

COMMON SCAB OF POTATO AS AFFECTED BY SOIL MINERAL ELEMENTS AND TUBER CHEMICAL CONSTITUENTS.

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ABSTRACT

During 2009/2010 growing season, a survey was conducted in three regions where potato was intensively cultivated in three different governorates. These were El-Nubaria, El-Salheya and El-Sheikh Zaied in El-Behera, El-Sharkia and El-Ismailia governorates respectively. The causal common scab isolates of *Streptomyces scabies* recovered were isolated from potato tubers showing different scab symptoms and these isolates were all monomorphic for the morphological, biochemical and physiological traits tested. However, two types of necrosis were developed in the pathogenicity test with the tested *S. scabies*. These were phenotype 1 which characterized with little brown flecks, and phenotype 2 which characterized with brown black necrosis. The study revealed that incidence and severity of common scab differed among the three surveyed regions of the three governorates with the highest incidence in El-Nubaria region (60.0 %) followed by El-Salheya (52.5 %) and El-Sheikh Zaied (22.5 %). The same trend was observed for the common scab disease severity with highest severity in El-Nubaria (25.8 %), followed by El-Salheya (22.8 %) and El-Sheikh Zaied (11.4 %). Severity of the scab was found to be correlated with the soil mineral elements and the tuber biochemical constituents. A positive and highly correlation was revealed in the three surveyed regions between soil calcium concentration and the potato scab severity ($r = 0.949 - 0.941$). The macronutrients, *i.e.* nitrogen and phosphorus,

exhibited mostly weak – medium correlation ($r = 0.289 - 0.591$). Meantime, soil content of potassium and magnesium exhibited mainly positive correlation ($r = 0.677 - 0.936$) with the scab severity in the surveyed regions. On the other hand, the micronutrients soil content, *i.e.* Fe, Zn, Mn and Cu, showed (mostly) proportional relationship between Mn and Cu and the scab severity ($r = 0.552 - 0.892$) while, Fe and Zn showed mostly negative medium correlation ($r = 0.187 - 0.695$). In addition, Ca/P ratio of the soil exhibited mainly positive correlation with high values of ($r = 0.824 - 0.952$) while the cation exchange capacity (CEC) revealed positive reaction with common scab severity where ($r = 0.893, 0.824$ and 0.952) in the three surveyed regions, respectively. Periderm content of N, P, K and Cu were found to be higher in the less susceptible (tolerant) red-skinned, cv Lady rosetta, compared to the white-skinned, cv Hermis, the more susceptible in all the analysed healthy potato tuber. On the other hand, the periderm N and Zn contents were not significantly different in the two cultivars tested, while Fe and Mn contents of periderm showed an opposite relation as the ,cv Hermis, had higher content than the less susceptible, cv L.rosetta, with significant differences were observed. In case of L. rosetta, N, P and K contents did not significantly differ among healthy and infected tubers as well as Mn, Zn and Cu. However, Fe content was higher in healthy than the infected tubers. Potato flesh contents of N, P, K, Fe, Zn, Mn and Cu were found to be higher in the less susceptible (tolerant) red-skinned, cv L.rosetta, compared to the white-skinned, cv Hermis, which was more susceptible. Meantime, protein, fiber, carbohydrate and total phenol percentages were found to be higher in the less susceptible (tolerant), cv L.rosetta, than the susceptible, cv Hermis, while moisture, fat and reducing sugars had a reverse tendency in the all analysed healthy tubers.

