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Sesame (Sesamum indicum L.) seeds and di ammonium phosphate (dap) potential for controlling Striga seed germination, sorghum growth and grain yield

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Abstract

Sorghum is important staple food for feeding humans and animals in sub-Saharan African country. Nowadays, with the advent of climate change couple to the population growth, the crop is faced to new challenges wish are gradually affecting the productivity. In Niger, a dry land country where farmers are growing sorghum at a small scale for family subsistence, the crop is confronted to biotic and abioticonstraints including nutrient deficiency in the soil. Among those constraint, Striga is the one that causes huge damage to sorghum cultivation through yield reduction. In addition, nutrient depletion in the soil are causing weed progresses in farmer's field at a large scale. In fact, to overcome Striga problem several control methods have been successfully tested, but some of them are efficient but not accessible to farmers. It is important to control the weed by using effective and accessible way for smallholder farme in Niger. The main objective of this study was to assess the effectiveness of different doses of sesame (0, 0.5 and 1.5 g) and DAP (0, 2 and 5 g) on Striga impact and sorghum grain yield. Two (2) grammes micro dosing utilization of DAP shows good result in Striga plant emergency and distribution along sorghum field. Concerning the three doses of sesame seed involve in this experiment, the micro dosing two (1.5 g) positively affect Striga effect. The combination sesame seed and DAP can significantly reduce Striga impact on sorghum cultivation and increased sorghum grain yield.

Introduction

Striga hermonthica is one of the most important parasitic weeds affecting sorghum productivity in sub-Saharan African regions, characterized by dry and harsh environmental conditions [10]. Nutrients depletion in the soil were noticed as the major constraints limiting sorghum cultivation [17] and the expected grain yield [4]. Thus, in some African countries, affected by poverty and low soil fertility farmers are not able to increase productivity of sorghum because of limited resources [3]. The lack of nutrients in the soil predispose plants to diseases and also to Striga, which seriously affects sorghum productivity in sub-Saharan African region with yield losses of between 20 to 80% [20].

In fact, there is a high correlation between soil fertility decline and the negative impact of Striga. Thus, when there are sufficient nutrients like nitrogen in the soil it will reduce strigolactone production from the host plant and vice versa [9]. Otherwise nitrogen presence in the soil considerably increase yield and reduce the impact of Striga [18]. Nutrient deficiency in the soil highly affect organic matter and biomass production [15]. In addition, phosphate utilization also has the ability to decrease strigolactone secretion and reduce Striga germination [7].

Fertilizer application can produce vigorous plants that smother the weed and improve sorghum yield [16]. Striga seed germination is an important step in the infection process between sorghum plants root and Striga root. The germination is conditioned by the presence of molecular signals from the host plants. Those signals are called strigolactone and are produced by an arbuscular mycorrhizal (AM) fungi through symbiotic interactions in the rhizosphere. When there is a lack of nutrients in the soil, strigolactone hormones are produced by the host plant for nutrients acquisition [6]. Fertilizer application that contains nitrogen and phosphorous can reduce Striga incidence through low strigolactone secretion in the soil [13].

In African countries, the inputs are greater than the outputs in terms of nutrients utilizations and are considerably affecting the yield [19]. Poverty, globalization, soil infertility coupled with the impact of Striga, has necessitated the investigation of fertilizer micro dosing application at very low levels for better grain yield. In Niger, in order to control the weed and to regenerate soil fertility, farmers are using Nere powder (Parkia biglobosa), fertilizers (NPK 15-15-15, Urea, DAP) and sesame seed. As the most accessible crop utilized by farmers' to fight the weed in Niger, sesame is a drought tolerant crop which give more benefit for less cost than the other crops. In Niger, it is cultivated in divers' agro ecological areas as a cash crops [2]. For many years' suicidal germination has been also promoted as a powerful technique for reducing Striga seed in the soil using sesame seed or cowpea. This Integrated Striga management (ISM) allows smothering of Striga plant after the germination process [14].

The high prices of fertilizers and manure inaccessibility are pushing the smallholder farmers to re-orient their energies on traditional management methods to reduce Striga incidence and increase sorghum grain yield.

The main objective of this study was to assess the effectiveness of three doses of sesame (0, 0.5 and 1.5 g) and DAP (0, 2 and 5 g) on Striga impact and sorghum grain yield.

Material and Methods

Sorghum and Striga seeds materials: This study involved twenty (20) sorghum varieties from diversified countries and landraces from Niger (Table 1). From the 20 varieties, 15 are documented Striga resistant lines and the five 5 others lines are Niger susceptible landraces highly preferred by famers in Tahoua and Maradi regions.

