinea Savanna of Nigeria. The two sites were naturally and heavily infested with *Striga hermonthica*.

The trials were established at Makurdi and Lafia on 28 May and 16 June, 2008, respectively. The two sites of the trials were ploughed, harrowed and ridged at 0.75 m apart. Two maize varieties (Across 97 TZL Comp-1 and a local) were planted 50 cm apart. At each planting hill, 2 g (53.33 kg ha^{-1}) of mycoherbicide in each treatment was applied pre-sowing in the planting hole. Four treatments were used as follows: *F. oxysporum* followed by (fb) 2, 4-D, *F. oxysporum* fb Supplementary Hoe Weeding (SHW), *F. oxysporum* fb triclopyr and a control (No *F. oxysporum*, but Hoe weeded). The trials were planted in a split-plot design with three replications. The two maize varieties formed the main plot treatments while, the weed control methods (*F. oxysporum* either fb 2, 4-D, SHW, triclopyr at 6WAS and a control) were the sub-plot treatments. The gross and net plot sizes were 9 and 4.5 m^2 (4 and 2 ridges of 3 m length each), respectively. Spot application of fertilizer was carried out at 120 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} 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 (CP_3) with spray volume of 250 L ha^{-1}.

Observations made included number of maize plants infected by *Striga*, *Striga* shoot count per unit area, days to first *Striga* emergence and flowering, crop damage syndrome and vigour maize stand at harvest and maize 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

Figure 1 shows the number of days to first *Striga* emergence and flowering. Although, there was no significant difference between the different *Striga* control treatments, but the trend indicated early emergence with Hoe Weeded check (38 DAS) when compared to all treatments that received *F. oxysporum*; with *F. oxysporum* fb POE 2, 4-D delaying the emergence of *Striga* the most. This confirms earlier research by Marley *et al.* (2005), who reported between 7-14 days delay in emergence of *S. hermonthica* with pre-plant inoculation of pathogen inoculums. Similarly, the number of days to first *Striga* flowering was low (63 DAS) and highest (75 DAS) with Hoe Weeded check and *F. oxysporum* fb POE 2, 4-D, respectively.

Generally, number of plant infected with *Striga* was highest throughout the period of observation with hoe weeded check when compared to other *Striga* control treatments (Fig. 2) At 6 WAS, the minimum was obtained with treatment that received *F. oxysporum* fb POE 2, 4-D at the rate of 0.36 kg a.i ha^{-1}.

However, at 9 and 12 WAS and harvest, *F. oxysporum* fb POE triclopyr at the rate of 0.36 kg a.i ha^{-1} recorded the minimum. This study confirms early research when complete inhibition of *S. hermonthica* emergence

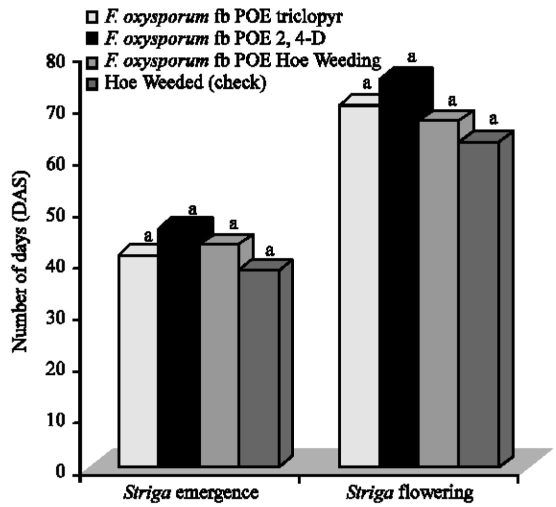

Fig. 1: Effects of *F. oxysporum* and post-emergence herbicides on days to *Striga* emergence and flowering. Mean values followed by the same letters are not significantly different at ($p<0.05$)

