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Role of Infected Seed Potato Tuber in Contamination of Land and Clean Potato Stocks with Common Scab

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Authors' contributions

This work was carried out in collaboration between all authors. Author AIAI designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MYAA and SME managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this study was to assess the role of scab-infected seed tubers in contamination of land and progeny of clean potato stock with common scab. The experiment was conducted over two consecutive years using the white-skinned cultivar 'Diamant' and the red-skinned 'Pekaro'. They were planted in separate plots as contaminated and clean seed tubers, respectively, or mixed along the same ridge in an alternating pattern of contaminated and clean seed stocks of the two potato cultivars. In both seasons, scabby seed tubers produced significantly the highest infection levels in the progeny tubers (34% and 41.7%, respectively). In comparison with the clean control, the progeny of the clean stock in the mixed treatment developed significantly higher common scab (17.3% and 30.3% in the two seasons, respectively). The abundance of scab on progeny tubers was also significantly different between the various treatments and followed the same trends as above. The disease development was significantly greater on tubers harvested twelve weeks after planting compared to earlier harvest. Thus the seed-borne scab inoculum appeared to play a profound role in contamination of land and consequentially a significant infection of clean potato stocks.

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1. INTRODUCTION

The total area under potato production in Sudan is estimated to have reached about 25000 ha with a total production of ~ 220 thousand tons. Of that, a total of ~ 130000 tons is produced yearly under irrigation in Khartoum State alone and most of it (~ 70%) is a late winter crop (Dec. – Apr.), in addition to an early winter crop (Oct. – Feb.). The other main area of potato cultivation in the low lands along the River Nile exist in the River Nile and Northern states. The other main potato growing area in Sudan is located in Jebel Marra area in Darfur region of Western Sudan where the local 'Zalinge' potato stocks are dominating and are grown under rain as "Kharif" crop. Minor production areas are also found in Kassala and Red Sea states (Fig. 1).

Common scab, caused by *Streptomyces* spp. is an economically important disease of potato throughout the world. The scab affected tubers may display superficial, raised or deep-pitted corky lesions, which often reduce the quality and marketability of both fresh market and processing potatoes depending on the *Streptomyces* strains and potato cultivars [1,2,3]. For more than a decade potato common scab has attained alarming levels in the main potato growing areas in Sudan reducing the quality of tubers, sometimes to the extent that they can no longer be sold [4]. In addition, severe seed-borne infection with common scab may also lead to down grading or rejection of seed potatoes [5] since it can constitute a great potential for survival and long distance dissemination of the causal species [6,7]. Contrary to few assumptions that the intensity of scab lesions on seed tubers has minor relationship with the disease on progeny tubers [8,9,10], several studies have shown that the severity of common scab in the daughter tubers is directly related to the severity on the mother tubers [6,11]. However, it is largely accepted that seed-borne inoculum may still be held responsible for introduction of common scab to new fields and regions [7,12,10]. Being a common soil inhabitant, the scab organism released from diseased seed tubers can survive in absence of host plants as saprophytes in the soil or on plant