The Striga hermonthica seeds for the field experiment were collected in November 2016 in Tahoua region, in highly infested farmers' sorghum fields. Thereafter the Striga plants were dried and seed extracted.

The extracted seeds were stored in bottles at 25 °C for use at Konni station in the Konni seed laboratory.

Methodology

The study was conducted in Konni station located around 5 km to Konni (Latitude: 13 48' 00" Longitude: 5 15' 00") a department of Tahoua region. It is located about 417 Km from Niamey the capital. In this area, the rainfall is around 500 to 600 mm per year. Konni is an important area devoted to agriculture (INS, 2017). It is a center of excellence of diverse sorghum varieties cultivation. However, the area is highly infested by the weed and an ideal site for field screening and sorghum cultivation. Thus, Konni is identified as one the most important sorghum producing places in Niger. Konni station is the only research center of INRAN Niger authorized to undergo Striga field screening activities with experienced technicians. Since 1990, several field screening activities were elaborated by diverse projects based on Striga management [21].

Experimental design and field preparation

In these experiments a 3 x 3 x 20 factorial design with three replications was used. The DAP and the sesame seeds contain each three different levels, 0, 2, and 5 g for the DAP and 0, 0.5, 1.5 g, giving nine combinations of DAP and Sesame (T1, T2, T3, T4, T5, T6, T7, T8, T9).

In the experimental design each combination of different level of DAP and Sesame represent a block separated by 1.5 m giving a total of 48 m x 27 m (1296 m2) per replication. Before the planting process, the field was ploughed and one gram of Striga seed (1 g = 160 000 seed) was applied per hill. In addition, the experiment was established on 4000 m2 of land, where the space between the replications were two meters, rows of three meters were used and inter-row spacing of 0.80 m. At the planting time, five to six seeds were applied per hill at a depth of 3 cm. At two weeks after planting, plants were thinned out to three per stand.

Field measurements: Fourteen days after the planting, vigor was scored on sorghum plants using visual assessment of the height of the seedling, the seedling development and the leaves colours, followed by Striga emergence date, Striga counts were taken at 45, 60 and 90 days after the sowing date in each row. The number of days to 50% sorghum flowering was determined. Plant height and number of panicles were also determined. At maturity, the sorghum panicles were harvested, dried and weighed for grain yield estimation.

Data analysis

SAS 9.4 software was used in a general linear model (GLM) for ANOVA of the different variables scored. Correlation was also determined to establish the relationships among the traits. Before the analysis a test for normality was performed using GenStat 15th Edition (2007).

Results

Effect of DAP and Sesame on sorghum agronomic traits

A highly significant variation was observed with the DAP (Fig 2) and a significant variation with the entries was observed (Table 2 and Fig 4) on the plant vigor. In addition, the sesame (Fig 1), the interaction

Sesame and DAP (Fig 3), Sesame and the entry interaction, DAP, entry and Sesame three-way interaction, DAP and entry interaction, have no significant effect on the plant vigor. For the number of hole, a significant variation was observed with the sesame seed and the interaction DAP and Sesame. Thus, a high significant variation was observed with the DAP and the entries. The others treatments which concern the sesame and the entry interaction, DAP and entry interaction and finally Sesame, DAP and entry interaction, have no significant effect on the number of hole. In fact, for the grain weight, a highly significant variation was observed with the entries (Table 2). The DAP, the sesame and their interaction, the DAP, the Sesame and the entry interaction were not significant. Concerning the plant height, a significant and a highly significant variation were respectively obtaining with sesame and DAP interaction and entry. Concerning the DAP, the Sesame, the interaction Sesame, Entry, the interaction DAP, Entry and finally DAP, Sesame and Entry interaction, no significant impact were observed on the plants weight. So for the 50% flowering date, a highly significant variation was observed with entry. In addition, no significant effect was observed with the DAP and the Sesame when they were used alone or in combination on the flowering. For the grain yield a highly significant variation was observed with the entries (Fig 2). Thus, the DAP, the Sesame, the Sesame and DAP interaction, the Sesame and entries interaction, the DAP and entries interaction, the Sesame, the DAP, the Sesame and the entries interaction, have no significant impact on the grain yield (Table 2).

