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Research Application Summary

Effect of crop rotation on aflatoxin contamination in groundnuts

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Abstract

Aflatoxins are secondary metabolites primarily produced by the fungi *Aspergillus flavus*, *A. parasiticus* and, to a lesser extent, *A. nomius.* Good agricultural practices can aid in the reduction of aflatoxin contaminatio in the field. Well planned crop rotations can reduce *A. flavus* populations in the soil and hence reduce the risk of aflatoxin develepment in the kernels. The main objective of the study was to assess the effect of crop rotation on aflatoxin contamination in groundnuts. The trial was carried out for two growing seasons from 2014/15 to 2015/16 at Chitedze Agricultural Research Station (CARS) in Lilongwe district and Mwimba in Kasungu of Malawi. In both sites, crop rotation treatments were sorghum, maize, sunflower, groundnuts, pegion peas, cotton, finger millet and a fallow. The following crop rotation sequences were effective in reducing aflatoxin contamination in the subsequent crops: fallow (0 ppb) / groundnuts (3.6 ppb), followed by pigeonpea (34.02 ppb)/maize (3.73 ppb), cotton (18.75 ppb)/ groundnuts (7.6 pbb) and finger millet (4.39 pbb)/cotton (3.40 pbb). On the other hand, the following crop rotation sequences increased the contamination of subsequent crops: groundnuts (3.52 pbb)/maize (7.33), maize (2.07 pbb)/groundnuts (19.6 pbb), sorghum (35.75 pbb)/Cotton (40 ppb), and pigeonpea (2.70 pbb)/ pigeonpea(39.73 pbb). The results indicated that selected rotations can be used to reduce aflotoxin contamination.

Key words: Aflatoxin, *Aspergillus flavus*, crop rotation, groundnuts, maize, Malawi

Résumé

Les aflatoxines sont des métabolites secondaires principalement produits par les champignons tels que *Aspergillus flavus*, *A. parasiticus* et, dans une certaine mesure, *A. nomius*. De bonnes pratiques agricoles peuvent aider à réduire la contamination des aflatoxines sur le terrain. Des rotations de culture bien planifiées peuvent réduire les populations d'*A. flavus* dans le sol et par conséquent réduire le risque de développement des aflatoxines dans les grains. L'objectif principal de cette étude était d'évaluer l'effet de la rotation des cultures sur la contamination de l'arachide par l'aflatoxine. L'expérimentation a été réalisée pendant deux saisons végétatives de 2014/15 à 2015/16 à la station de recherche agricole de Chitedze dans le district de Lilongwe et à Mwimba à Kasungu au Malawi. Sur les deux sites, les traitements de rotation de culture étaient le sorgho, le maïs, le tournesol, l'arachide, le pois d'angole, le coton, le mil. Les rotations des cultures suivantes ont été efficaces et ont permis de réduire la contamination par les aflatoxines: jachère (0 ppb) / arachide (3,6 ppb), suivi de pois d'angole (34,02 ppb) / maïs (3,73 ppb), coton (18,75 ppb) / arachide (7.6 pbb) et le mil (4.39 pbb) / coton (3.40 pbb). Par ailleurs, les séquences de rotation des cultures suivantes ont augmenté la contamination des cultures suivantes: arachide (3,52 pbb) / maïs (7,33), maïs (2,07 pbb) / arachide (19,6 pbb), sorgho (35,75 pbb) / coton (40 ppb), et le pois d'angole (2.70 pbb) / pois d'angole (39.73 pbb). Les résultats ont indiqué que des rotations sélectionnées peuvent être utilisées pour réduire la contamination par l'aflatoxine.