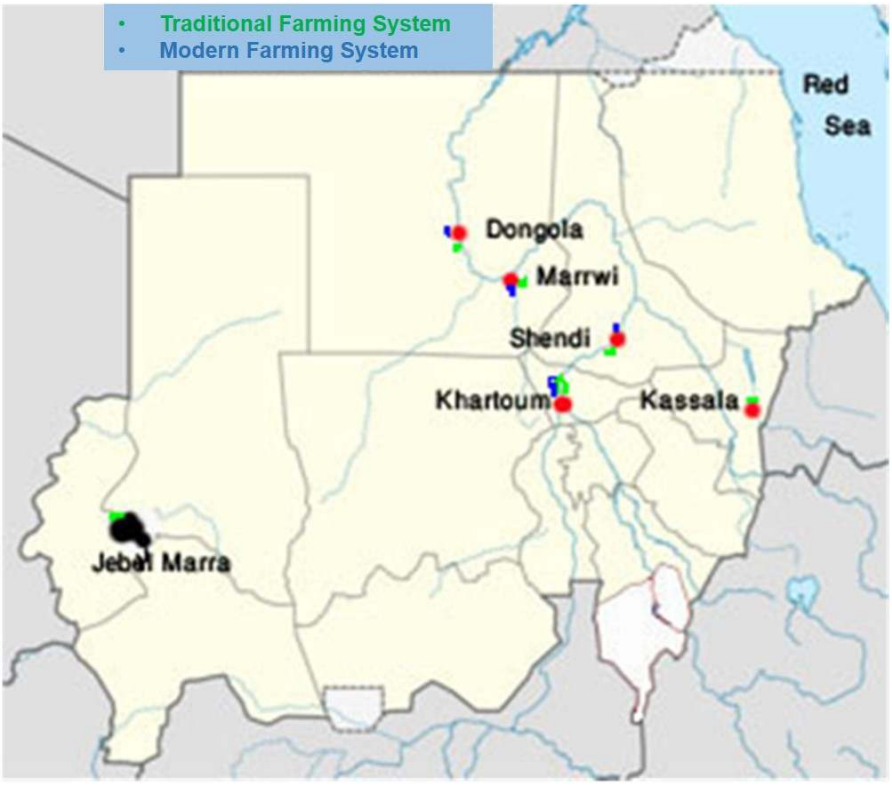

Fig. 1. Main potato production areas under traditional and modern farming systems in Sudan

debris for over a decade [13] leading to serious contamination of land. The soil-borne inoculum multiply in rhizosphere and follow the growth of tubers causing infection of newly formed progeny tubers primarily through immature lenticels [14,12]. However, there has been little work carried to determine the means by which *Streptomyces* spp. spread to new areas and their distribution within field and to neighbouring fields [12]. Therefore, the main objective of the present paper was to investigate the role of scab–affected seed potato tuber in contamination of land and infection of clean potato stocks with common scab.

2. MATERIALS AND METHODS

2.1 Field Experiment

The experiment was intended to indicate the epidemiological role of scabby seed tubers in perpetuation of common scab in a non-infested land and subsequent infection of clean potato stocks planted in the same land. Clean potato seed tubers (free of scab lesions) were surface disinfested with 0.5% NaOCl for 10 min before planting. Two certified scab-susceptible cultivars; 'Diamant' (white-skinned) and 'Pekaro' (red-skinned) were used in the experiment and planted in a field that has never been grown before with potato or any other crop (*i.e*. non-scab-infested soil) at WAS farm, 10 km west of Omdurman city (latitude 15º: 40" N, longitude 32º: 32" E, 280 m above sea level), Khartoum State during seasons 2008/2009 and 2009/2010. The climate is semi-arid and the soil is high terrace sandy soil about 15 kms away from the River Nile. The experiment was designed as a factorial experiment in a Randomized Completely Block Design (RCBD) consisting of 3 treatments.

The treatments were as follows:

1- Clean: in which only scab-free, disinfested seed tubers were planted.
2- Infected: scabby seed tubers were used (Fig. 2).
3- Mixed treatment: In this treatment, scab-infected seed tubers, with moderate inoculum load, of one variety (white- or red-skinned) were planted in alternate drills along the same ridge with clean seed tubers of the other variety. Each treatment consisted of three replications, each having 4 ridges (2 m long spaced at 0.75 m apart and 0.20 m between holes). Fertilization and watering were performed as recommended by the Agricultural Research Corporation, Sudan. Assessment of common scab development in the progeny tubers was carried out after 8, 10 and 12 weeks from planting. The scab incidence was evaluated according to the following formula:

$$\text{Common scab incidence (\%)} = \frac{\text{Number of infected tubers} \times 100}{\text{Total number of tubers inspected}}$$

The infected tubers were rated for scab severity on a scale of 1–4, from those showing typical scab lesions, where 1 ≡ superficial lesions occupying ≤ ⅛ of the tuber surface area; 2 ≡ slightly raised or slightly pitted lesions occupying > ⅛ - ¼ of the tuber surface area; 3 ≡ moderately raised or moderately pitted lesions occupying > ¼ - ½ of the tuber surface area; 4 ≡ severely raised or pitted lesions covering > ½ of the tuber surface area.