Striga management strategies and count

Several combinations were assessed on striga emergency days, the number of striga plant at 45, 60 and 90 days after planting. Thus, for the emergency date, the DAP (Fig 5) used at different level, the DAP and the Sesame interaction (Fig 6) and the interaction between Sesame, DAP and the entries (Fig.7) undergo a significant effect. Concerning the entries, a highly significant effect was observed. In addition, for the number of striga plant at 45 days, a highly significant effect was observed with the DAP (Fig 8), the Sesame and the DAP (Fig 10) interaction, and the entries (Fig11). The sesame seed has a significant effect on the number of striga at 45 days after planting (Table 3 and Fig 9). The interaction Sesame, entries, the interaction DAP, entries, and finally the interaction Sesame, DAP and entries have no significant effect on the number of striga plants at 45 days. To say more, a highly significant effect was observed with the DAP (Fig12), the interaction Sesame, DAP (Fig14), and the entries (Fig 15) on the number of striga plants at 60 days after planting. In addition, a significant impact was observed with sesame seed on the striga plant number at 60 days (Fig.13 and Table 3). The interactions, Sesame and entries, the interaction DAP and the entries, and the interaction DAP, Sesame and the entries have no significant effect on the number of striga at 60 days after planting. The Sesame and the entries interaction, the DAP and the entries, the interaction Sesame, DAP and entries were not significant. Thus, for the striga plant number at 90 days, a high significant effect was observed with the DAP (Fig16), the Sesame seed (Fig 17) their interaction (Fig18 and Table 3) and the entries (Fig19). Concerning, the Sesame and the entries interaction, the DAP and the entries interaction, the Sesame, the DAP and the entries have no significant impact on the striga plant number at 90 days (Table 3).

Discussion

Nitrogen deficiency and phosphorous depletion in the soil were reported by many researchers to be involved in the increases of Striga hermonthica impact in sorghum cultivation in sub-Saharan African regions [1].

In this experiment characterized by the utilization of three different doses of DAP and sesame seeds utilization respectively at 0, 2, 5 g and 0, 0.5, 1.5 g on Striga emerged plants number and sorghum plant growing parameters. Thus, those parameters include the plant vigor, the Striga emergence, the number of Striga plants that have emerged at 45, 60, 90 days after sorghum sowing date, and the grain yield. The assessment also concerned the interaction effect of DAP and sesame. The different results obtained on each treatment gave more information on the impact of the different doses effect used in the study.

Table 1. Mean squares for growth and yield traits of 20 sorghum genotypes under various Striga management options

Source	DF	Vig	NPSorg	PoiGR	HTR	FLO	Yield
Rep	2	0.79ns	9.34ns	80875.32***	37974.21***	1463.02ns	59811.43**
SESAME	2	1.15ns	28.64*	846.55ns	3014.76ns	1098.47ns	18111.03ns
DAP	2	15.75***	334.89***	5561.04ns	3990.94ns	1132.55ns	33541.32ns
SESAME*DAP	4	1.47ns	27.95*	29040.91*	17866.52**	1967.42ns	34561.01ns
Entry	19	4.33**	72.39***	162645.23***	88133.47***	6771.60***	172409.77***
SESAME*Entry	38	1.85ns	4.34ns	6216.03ns	3362.81ns	360.77ns	17111.07 ns
DAP*Entry	38	1.61ns	6.68ns	3367.20ns	2591.65ns	548.78ns	30541.34 ns
SESAME*DAP*Entry	76	2.04ns	4.98ns	5755.61ns	3357.03ns	657.51ns	30561.01ns
Error	358	1.62	5.81	6133.75	3399.72	537.53	11589.89

Plant vigor = Vig; NPSorg = Hill number; PoiGR= 1000 grain weight; Vig= Plant vigor; Yield = grain yield Kg/ha; HTR= plant height; 50% flowering days= Flo; ns = non-significant; highly significant ***; Significant **

Table 2. Mean squares for Striga related variables under various Striga management option

Source	DF	EMR	NS45	NS60	NS90
Rep	2	1151.48ns	2315.92***	18333.03***	8273.77ns
SESAME	2	497.02ns	1125.25**	9121.86**	25403.03***
DAP	2	2465.00**	1638.64***	17328.32***	39746.90***
SESAME*DAP	4	2301.15**	1780.89***	14213.90***	25012.09***
Entry	19	2392.06***	571.02***	5830.55***	21212.74***
SESAME*Entry	38	449.22ns	142.51ns	775.68ns	2158.67ns
DAP*Entry	38	618.58ns	110.49ns	912.01ns	2658.93ns
SESAME*DAP*Entry	76	672.31**	146.82ns	902.57ns	2117.97ns
Error	358	380.149	148.09	1209.79	2360.67