Mots clés: Aflatoxine, *Aspergillus flavus*, rotation de culture, arachide, maïs, Malawi

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Introduction

Malawi has a human population of about 17.96 million (CIA World Factbook, 2016), a large percentage of which lives in rural areas and mostly depend on subsistence farming on small pieces of land. According to Simtowe *et al*. (2012), Malawian agriculture is predominated by production of maize and groundnuts. So rotations are dominated by these two crops. Aflatoxin contamination is reportedly high in these crops because they are susceptible to *Aspergillus flavus*. Aflatoxin contamination is a recurrent problem in several crops in Africa (Bennett, 2003) with many crops grown in sub-Saharan Africa prone to aflatoxin-producing *Aspergillus* spp. due to favorable conditions that prevail in this region. It is against this background that a study was done to assess the effectiveness of other crops in reducing aflatoxin contamination when grown in rotation with maize and groundnuts.

Literature summary

In Malawi, groundnuts and maize are the most cultivated crops (MoAFS, 2012). However, these crops are prone to *Aspergillus flavus* and therefore there is often high aflatoxin contamination (Hell and Mutegi, 2011). Malawi Bureau of Standards (MBS) and CODEX alimentarius categorizes produce sample with over 10 μg kg^{-1} as unfit for human consumption. The European Union has stringent guidelines that groundnuts imports with aflatoxin content above 4 μg kg^{-1} can not be allowed in Europe. AS such, in developing countries including Malawi, much attention has been given to aflatoxin contamination and other quality issues in groundnuts produced for export. However, far less attention has been given to groundnuts produced for local consumption, as such, there is high and chronic exposure to aflatoxin. This exposure is associated with immunodeficiency, immunosuppression, stunting, kwashiorkor, liver cancerand liver diseases (Garcia *et al*., 2009).

Aflatoxin contamination before and after harvest occurs provided there is a conducive environment (high temperatures, insect damage and dry conditions). During pre-harvest, improper agricultural practices such as crop rotation, planting date, harvesting date, irrigation and fertilization can increase *A. flavus* incidences and aflatoxin contamination in groundnuts

(Torres *et al.,* 2014). Mono cropping of groundnuts or maize may result in high infection by fungi and aflatoxin contamination (Mutegi *et al*., 2009). Fandohan *et al.* (2008) and Mutegi *et al.* (2012) reported that crop rotation may reduce or lower the rate of between season survival of different fungal species, most especially if the crops involved are non-host to *Aspergillus* species. Aflatoxin contamination is common in various food products like cereals (maize, sorghum, pearl millet, rice and wheat); oilseeds (groundnut, soybean, sunflower and cotton); spices (chillies, black pepper, coriander, turmeric and ginger); tree nuts (almonds, pistachio, walnuts and coconut); and milk and milk products (Bankole and Adebanjo, 2003; Afolabi *et al.*, 2006; Lopez *et al.,* 2011).

Methodology

The study was done in Mwimba and Chitedze. Mwimba (1084 m asl) receives annual rainfall ranging from 750-1200 mm. The major soil groups and soil series of Mwimba are weakly ferallitic latosol (ultisol), Mwimba series (medium-textured sandy clay loam). Chitedze (1177 m asl) receives annual rainfall ranging from 700-1200 mm and is comprised of Ferruginous latosal (Alfisol) soils. The following crops were grown in following sequences: at Mwimba: Sunflower-Fallow, groundnuts-Maize, Maize-Groundnuts, Sorghum-Pigeonpea, Millet-Cotton, Fallow-Sunflower, and Pigeonpea-Sorghum. At Chitedze site the following crops and sequence were studied: Cotton-Groundnuts, Maize-Groundnuts, Sunflower-Sorghum, Fallow-Groundnuts, Pigeonpea-Maize, Groundnuts-Maize and Sorghum-Cotton. The trial at Chitedze was established on 22 December 2015 and harvesting started on 14 April 2016 to 7 May, 2016. At Mwimba, the trial was established on 23 December 2015 and harvesting started on 16 April, 2016 . Aflatoxin contamination levels (AfB1) in grain samples in year one was analyzed using ELISA while in the second year it was analyzed using Rapid test (Mobile assay) using neogine strips. Data were analysed using analysis of variance in Gensat computer statistical package, 17th Edition.