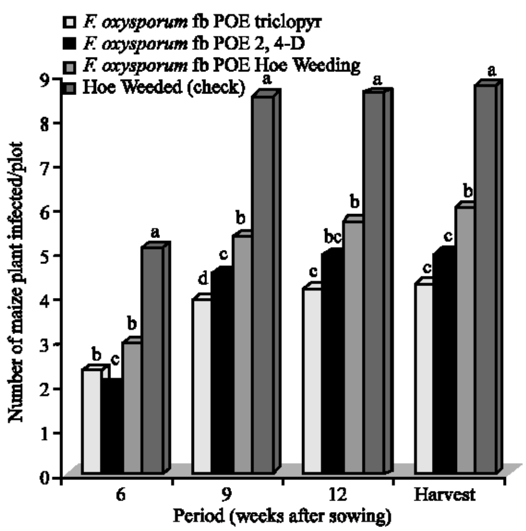

Fig. 2: Effects of *F. oxysporum* and post-emergence herbicides on number of maize plants infected with *Striga* at various periods. Mean values followed by the same letters are not significantly different at ($p<0.05$)

was observed when a chlamydospore powder was added to the soil at sowing or sorghum seeds coated with chlamydospore were sown (Ciotola *et al*., 2000). Also, Marley *et al*. (2004) had earlier reported effective control of *S. hermonthica* when 5 g of Fusarium-colonized grains (mycoherbicide) was applied in each planting hole at sowing.

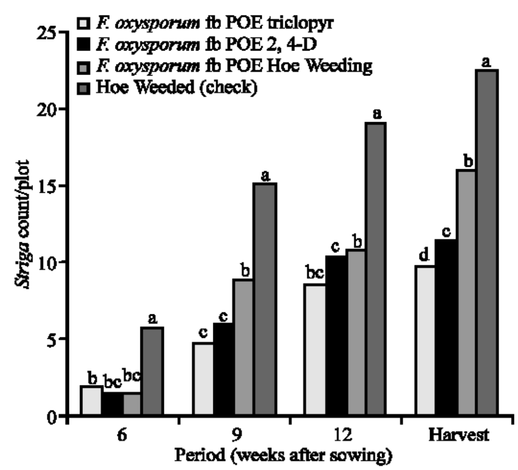

Fig. 3: Effects of *F. oxysporum* and post-emergence herbicides on *Striga* shoot count/plot. Mean values followed by the same letters are not significantly different at ($p<0.05$)

Similarly, Fig. 3 shows that hoe weeded check recorded the highest *Striga* shoot count throughout the period of observation, which was seconded by *F. oxysporum* fb SHW, except at 6 WAS when *F. oxysporum* fb POE triclopyr followed the hoe weeded check in total *Striga* shoot count. However, from 9 WAS to harvest, the least *Striga* shoot count was obtained with treatments of *F. oxysporum* fb POE triclopyr at the rate of 0.36 kg a.i/ha. This research is similar to earlier research done by Kroschel *et al*. (1996) in which the use of *Fusarium oxysporum* (Foxy 2) was able to reduce the germination of *S. hermonthica* seeds by >90% when the fungus was applied during the seed-conditioning phase and it prevented the emergence by 98%, when it was used as inoculum. It is assumed that the reduction in seed germination and death of the germinated seeds before their attachment by foxy 2 led to the reduced *Striga* shoot as well. Thus, Foxy 2 exerts its effect by destruction of the seeds and prevention of emergence and subsequent reproduction.

There was significant difference in number of maize plants infected with *Striga* and shoot count throughout the period of observation in respect to locations (Fig. 4 and 5). The number of *Striga* shoot count was significantly higher for Makurdi than Lafia throughout the period of observation in this trial. The observed difference may be attributed to environmental effects-like temperature, moisture or presence of other stimulants in the soil, which favoured Makurdi over Lafia. The farmers local had significantly higher *Striga* shoot count than CV across 97 TZL Comp 1-W throughout the period of observation in this trial (Fig. 6). In the context of this