EMR: Striga emergency date; NS45= Number of Striga plants at 45 days after planting date; NS60= Number of Striga plants at 60 days after planting date; NS90= Number of Striga plants at 90 days after planting date; ns = non-significant; highly significant ***; Significant **

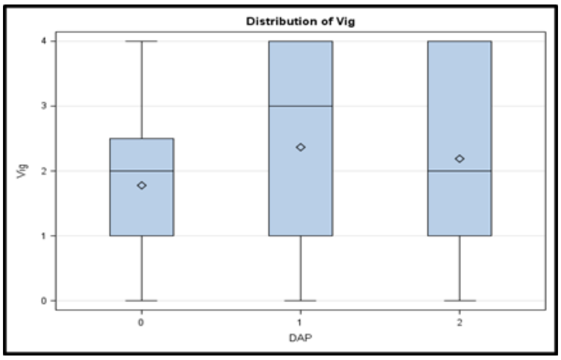

Figure 1. DAP effect on plant vigor

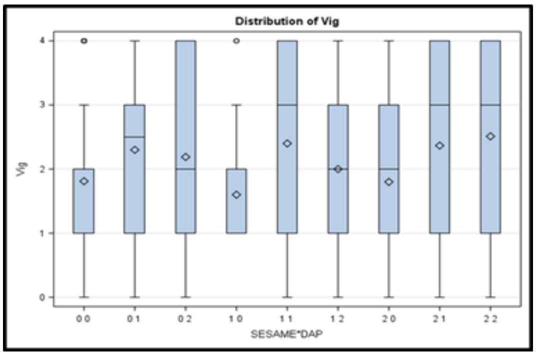

Figure 2. DAP and sesame interaction effect on plant vigor

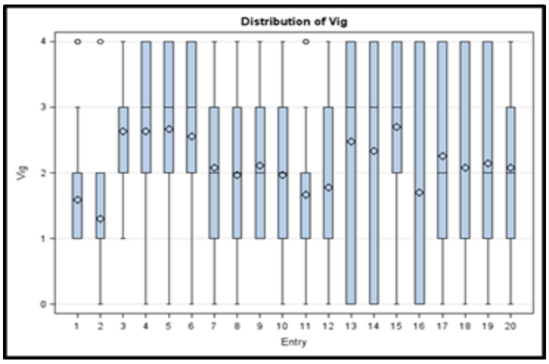

Figure 3. Entries effect on plant vigor

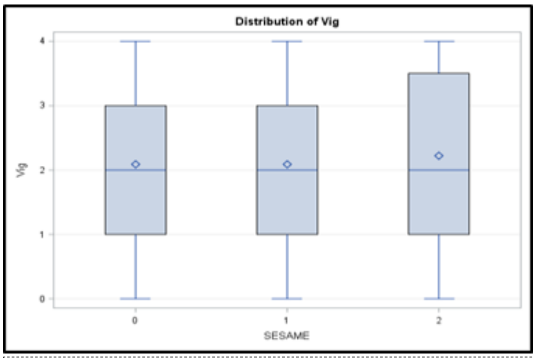

Figure 4. Sesame seed distribution effect on plant vigor

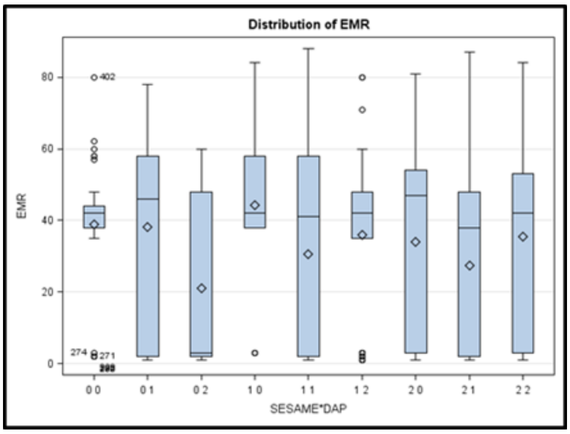

Figure 5. DAP, sesame and entries interaction effect on striga emergency

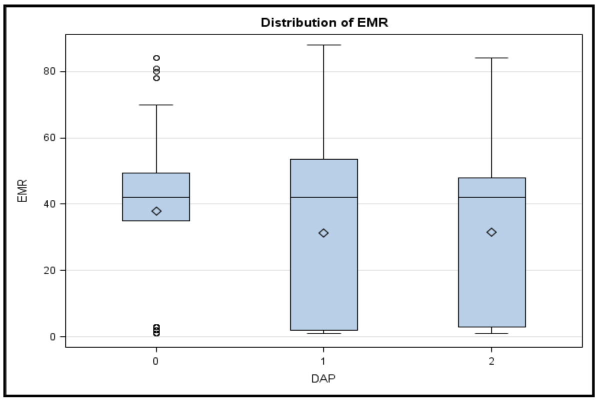

Figure 6. DAP and Sesame interaction effect on striga emergency

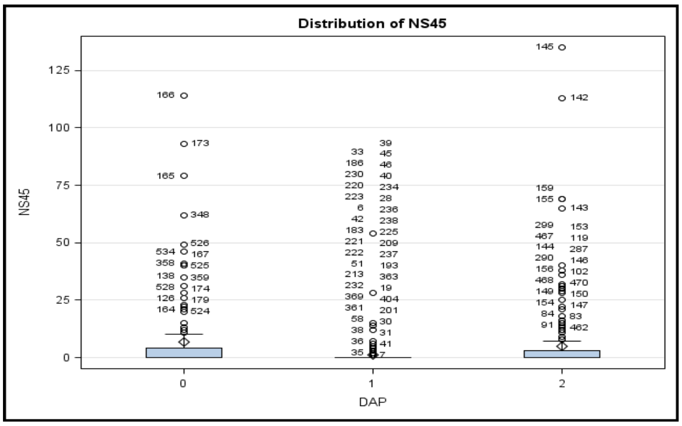

Figure 7. DAP effect on striga emergency

Therefore, the DAP was highly significant on the plant vigor. Between the three level of DAP use, the dose one of DAP (2g) have positively impact the plant vigor. Concerning the Striga emergence, no significant impact was observed from the sesame seeds doses. Thus, for the DAP application at different doses on the Striga emergence, moderate effect was observed with the dose two of DAP. For the interaction several combinations have performed well for Striga emerged plant number reduction, it concerns the combination one (T1), two (T2), seven (T7), five (T5) and three (T3). Between the cited combinations, the number one and two are the best response in terms of less emerged Striga plants. The different effect of the DAP fertilizer and the sesame seed have consistent effect on the plant vigor and the Striga emergence. The number of emerged Striga plants at 45, 60 and 90 days were also highly impacted by the different combinations in this study, confirmed by the study made Jamil 2012. Thus, the DAP fertilizer micro dose level one (2g) performed well by decreasing the Striga plant numbers in the different plots at 45, 60 and 90 days