Research application

Aflatoxin levels (AfB1) in various crops at Chitedze. Aflatoxin contamination levels in crops ranged from 0.73 pbb in sunflower to 40 pbb in cotton both grown in the second year of the trial. Some of the sequences were effective in reducing contamination in the following growing season whilst others increased the infection (Fig. 1). For instance, pigeonpea-maize, fallow-groundnuts and cotton-groundnuts sequences were effective in reducing aflatoxin contamination. Nevertheless, only pigeonpea (34.02 pbb)-maize (3.7 pbb) and fallow-groundnuts (3.6 pbb) sequences reduced aflatoxin levels to allowable limits by the European Union (below 4 ppb). However, according to CODEX (1995), aflatoxin levels not exceeding 10 ppb are safe for human consumption. Therefore pigeonpea, fallow and to a less extent, cotton if used in rotation may reduce soil fungal inoculum. Diener *et al*. (1987) reported that pigeonpea followed by a fallow of not less that two growing seasons significantly reduced *Aspergillus flavus* population and aflatoxin contamination. On the other hand, groundnuts (3.52 pbb) - maize (7.33), maize (2.07 pbb) - groundnuts (19.6 pbb), sorghum (35.75 pbb) - Cotton (40 ppb) and pigeonpea (2.70 pbb) - sorghum (39.73 pbb) sequences increased contamination levels of aflatoxin.

Aflatoxin levels (AfB1) in various crops at Mwimba. Some crop rotation sequences that increased aflatoxin contamination in the subsquent crops at Chitedze also also did the same at Mwimba. Such sequences included maize (4.81 pbb)/groundnuts (9.8 pbb) and groundnuts (7.22 pbb)/maize (55.80 pbb). Another cropping sequence that increased aflatoxin contamination at this site was pigeonpea (2.70 pbb)/sorghum (39.73 pbb) (Fig. 2). On the

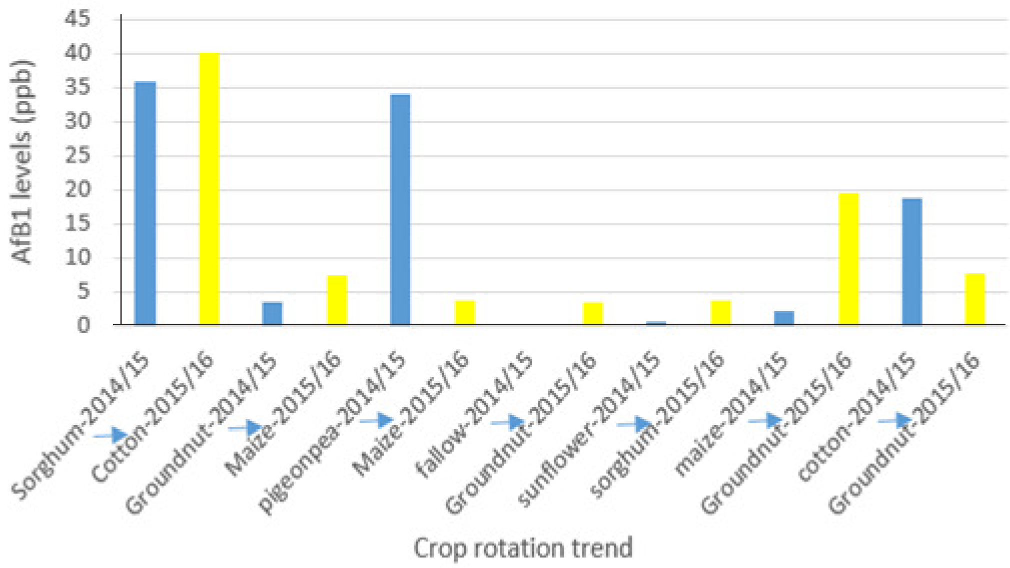

Figure 1. Aflatoxin levels for crops grown at Chitedze under crop rotation (blue indicates crop grown in 2014/15 and yellow indicates crop that followed in the 2015/16 growing season)