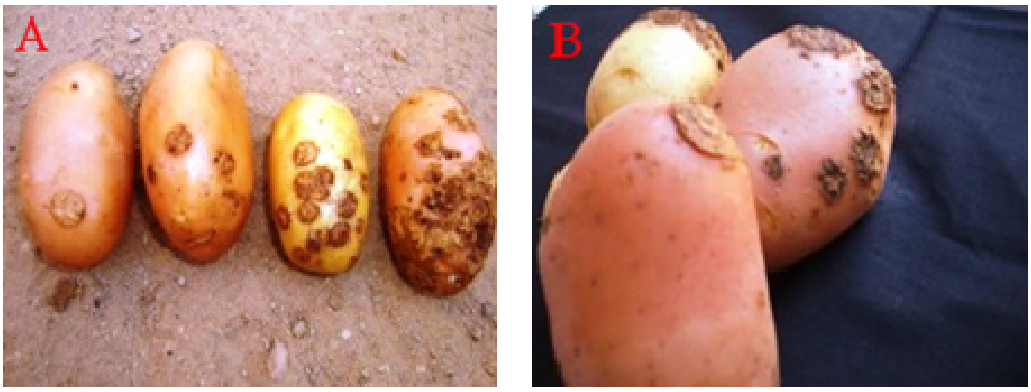

Fig. 2. Lesion types of common scab disease encountered on potato tubers in Khartoum area
Different, well developed lesion types: A) Superficial lesions B) Raised lesions

3. RESULTS

3.1 Scab Incidence (seasons 2008/09 and 2009/10)

The results for season 2008/09 were shown in Table 1a. Significant differences in scab incidence were found among the three seed tuber conditions. Whereas planting clean seed produced progeny tubers carrying no scab lesions (0% incidence), pronounced contamination of land and clean potato stock appeared to occur as a consequence of planting infected or infected alternating with scab-free seed tubers as assessed 8, 10 and 12 weeks after planting. The greatest overall mean of scab incidence (~34%) resulted from the infected seed, followed by the mixed (infected alternating with clean seed) treatment (~17.3%). Although the red-skinned cultivar, 'Pekaro' appeared to be relatively more susceptible to scab than the white-skinned 'Diamant', no significant differences were found between these two cultivars. Likewise, the increase in scab incidence with time (from 8-12 wk) was also non-significant.

In season 2009/10, similar results to the previous season were obtained (Table 1b) except that more scab incidence was recorded for both the infected (~41.7%) and the mixed (30.3%) treatments. However, scab incidence due to planting clean seed tubers remained unchanged (0%).

3.2 Scab Severity (season 2008/09 and 2009/10)

The role of infected seed tubers played a significant role in contamination of land and clean potato stocks as shown in Tables 2a and 2b. The results of both seasons (2008/09 and 2009/10) had the same trend with regard to scab severity.

Significant differences in scab severity were found among the three seed tuber conditions; the infected seed resulted in the greatest severity, followed by the mixed treatment, while the clean seed produced non-scabby progeny tubers.

Although no significant differences in scab severity were found between the 8 and 10 wks after planting, the scab severity at 12 weeks from planting was significantly higher than at 8 and 10 wks after planting. Being selected based on their sensitivity to scab, no significant differences between the two cultivars in the overall means of scab severity.