as mentioned by Jamil 2012 where it reduced Striga plant number from 66 to 70%. The sesame level two (1.5 g) well performed on the Striga plants number reduction at 45, 60, 90 days. Concerning the interaction impact, according to the different parameters the responses were different. Therefore, for the number of Striga plants at 45 days after sowing, the combination one, two, three, four, five, seven gave less Striga plants compared to the other combinations. Among those treatment, the number one, four, seven were the best treatment which highly reduced Striga plants number at the 45 days. Thus, concerning the entries responses at 45, 60 and 90 days after sowing there were nine genotypes which performed well by showing less Striga plants around, those genotypes are the genotype 3 (P9401), the genotype 4 (P9403), the genotype 5 (Brahan), the genotype 6 (S35), the genotype 7 (F2-20), the genotype 8 (CE 150-262), the genotype 9(04CZ-F5P-52), the genotype 10 (ICS1049), the genotype 13 (P9406), the genotype 14 (P9405) and the genotype 16 (TXN13 BC3F5-41).

Those genotypes are documented Striga resistant sorghum genotypes from diverse countries [5, 8]. This confirmed the fact that there are Striga resistant varieties despite the aggressiveness of the Striga hermonthica found in Niger. For the grain yield, the sesame seed effect was not significant. That means, it does not affect the yield of the twenty genotypes used in the experiment.

Concerning the DAP, it is highly effective on the grain yield with the level 2. The results confirm the previous studies made by Jamil 2010, where they have mentioned that West African country soil are characterized by less nitrogen and phosphorous, and the effectiveness of DAP micro dosing utilization can increase the yield with different level of micro dosing. Thus, according to the country and the type soil we are dealing with, the DAP quantity for the grain yield and the Striga management should be different. The interaction sesame and DAP also performed well on the grain yield with the treatment one and the treatment eight.