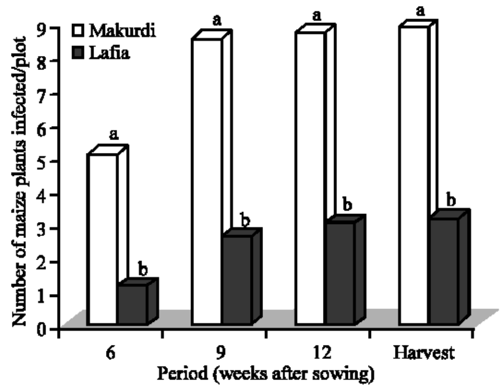

Fig. 4: Effects of location on number of maize plants infected. Mean values followed by the same letters are not significantly different at (p<0.05)

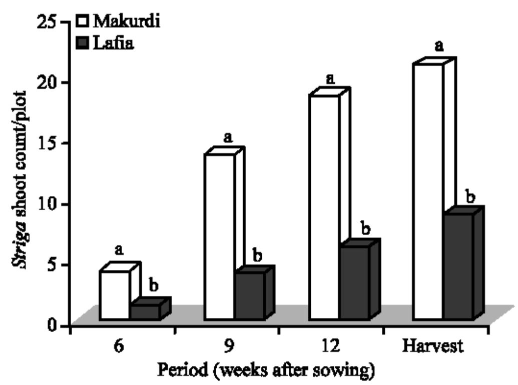

Fig. 5: Effects of location on *Striga* shoot count/plot. Mean values followed by the same letters are not significantly different at (p<0.05)

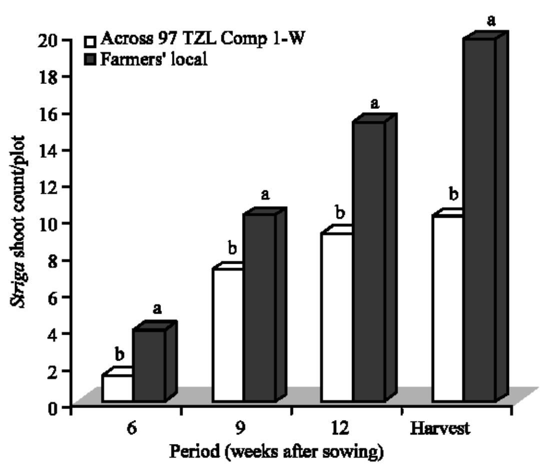

Fig. 6: Effects of maize varieties on *Striga* shoot count/plot. Mean values followed by the same letters are not significantly different at (p<0.05)

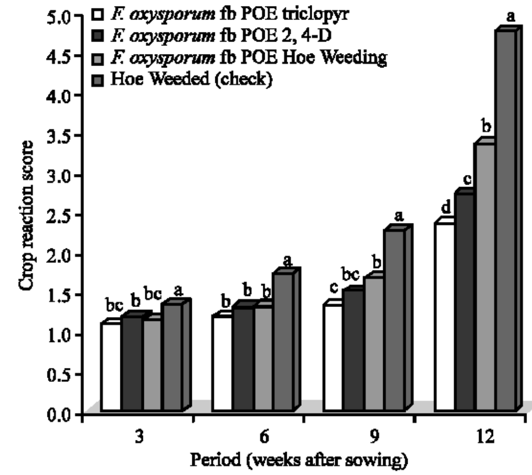

Fig. 7: Effects of *F. oxysporum* and post-emergence herbicides on crop damage syndrome score. Mean values followed by the same letters are not significantly different at (p<0.05). Crop damage symptom score scale (1-5), while, 1 = normal crop plant growth, no chlorosis, no blotching, no scorching and 5 = total leaf scorching or/and obviously stunted or dead plants

study, resistant refers to host cultivars that are less attacked and thus have less damage and number of emerged *Striga* plants (Parker and Riches, 1993). Maize variety, across 97 TZL Comp 1-W being a resistant variety have been reported to produce lower amounts of germination stimulants in their root exudates, leading to smaller numbers of attached parasites and/or to later attachment of the parasites to the host (Gurney *et al*., 2002).

