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Does the informal seed system threaten cowpea seed health?

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ABSTRACT

Most smallholder farmers in developing countries depend on an informal Seed System (SS) for their seed. The informal SS is often criticized because farmer-produced seed samples are not tested for seed health, thus accepting the risk of planting infected seeds. Here we aimed at assessing the quality of seeds acquired from the informal SS, and compared this with the quality of seeds obtained from the formal SS. Cowpea seed production in northern Nigeria was used as a case study to evaluate the seed health of samples from farmers, seed companies, and foundation seed producers. In two years, a total of 45,500 seeds from 91 seed samples from 43 sources (farmers, seed companies and research) were tested for seed-borne bacteria and fungi by plating disinfested seed onto an agar medium. The most commonly isolated plant pathogens were *Fusarium oxysporum* (69% of the samples), *Macrophomina phaseolina* (76%) and *Pseudomonas syringae* pv. *phaseolicola* (48%). The infection incidence, the percentage of seeds infected per sample, varied from 0.2 to 75.6%. *F. oxysporum* had a median infection incidence of 9% in 2009 and 25% in 2010, while *M. phaseolina* had a median infection between 4 and 10%. On average, 8.8 species per sample were isolated from foundation seed, 9.2 from farmer-produced seed and 9.8 from seed companies' seed. No evidence was found that seed recycling in the informal SS did lead to increased levels of seed-borne pathogens. In contrast to farmers, seed companies distribute seed over large distances, and therefore form a potential threat for spreading diseases at relatively large scale. Responsible authorities are recommended to make seed dressing mandatory for all seeds sold by seed companies.

1. Introduction

Over 80% of smallholder farmers in developing countries depend on the informal Seed System (SS) for their seed supply (Louwaars and De Boef, 2012). The informal SS is defined as a system in which farmers are involved in selection, production and dissemination of seed, whereby sales, exchanges or donations of seed occur in the local community. In contrast, the formal SS is defined as all public institutions and private seed companies involved in breeding, seed production, quality control and dissemination of seed. Farmers in the informal SS use the formal SS from time to time to access new varieties (Almekinders and Louwaars, 2002). Another reason to frequently replace seed is to avoid seed recycling, which is supposed to lead to low yields through decline of seed quality (Amaza et al., 2010). The formal SS aims at regulating the seed sector in an attempt to guarantee sufficient supply of high quality seed. In contrast, the informal SS excludes seed testing, which leads to substantially lower prices than the formal SS, thereby accepting the presumed risk of reduced seed quality (Van Gastel et al., 2002).

Plant diseases are a major threat to food security, contributing to the malnutrition of over 800 million people worldwide (Strange and Scott, 2005). Many plant diseases are seed-borne, i.e. they are transmitted by the seed. Planting infected seeds increases germination failure, seedling mortality and diseased plants, and all may lead to lower yields. Moreover, infected crops may lead to increased levels of seed infection in the progeny. Since various soil-borne pathogens can be seed-borne, trade of infected seeds can facilitate the introduction of soil-borne pathogens to hitherto uninfested soils. Therefore most countries put phytosanitary regulation in

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place to ensure that only healthy seeds are traded (Maddox, 1998). However, an infrastructure for seed health testing is required to enforce these regulations. Although the formal SS has these institutions in place, their performance in developing countries is unknown, despite efforts of the International Seed Testing Association (ISTA) to improve and standardize seed testing in these countries. This study assesses the performance of both SSs for cowpea [*Vigna unguiculata* (L.) Walp.] seed health in northern Nigeria.

Cowpea is a widely grown legume in Nigeria, providing vital proteins to millions of people (Langyintuo et al., 2003). Cowpea fields can suffer significant yield losses from plant diseases, including seed-borne diseases (Bankole and Adebanjo, 1996). The role of the informal SS in transmitting cowpea diseases was previously analyzed in Zimbabwe. Manyangarirwa et al. (2009) tested 20 samples of farmer-retained cowpea seeds on seed-borne fungi and bacteria, and investigated seed to plant transmission. The results showed that the samples were heavily infected with seed-borne fungi and bacteria, including *Bipolaris* spp. (present in 25% of the samples), *Fusarium oxysporum* (60%), *Phoma* spp. (75%), and *Macrophomina phaseolina* (25%). *F. oxysporum and M. phaseolina* were also observed on cowpea seeds that had been produced in northern Nigeria (Emechebe and McDonald, 1979).