Conclusion

DAP utilization at the level one micro dosing (2 g) highly reduced Striga emergence and plant number distribution in sorghum cultivation. Concerning the sesame seed, effective responses were also observed on Striga related parameters with the level two micro dosing (1.5g) by reducing striga effect. In this study, the combination sesame seed, and DAP significantly reduced the negative impact of Striga on sorghum plants and increased sorghum grain yield.

References

1. Adagba, M.A., Lagoke, S.T. and Imolehin, E.D. (2002). Nitrogen effect on the incidence of Striga hermonthica (Del.) Benth in upland rice. Agronomic Hungarica, 50, 145 -150.
2. Andres, L. Lebailly, P. (2013). Le sésame dans le département d'Aguié au Niger : analyse d'une culture aux atouts non-négligeables dans une zone agricole à forte potentialité.
3. Bagayoko, M., Pale, S., Maman, N., Sirifi, S. (2011). Microdose and N and P fertilizer application rates for pearl millet in West Africa. African journal of agricultural research, 6(5), 1141-1150.
4. Bationo, A. and A.U. Mokwunye. (1991). Alleviating soil fertility constraints to increased crop production in West Africa. The experience in the Sahel. Fertilizer Research, 29, 95–115.
5. Bayu, W., Binor, S., Admassu, L. (2001). Tolerance of sorghum landraces and cultivars to Striga (Striga hermonthica) infestation in Ethiopia. Acta Agronomica Hungarica, 49, 343-349.
6. Bouwmeester, H.J., Roux, C., López-Raez, J.A, Bécard, G. (2007). Rhizosphere communication of plants, parasitic plants and AM fungi. Trends Plant Science, 12, 224–230.
7. Cardoso, C., Ruyter-Spira, C., and Bouwmeester, H.J. (2011). Strigolactones and root infestation by plant-parasitic Striga, Orobanche and Phelipanche spp. Plant Science. 180, 414–420.
8. Dugje, L.Y., Ekeleme, F., Kamara, A.Y., Menkir, A., Chikoye, D. and Omoidui, L.O. (2010). Field evaluation of Sorghum cultivars to Striga hermonthica infestation in north eastern Nigerian Savannas. Nigeria journal of weed science, 23, 1-11.
9. Gacheru, E., Rao, M. R. (2011). Managing Striga infestation on maize using organic and inorganic nutrient sources in Western Kenya. International Journal of Pest Management, 47(3), 233-239·
10. Haussmann, B. I. G., Obilana, A. B., Blum, A., Ayiecho, P. O., Schipprack, W., and Geiger, H.H. (1998).
11. Hybrid performance of sorghum and its relationship to morphological and physiological traits under variable drought stress in Kenya. Plant Breeding, 117, 223-229.
12. Institut National de la Statistique du Niger (INS) (2017).
13. Jamil, M., Charnikhova T., Houshyani, B., Ast, A., Bouwmeester, H.J. (2012). Genetic variation in strigolactone production and tillering in rice and its effect on Striga hermonthica infection. Planta,

235, 73–484.

14. Kountche, B.A., Jamil, M., Yonli, D. and Minimassom, P.N. et al (2019). Suicidal germination as a control strategy for Striga hermonthica (Benth.) in smallholder farms of sub-Saharan Africa. The New Phytologist Trust, 1(2), 107-118.
15. Larsson (2012). Soil fertility status and Striga hermonthica infestation relationship due to management practices in Western Kenya. pp 4-48.
16. Oswald, A., Ransom, J.K. (2001). Striga control and improved farm productivity using crop rotation. Crop Protection, 20, 113–120.
17. Ridder, N., Breman, H., Keulen, V.H. (2004). Revisiting acure against land hunger': soil fertility management and farming systems dynamics in the West African Sahel. Agriculture System, 80, 109–131.
18. Sjögren, H., Shepherd, K.D. and Karlson, A. (2010). Effects of improved fallow with Sesbania sesban on maize productivity and Striga hermonthica infestation in Western Kenya. Journal of Forest Ressources, 21 (3), 379-386.
19. Stoorvogel, J.J., Smaling, E.M.A., and Janssen, B.H. (1993). Calculating soil nutrient balances in Africa at different scales. I. Supra-national scale. Fertilizer Research, 35, 227-235.
20. Teka, H.B. (2014). Advanced research on Striga control: A review. African Journal of Plant Sciences, 8(11), 492-506.
21. Tunistra, M.R., Soumana, S., Al-Khatib, K. (2009). Efficacy of herbicide seed treatments for controlling Striga infestation of sorghum. Crop Science. 49, 923–929.