Striga control methods differed in crop damage syndrome score throughout the period of observation in this trial (Fig. 7). Generally, the Hoe Weeded check had the highest damage syndrome score throughout the period of observation with the minimum recorded with treatments that received *F. oxysporum* fb POE triclopyr at 0.36 kg a.i ha^{-1}. However, at 3, 6 and 9 WAS all treatments or plots that received *F. oxysporum* either fb POE 2, 4-D, triclopyr or SHW had lower and the same statistically when compared to the hoe weeded check. Also, crop vigour score was significantly influenced by the *Striga* control methods throughout the period of observations (Fig. 8). Generally, in respective of treatments, crop vigour score was better/higher within the first 3-6 WAS. This may be attributed to the fact that not many of the *Striga* seeds might have emerged. However, from 9-12 WAS, there was a general decline in the vigour of the maize plants with Hoe Weeded check recording the least crop vigour. Figure 9 represents maize stand count at harvest as influenced by *Striga* control treatments. Treatments of *F. oxysporum* fb POE of either triclopyr or 2, 4-D at the

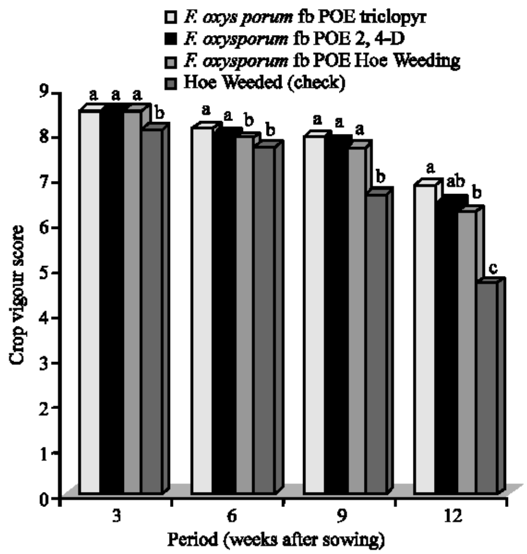

Fig. 8: Effects of *F. oxysporum* and post-emergence herbicides on crop vigour score. Mean values followed by the same letters are not significantly different at ($p<0.05$). Crop vigour score scale (1-9), where 1 = completely killed plants and 9 = most vigorous plants

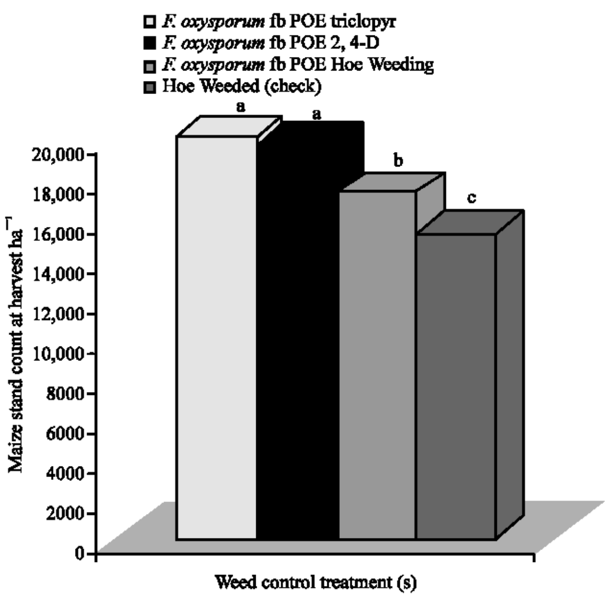

Fig. 9: Effects of *F. oxysporum* and post-emergence herbicides on maize stand count at harvest. Mean values followed by the same letters are not significantly different at ($p<0.05$)