4. DISCUSSION

The data disclosed that the experimental system used in this study was conveniently simple, practical and yielded interesting results. The scab organism released from infected tubers of one cultivar seemed to have contaminated the land in the early stages of its life cycle and later incited significant infection of the progeny tubers of the other clean potato cultivar. This experimental system has been successfully tested before to assess the role of seed tuber in the contamination by *Erwinia carotovora* of potato crops in Scotland [15]. Thus, the seed-borne inoculum appears to play an ingrained role in contamination of land and consequentially a significant infection of progeny tubers with common scab [13,7,11]. Under Australian conditions, Wilson et al. [6] clearly demonstrated the importance of both seed- and soil-borne inoculum in the epidemiology of potato common scab. They found that the severity of disease in harvested potatoes was directly related to the severity of scab in the planted seed tubers. Similarly, Tajul et al. [12] working in Bangladesh suggested that inoculums from scabby seed potato can result in contaminated progeny tubers the next season. Also, Khatri et al. [16] found that scab-contaminated seed tubers play a critical role in the introduction and establishment of common scab organisms in new potato cropping areas free of soil contamination. Conversely, few other reports [8,9,10] have claimed that the abundance of common scab on seed tubers seems to play a minor role for common scab incidence in progeny tubers. The fact that the progeny tubers of the clean stock planted in non-contaminated soil carry a considerably high load of common scab indicate that the diseased mother tubers of the other potato cultivar released the bacteria and contaminated the land where the two cultivars (White- and Red – skinned potatoes) were planted. The soil-borne scab inoculum then multiplied in rhizosphere and attacked actively growing young tubers [12]. According to Stevenson et al. [14], infection of progeny tubers is primarily through young lenticels. This was substantiated by the present results in which considerable infection with common scab was detected on progeny tubers of eight-week-old plants. Thus tubers seem to

Table1a. Role of infected seed tuber in contamination of land and clean potato stocks with common scab estimated at different plant age a) Scab incidence (%), season 2008/09

Seed tuber condition[2]	Assessment time[1] (wks)									Overall mean of tuber condition
	8			10			12			
	WS	RS	Mean	WS	RS	Mean	WS	RS	Mean	
Clean	00.00d*	00.00d	00.00C	00.00c	00.00c	00.00C	00.00c	00.00c	00.00C	00.00C
Infected	23.97b	35.56a	29.77A	30.52a	34.05a	32.29A	37.61a	41.90a	39.76A	33.97A
Mixed	13.77c	18.71bc	16.24B	15.26b	18.20b	16.73B	19.05b	18.09b	18.87B	17.27B
Mean of cv.	12.58A	18.09A		15.26A	17.42A		18.89A	20.20A		
Overall mean of (WS)	15.60A									
Overall mean of (RS)	18.57A									
Overall mean of wks			15.34A			16.34A			19.55A	

The experiment was conducted in a scab-free virgin soil.

[1]Scab incidence was assessed in progeny tubers after 8, 10 and 12 weeks (wks) from planting. In Mixed treatment, scab development was assessed in the progeny tubers produced from the scab-free seed tubers.

[2]Seed tubers from white-skinned (WS) and red-skinned (RS) cultivars were planted as follows: Clean: seed tubers free of scab lesions were used; Infected: seed tubers with scab lesions (12.5-25% of the tuber surface was occupied) were used; Mixed: seed tubers with scab lesions of one cultivar (white- or red- skinned) were planted in alternate drills in the same ridge with seed tubers free of scab lesions of the other cultivar.

** Means having the same letter within each column or row are not significantly different at P = 0.05, according to Duncan's Multiple Range Test*

Table1b. Role of infected seed tuber in contamination of land and clean potato stocks with common scab estimated at different plant age b) Scab incidence (%), season 2009/2010

Condition of seed tuber[2]	Assessment time[1] (wks)									Overall mean of tuber condition
	8			10			12			
	WS	RS	Mean	WS	RS	Mean	WS	RS	Mean	
Clean	00.00d*	00.00d	00.00C	00.00c	00.00c	00.00C	00.00c	00.00c	00.00C	00.00C
Infected	32.57b	36.99a	34.75A	41.06a	45.12a	43.09A	44.06a	50.00a	47.10A	41.67A
Mixed	26.83c	29.40bc	28.11B	28.65b	31.82b	30.24B	30.85b	34.50b	32.70B	30.33B
Mean of cv.	20.40A	22.13A		23.24A	25.65A		27.30A	28.20A		
Overall mean of (WS)	22.87A									
Overall mean of (RS)	25.33A									
Overall mean of (wks)			21.26A			24.44A			26.60A	

The experiment was conducted in a scab-free virgin soil, [1] Scab incidence was assessed in progeny tubers after 8, 10 and 12 weeks (wks) from planting. In Mixed treatment, scab development was assessed in the progeny tubers produced from the scab-free seed tubers.