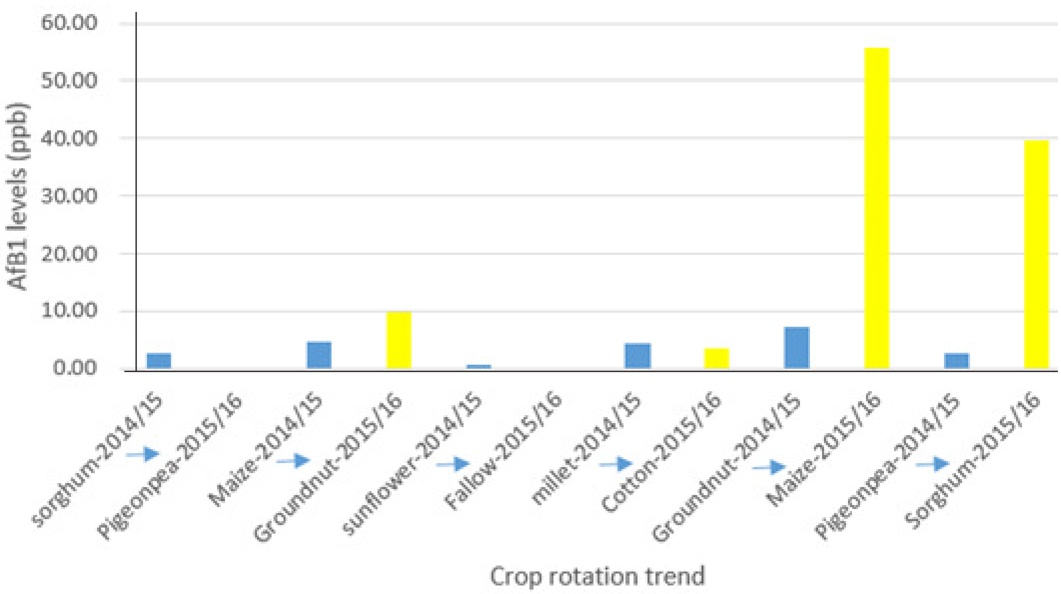

Figure 2. Aflatoxin levels for crops grown Mwimba (Kasungu district) in two growing season under crop rotation (blue indicates crop grown in 2014/15 and yellow which indicates crop that followed in the 2015/16 growing season)

other hand, only finger millet (4.39 pbb/ Cotton (3.40 pbb) sequence was effective in reducing aflatoxin contamination. Contamination ranged from 3.40 pbb in cotton to 55.80 pbb in maize for all crops grown in the second year. Results of aflatoxin contamination in pigeonpea at this site have not been discussed as the crop was not harvested by the time of writing.

Conclusion

The results from both sites showed that the following sequences; pigeonpea-maize, fallow-groundnuts, cotton-groundnuts and millet-cotton were effective in reducing aflatoxin levels. But only pigeonpea-maize and fallow-groundnuts sequences reduced aflatoxin levels to allowable limits by European Union (below 4 ppb). These sequences may be adopted by both smallholder and commercial farmers particularly in central Malawi as one of the means of combating aflatoxin challenges. Furthermore, the sequences groundnuts-maize, maize-groundnuts, sorghum-cotton and pigeonpea-sorghum have been observed to increase aflatoxin contamination and these should be avoided. It was also noted that sorghum contamination levels tended to be higher in both sites irrespective of the crop it followed. This was thought to be due to heavy attack by birds and covered kernel smut (*Sphacelotheca sorghi)* which may have predeposed the plants to aflatoxin contamination. Therefore prevention of these pests in the field might reduce aflatoxin contamination in sorghum.

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