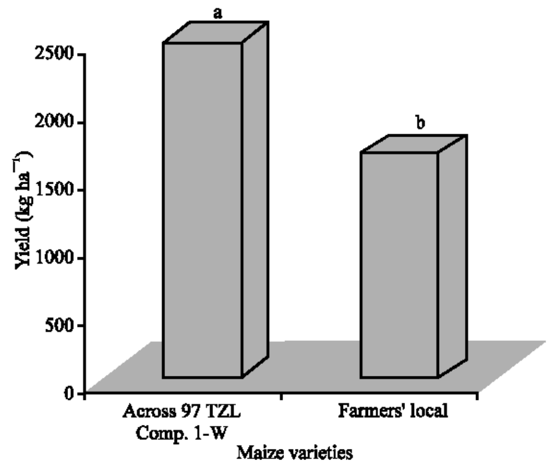

Fig. 10: Effects of *F. oxysporum* and post emergence herbicides on maize grain yield. Mean values followed by the same letters are not significantly deferent at ($p<0.05$)

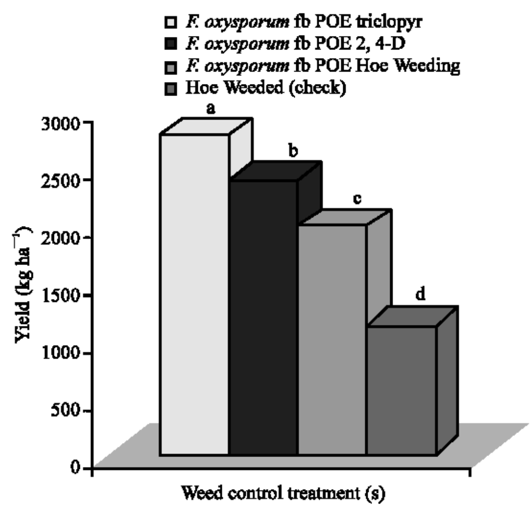

Fig. 11: Effects of *F. oxysporum* and Post-emergence herbicides on grain yield. Mean values followed by the same letters are not significantly different at ($p<0.05$)

rate of 0.36 kg a.i ha^{-1} each were higher and similar in terms of maize stand count when compared to the least obtained with hoe weeded check. The lower maize stand count recorded with *F. oxysporum* fb SHW and the Hoe Weeded check may be attributed to the mechanical damage done to crop plants during weeding, which high have led to the death of some of the maize stand as compared to those that received POE triclopyr and 2, 4-D.

In this trial, the variety across 97 TZL Comp 1-W produced higher maize grain yield than that of the farmers local (Fig. 10), as 2500 and 1700 kg ha^{-1}, respectively. This study has confirmed earlier research reported by Kim (1994) and Buhler *et al.* (2000) that improved Open-Pollinated (OP) maize varieties and hybrids are less damaged owing to tolerance to *Striga*. They have been reported to produce higher grain yields than the susceptible cultivars and/or farmers local maize varieties.

The use of *F. oxysporum* fb either POE triclopyr or 2, 4-D each at 0.36 kg a.i ha^{-1} resulted in significantly higher maize grain yield than those fb SHW or Hoe Weeded check (Fig. 11). The low yield in the Hoe Weeded check can be attributed to higher level of *Striga* infestation and shoot counts in those plots. The higher grain yield obtained with treatments that received POE of either 2, 4-D or triclopyr confirmed earlier research when 2, 4-D alone, mixture with diflufenican, triclopyr resulted in higher grain yield than the control (Lagoke *et al*., 1993).

CONCLUSION

Several decades of research on *Striga* control technologies have resulted in the identification of a range of technologies. Farmers' themselves have developed a range of coping strategies to combat *Striga*. These include hand roguing, Hoe Weeding, the use of manure or compost and fallowing (Emechebe *et al*., 2004). As none of the available technologies on its own can provide satisfactory *Striga* control in broad range of biophysical and socio economic environments, many farmers in West Africa fail to control *Striga* in cereals, despite the availability of a whole range of control techniques that have proved to be successful. Therefore, there is the need to look at other control options like the use of mycoherbicides that will be environmentally friendly. This study results demonstrate the high potentiality of using *F. oxysporum* (mycoherbicide) for the control of *S. hermonthica* by spot application at sowing and thereafter, followed by either 2, 4-D or triclopyr POE at 6 WAS. The use of maize grits, which is readily available to propagate *F. oxysporum* makes it quite cheap for local farmers' instead of the use of potato dextrose agar.