[2]Seed tubers from white-skinned (WS) and red-skinned (RS) cultivars were planted as follows: Clean: seed tubers free of scab lesions were used; Infected: seed tubers with scab lesions (12.5-25% of the tuber surface was occupied) were used; Mixed: seed tubers with scab lesions of one cultivar (white- or red- skinned) were planted in alternate drills in the same ridge with seed tubers free of scab lesions of the other cultivar.

** Means having the same letter within each column or row are not significantly different at P = 0.05, according to Duncan's Multiple Range Test*

Table 2a. Role of infected seed tuber in contamination of land and clean potato stocks with common scab estimated at different plant age a) Scab severity, season 2008/09

Seed tuber condition	Assessment time (wks)									Overall mean of Tuber condition
	8			10			12			
	WS	RS	Mean	WS	RS	Mean	WS	RS	Mean	
Clean	0.00c*	0.00c	0.00C	0.00c	0.00c	0.00C	0.00c	0.00c	0.00C	0.00C
Infected	1.80a	1.80a	1.80A	1.90a	2.10a	2.00A	2.20ab	2.70a	2.50A	2.10A
Mixed	1.00b	1.80a	1.40B	1.80b	1.50b	1.70B	2.20ab	1.90b	2.10B	1.70B
Mean of cv.	0.90B	1.20A		1.20A	1.20A		1.20A	1.20A		
Overall mean of (WS)	1.20A									
Overall mean of (RS)	1.30A									
Overall mean of wks			1.05B			1.20B			1.50A	

The experiment was conducted in a scab-free virgin soil.

-Disease severity was rated on a scale of 1-4, where: 1 ≤ ⅛ of the tuber surface occupied by superficial scab lesions and 4 > ½ occupied by raised or pitted scab lesions.

- Mean disease severity was obtained by the expression: number of tubers in each severity scale × severity scale / total numbers of tubers assessed.

**Means having the same letter within each column or row are not significantly different at P = 0.05, according to Duncan's Multiple Range Test*

Table 2b. Role of infected seed tuber in contamination of land and clean potato stocks with common scab estimated at different plant age b) Scab severity, season 2009/10

Seed tuber condition	Assessment time (wks)									Overall mean of tuber condition
	8			10			12			
	WS	RS	Mean	WS	RS	Mean	WS	RS	Mean	
Clean	0.00d*	0.00d	0.00C	0.00c	0.00c	0.00C	0.00c	0.00c	0.00C	0.00C
Infected	1.70a	1.80a	1.80A	2.10ab	2.40a	2.30A	2.30b	3.30a	2.80A	2.30A
Mixed	1.70a	1.20b	1.50B	1.90b	1.40c	1.70B	2.10b	1.80b	2.00B	1.73B
Mean of cv.	1.10B	1.00B		1.30B	1.30B		1.50B	1.70A		
Overall mean of (WS)	1.26A									
Overall mean of (RS)	1.33A									
Overall mean of wks			1.10B			1.30B			1.60A	

The experiment was conducted in a scab-free virgin soil.

-Disease severity was rated on a scale of 1-4, where: 1 ≤ ⅛ of the tuber surface occupied by superficial scab lesions and 4 > ½ occupied by raised or pitted scab lesions.

- Mean disease severity was obtained by the expression: number of tubers in each severity scale × severity scale / total numbers of tubers assessed.