This research compares the seed health status of cowpea samples from the formal (seed companies and foundation seed producers) and informal (farmers) SS in northern Nigeria. Since the informal SS does not have any quality control in contrast to the formal SS, the hypothesis is that farmer-produced seed (=informal SS) are infected with relatively high levels of seed-borne pathogens, while seed company and foundation seed samples (=formal SS) are relatively free of seed-borne pathogens. This study also assesses the relation between seed recycling and seed health, expecting increased seed health risks after more seasons of seed recycling. Furthermore, the study assesses which pathogens occurred in the collected samples and whether infection of the various pathogens encountered showed correlations. We also tested the effect of seed infection on cowpea germination for all pathogens in the infected samples.

2. Materials and methods

2.1. Seed samples

Seed samples of 2.5 kg each were collected from farmers and seed companies in Borno and Kaduna states in northern Nigeria. Borno was a focus state for the project "Promoting Sustainable Agriculture in Borno state" (PROSAB), which trained and supported farmers in seed production to enhance seed availability and improve seed quality. Kaduna state is situated in the center of northern Nigeria, comprising the Southern and Northern Guinea savannah agro-ecologies. Borno state is the most north-eastern state of Nigeria, containing both Guinea savannah zones and the dryer Sudan savannah zone. Three improved cowpea varieties were selected based on their maturity type and wide adoption among farmers. The late-maturing variety IT89KD288 and medium-maturing IT89KD391 were most popular in Borno State. The very-early-maturing variety IT93K452-1 was the most preferred variety in Kaduna State.

A total of 91 cowpea seed samples were collected, 45 in 2009 and 46 in 2010 (Table 1). Eighty-one samples originated from 40 seed producing farmers, five samples from two seed companies and five samples from the International Institute of Tropical Agriculture (IITA). Twenty-seven farmers each contributed one sample in 2009 and one from the same variety in 2010, and four farmers delivered samples from two varieties in both years. One farmer delivered three samples, and eight farmers only one sample. The farmers were recorded by name and village. To calculate the number of on-farm multiplications of the seed, farmers were asked which year they received foundation seed. Farmers were also asked whether they applied the insecticide phostoxin prior to storage, a common way to prevent seed damage from the storage pest *Callosobruchus maculatus* F., commonly called weevils.

Table 1
Overview of cowpea seed samples collected from farmers, seed companies and foundation seed producers. Farmers received foundation seed between 2001 and 2009, and multiplied their seed for 1–9 seasons until our sampling in 2009 or 2010. The number of seasons the farmer multiplied the seed on-farm is referred to as "on-farm multiplication".

Source	State	Number of on-farm multiplications	Number of samples	
			2009	2010
Foundation seed	[a]	0	3	2
Seed company	[a]	0	1	4
Farmers	Borno	1	3	3
		2	2	3
		3	1	2
		4	2	1
		5	2	0
		6	0	1
	Kaduna	1	5	0
		2	6	5
		3	7	6
		4	5	7
		5	3	4
		6	2	3
		7	0	2
		8	3	0
		9	0	3
Total			45	46

[a] Outlet and production location may not be the same.

Samples from commercial seed companies were purchased from the company outlets in Borno, Kaduna, and Kano states, one sample in 2009 and four samples in 2010. IITA delivered five foundation seed samples; one for each variety in 2009, and one for varieties IT89KD288 and IT89KD391 in 2010. In contrast with IITA policy for seed delivery, the foundation seed samples had not been tested and selected for being free from diseases. All seed samples were stored at room temperature between collection and planting time to mimic storage conditions of farmers buying seed from their colleagues. Prior to the storage period, samples with weevil damage were treated with Degesh phostoxin with 56% aluminum phosphide, produced by Detia Freyberg GmbH from Germany, to stop the insect from spreading through the seed sample.

2.2. Seed health testing

Five hundred seeds from each sample were analyzed for seed-borne pathogens. Seeds in each sample were visually inspected to select undamaged seeds (e.g. insect damage, discolorations, malformation), because damaged cowpea seeds are less likely to germinate (Biemond et al., 2012). The root of germinating seeds physically opens the seed, increasing the chance that pathogens inside the seed escape and invade the agar medium of the petri-dish. Seeds were surface-sterilized by soaking them in a 10% (v/v) sodium hypochlorite solution for 1 min followed by washing with three changes of sterile distilled water and blotting dry on paper towels. Seeds were then planted on nutrient broth yeast (NBY) agar media plates (10 seeds per plate) and incubated at 27 °C for four days. Any fungal/bacterial growth was transferred and purified using the hyphal tip/single spore technique. Fungal cultures were identified based on the morphological characters (Barnett and Hunter, 1998) and bacterial cultures were identified