REFERENCES

Abbasher, A.A., D.E. Hess and J. Sauerbom, 1998. Fungal Pathogens for biological control of *Striga hermonthica* or Sorghum and pearl millet in West Africa. Afr. Crop Sci. J., 6 (2): 179-188. http://www.bioline.org.br/request?cs98020.

Adeoti, A.A., 1993. Fungi associated with *Striga hermonthica*. *Striga* Newslett., 4: 9.

Ariga, E.S. and D.K. Berner, 1993. Response to *Striga hermonthica* seeds to different germination stimulants and concentrations. Phyto control. A perspective from Africa. Plant Dis., 79: 652-660.

Bagonneaud-Berthome, V., M.C. Arnaud and A. Per, 1995. A new experimental approach to the chemical control of *Striga* using simplied models *in vitro*. Weed Res., 35: 25-32.

Buhler, D.D., M. Liebman and J.J. Obrycki, 2000. Theoretical and practical challenges to an IPM approach to weed management. Weed Sci., 48: 274-280.

Ciotola, M., A. Ditommaso and A.K. Watson, 2000. Chlamydospore production, inoculation methods and pathogenicity of *Fusarium oxysporum* M12-4A, a biocontrol for *Striga hermonthica*. Biocontrol Sci. Technol., 10: 129-145. DOI: 10.1080/09583150029279. http://pdfserve.informaworld.com/900031_758062852_713655514.pdf.

Elzein, A.E.M., 2003. Development of Granular Mycoherbicide Formulation of *Fusarium oxysporum* Foxy 2 for the Biological Control of *Striga hermonthica* (Del.) Benth. In: Kroschel, J. (Edn.). Research 2. Margraf Verlag, Weikersheim, Germany, pp: 174.

Emechebe, A.M., J. Ellis-Jones, S. Schulz, D. Chikoye, B. Douthwaite, I. Kureh, G. Tarawali, M.A. Hussaini, P. Kormawa and A. Sanni, 2004. Farmers' perception of the *Striga* problem and its control in Northern Nigeria. Exper. Agric., 40: 215-232.

Gurney, A.L., A. Taylor, A. Mbwaga., J.D. Scholes and M.C. Press, 2002. Do Maize cultivars demonstrate tolerance to the parasitic weed *Striga* asiatica? Weed Res., 42: 299-306. http://www.aginternetwork.et/halecomdownload.interscience.wiley.com/whalecom0/cgi-bin/fulltext/118835370/Pdfstart.

Hess, D.E. and H. Dodo, 2003. Potential of sesame to contribute to integrated control of *Striga hermonthica* in the West Africa Sahel. Crop. Rotection, 23 (6): 515-22. DOI: 10.1016/j.ropro.003.0.008. http://www.aginternetwork.net/whalecom.ww.sciencedirect.com/whalecom0/science?_ob=MImg&_imagekey=B6T5T-4B6KG87-2-9&_cdi=5011&_user=2789858&_orig=browse&_coverDate=06%2F30%2F2004&_sk=999769993&view=c&wchp=dGLbVzW-zSkzV&md5=e19b44efa43829db212c85b96090ac&ie=/sdarticle.pdf.

Kim, S.K., 1994. Genetics of maize tolerance to *Striga hermonthica*. Crop Sci., 34: 900-9007.

Kling, J.G., J.M. Fajemisin, B. Badu-Apraku, A. Diallo, A. Menkir and A. Melake-Berhan, 2000. *Striga* Resistance Breeding in Maize. In: Haussman, B.I.G., D.E. Hess, M.I. Koyama, I. Griver, H.F.W. Rattunde and H.H. Geiger (Eds.). Breeding for *Striga* resistance in Cereals, Margraf Verlag, Weikersheim, Germany, pp: 108-118.

Kroschel, J., A. Hundt, A.A. Abbasher and J. Sauebom, 1996. Pathogenicily of fungi collected in Northern Ghana to *Striga hermonthica*. Weed Res., 36: 515-520. http://www.aginternetwork.net/whalecomdownload.interscience.wiley.com/whalecom0/cgi-bin/fulltext/119207018/PDFSTART.