**Means having the same letter within each column or row are not significantly different at P = 0.05, according to Duncan's Multiple Range Test*

be most susceptible to infection during the early period of rapid tuber growth. However, Khatri et al. [16] suggested that the infection window may last until eight weeks after tuberization. This might be supported by the higher scab development in progeny tubers from 12 week-old plants compared to those from 8 and 10 week-old potato plants. The practical implication of these findings is that, since resistant cultivars may not be available so far, common scab cannot be effectively controlled except by maintaining soils and planting seed stocks free of scab.

5. CONCLUSION

The seed-borne inoculum is responsible for the dispersal of new pathogenic *Streptomyces* strains or species to fields and areas where they are absent. A consequential practical implication is that common scab must be within the checklist of seed potatoes pathogens with quarantine significance. This is substantiated by the results of the role played by seed tubers in contamination of land and clean potato stocks.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hiltunen LH, Laakso I, Chobot V, Hakala KS, Weckman A, Valkonen JPT. Influence of thaxtomins in different combinations and concentrations on growth of micro-propagated potato shoot cultures. J Agri and Food Chemistry. 2006;54:3372-3379.
2. Loria R, Kers J, Joshi M. Evolution of plant pathogenicity in *Streptomyces*. Ann Rev Phytopathol. 2006;44:469-487.
3. Wanner LA. Apatchwork of *Streptomyces* species isolated from potato common scab lesions in North America. Am J Potato Res. 2009;86:247-264.
4. Irabi AIA. Etiology, ecology and management of common scab (*Streptomyces* spp.) Under traditional and modern potato farming systems in Sudan. Ph. D. Thesis, Faculty of Agriculture, University of Khartoum; 2012.
5. Gouws R. Etiology and integrated control of common scab on seed potatoes in South Africa. Ph. D. Thesis, University of Pretoria; 2006.
6. Wilson CR, Ransum LM, Pemberton BM. The relative importance of seed-borne inoculum to common scab disease of potato and the efficiency of seed tuber and soil treatments for disease control. J Phytopathol. 1999; 147:13-18.
7. Wang A, Lazarovits G. Role of seed tubers in the spread of plant pathogenic *Streptomyces* and initiating potato common scab disease. Am. J. Potato Res. 2005;82:221-230.
8. Bjor T, Roer L. Testing resistance of potato varieties to common scab. Potato Res. 1980;23(1):33-47.
9. Pavlista AD. How important is common scab in seed potatoes. Am Potato J. 1996;73:275-278.
10. Johansen TJ, Dees MW, Hermansen A. High soil moisture reduces common scab caused by *Streptomyces turgidiscabies* and *Streptomyces europaeiscabiei* in potato. Acta Agriculturae Scandinavica, Section B-soil & Plant Sci. 2015;65(3):193-198.
11. Tegg RS, Corkrey R, Herdina H. Modeling pathogen DNA content and visual disease assessment in seed tubers to inform disease in potato progeny root, stolon, and tubers. Plant Dis. 2015; 99(1):50-57.
12. Tajul MI, Hossain MI, Dey TK. Effect of inoculums level of common scab of potato (*Solanum tuberosum* L.) caused by *Streptomyces scabies* on progeny tubers. J Biol. 2013;1(3):60-65.
13. Loria R, Bukhalid RA, Fry BA, King RR. Plant pathogenicity in the genus *Streptomyces.* Plant Dis. 1997;81: 836-846.
14. Stevenson WR, Loria R, Franc GD, Weingartner DP. Compendium of potato diseases. 2nd ed. APS

Press St. Paul. Minnesota; USA. 2004; 106.

15. Perombelon MCM. The role of seed tuber in the contamination by *Erwinia carotovora* of potato crops in Scotland. Potato Res. 1974;17:187-199.

16. Khatri BB, Tegg RS, Brown PH, Wilson CR. Temporal association of potato tuber development with susceptible to common scab and *Streptomyces* scabiei-induced response in the potato periderm. Plant Pathol. 2011;60(4):776-786.

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