Lagoke, S.T.O., V. Parkinson and R.M. Agunbiade, 1991. Parasitic Weeds and Control Methods in Africa. In: Kim, S.K. (Edn.). Combating *Striga* in Africa. Proceedings of the International Workshop organized by Iita, Icrisat and Idrc, IITA, Ibadan, Nigeria, pp: 3-14.

Lagoke, S.T.O., J.A. Shebayan, E.I. Magani, P. Olorunju and O.O. Olufajo *et al*., 1993. *Striga* Problem and Development and Appropriate Control Technologies in various Crops in Nigeria. In: Lagoke, S.T.O., L.E. Vander Straten and S.S M'Boob (Eds.). Proceedings of the third General Workshop of the Pan-African *Striga* Control Network (PASCON) Harare, Zimbabwe, pp: 89-100.

Marley, P.S., S.M. Ahmed, J.A. Shebayan and S.T.O Lagoke, 1999. Isolation of *Fusarium oxysporum* with potential for biocontrol of the witchweed *Striga hermonthica* in the Nigerian Savanna. Biocontrol Sci. Technol., 9: 159-163. DOI: 10.1080/09583159929749.

Marley, P.S., A. Toure, J.A. Shebayan, D.A. Aba, O.A. Toure, G.A. Diallo and S.O. Katile, 2004. Variability in host plant resistance of sorghum to *Striga hermonthica* in West Africa. Archives of Phytopathol. Plant Protec., 37: 29-34. DOI: 10.1080/03235400410001662157. http://pdfserve.informaworld.com/50584_758062852_713677300.pdf.

Marley, P.S. and J.A. Shebayan, 2005. Field assessment of *Fusarium oxysporum* based mycoherbicide for control of *Striga hermonthica* in Nigeria. Biocontrol, 50: 389-399. http://www.aginternetwork.net/whalecom. www.springerlink.com/whalecom0/content/j2l0325248800360/fulltext.pdf.

Marley, P.S., J. Kroschel and A. Elzein, 2005. Host specificity of *Fusarium oxysporum* schlect (isolate PSM 197), a potential mycoherbicide for controlling *Striga* sp. in West Africa. Weed Res., 45: 407-412. http://www.aginternetwork.net/whalecomdownload.interscience.wiley.com/whalecom0/cgi-bin/fulltext/118649052/PDFSTART.

Musselman, L.J., 1983. A need for consideration of biocontrol in *Striga*. In: Ramaiah, K.V. and M.J. Vandeva-Rao (Eds.). Proceedings of the Second International Workshop on *Striga*, IDRDC/ICRISAT, India, pp: 109-110.

Nekoum, N. and P.S. Marley, 2002. Microorganisms associated with *Striga hermonthica* and rhizosphere soil in the Nigerian Savanna: Isolation and Evaluation for possibilities in biological control of the witchweed. In: African Savannas, Areas of change, stakeholders faced with new challenges. Regional pole of Industrial Research to the Development of Savannas of Central Africa (PRASAC) Bebedjia, Tchad, pp: 150-167.

Onu, I., P.S. Chindo, A.A. Adeoti and I.J. Bamaiyi, 1996. Preliminary report on the insect pests of *Striga* sp. in the Northern Guinea and Sudan Savanna of Nigeria. J. Sustainable Agric., 8: 73-78.

Parker, C. and C.R. Riches, 1993. In Parasitic weeds of the world: Biology and control. CABI Publishing, Wallingford, UK, pp: 1-74.

Pieterse, A.H. and J.A.C. Verkleij, 1991. Effect of soil conditions on *Striga* development. Proceedings of the 5th International Symposium on Parasitic Weeds. A Rev., pp: 329-339.

Weber, G.K., K.A. Elemo, A.A. Wad, S.T.O Lagoke and S. Oikeh, 1995. *Striga hermonthica* in Cropping System of the Northern Guinea Savanna. Resource and Crop Management Monograph No. 19, IITA, Ibadan, Nigeria.