INTRODUCTION

Common scab of potato (*Solanum tuberosum*) caused by *Streptomyces scabies* (Lambert *et al.*, 2005) is found in all potato growing regions throughout the world. The scab organism sometimes occurs in soils where potatoes have never been grown. In most potato soils, however, scab was probably introduced with infected seed tubers. It presents a major threat to the potato production in Egypt particularly in the last decade in the newly reclaimed lands, such as El-Nubaria, El-Salheya and El-Sheikh zaied in El-Behera, El-Sharkia and El-Ismailia governorates respectively, and other regions. This disease does not affect yield, but spoils the appearance and quality of tubers and this is important especially with potatoes grown for consumption and exportation (Kristufek *et al.*, 2000). Control of common scab is mainly caused by different soil amendments and breeding for disease resistance (Kristufek *et al.*, 2000). Concentration of mineral elements and other constituents in the potato periderm and flesh such sugars and phenols was reported to influence disease incidence and severity. Potato cultivars differ in the accumulation of nutrients from soil (Walworth and Muniz, 1993) and they can influence the content of minerals in plant tissue. Lambert *et al.*, (2005), Dordas, (2008) and Wiechel and Crump (2010). Analysis of mineral elements contained in tuber periderm tissue was done on samples harvested at the end of the vegetative period and soil analysis may be attributed to find the relationship between mineral elements and common scab incidence. The soil conditions responsible for potato scab have long been a topic of study, but the findings have been inconsistent or contradictory Lambert *et al.*, (2005). Common scab occurs worldwide, but there are significant gaps and contradictions in the knowledge about the role of soil and tuber mineral elements and constituents that influence the potato common scab. Growers report that scab disease has become more severe, on potato cultivars that have previously been considered relatively resistant (Lambert *et al.*, 2005). There has been little investigation of possible reasons for such contradictions. The differences in findings about the relationship between soil conditions and outbreak of potato scab may be ascribed

to a variety of different environmental factors. The objectives of the present study were to investigate the role of soil and the tuber content of mineral elements and chemical constituents of the tubers on the common scab incidence and its severity on a variety of potato cultivars, to find new approach to a sustainable management of the disease.

MATERIALS AND METHODS

Common scab survey:

During the 2009/2010 growing season, samples of potato tubers showed common scab symptoms were collected at random from three different regions of three different governorates in which potato was intensively cultivated, El-Nubaria, (El-Behera governorate), El-Salheya (El-Sharkia governorate), and El-Sheikh zaied (El-Ismailia governorate).

Isolation and Identification of the causal bacteria:-

Diseased potato tubers showing scab symptoms were collected from the three different regions previously mentioned. Tubers were washed, surface-sterilized with sodium hypochlorite (NaOCl), diluted to give 1.0 % available chlorine for 1 min and rinsed well with sterile water. Scab lesions were excised with a sterile scalpel and grinded in a mortar. One milliliter of the homogenate was mixed with 9 ml of phenol-water suspension (1-140). Different dilutions of homogenate were spread on oatmeal agar (OA) and incubated at 28 °C for 4-14 days, after which colonies characteristic of streptomycetes were transferred onto fresh OA (Lawrence, 1956 and Lindholm *et al.*, 1997). The isolates were characterized and identified according to Bergy's Manual of Determinative Bacteriology of Bergy *et al.*, (1989), and the International Streptomyces Project (Shirling and Gottlieb, 1966) and (Park *et al.*, 2003).

Pathogenicity tests and varietal reaction:

Plant material: Two potato cultivars of different susceptibility to common scab were selected and obtained from Horticultural Research Institute, Giza. These were the red skinned, cv Lady rosetta, and white skinned, cv Hermis. Five tubers uniformed in shape and size were

prepared, and discs (3-cm diameter) were made from the tubers, one disc from each tuber.

Inoculum: Inoculum of *Streptomyces scabies* was prepared by growing the isolates on oatmeal broth OMB medium for seven days according to Loria *et al.*, (1997).

Inoculation: Tuber slice test was conducted as described by Loria *et al.*, (1997). Tubers were surface sterilized with 0.5 % Naocl for 10 min, air-dried under sterile conditions, dipped in ethanol and flamed, the tubers sliced (3-cm diameter), 0.5 cm thickness. One milliliter of the resulted suspension was placed on the potato tuber slices and kept in humid chamber. Controls were immersed in sterile distilled water. The inoculated tuber slices were incubated at 28 °C in the dark and evaluated after 7 days.

Diameter of the necrotic area was assessed as a percentage as follows:- highly susceptible, i.e., necrosis covered ≥ 75 % of the tuber slice diameter, moderately susceptible, i.e., necrosis < 75 % - > 25 % of the tuber slice diameter and low susceptible, i.e., necrosis < 25 % of the tuber slice diameter. The developed symptoms were characterized according to the appearance of lesions developed and classified to different phenotypes (Loria *et al.*, 1997).

Factors affecting common scab incidence and severity in nature.

1- Soil mineral element analysis: soil samples were taken from the upper 15 cm layer (near the tubers) from the three surveyed regions previously mentioned. Samples were air-dried and sieved through 2 mm mesh. Nutrients extractable with Mehlich II solution were determined using standard methods of analysis. The contents of microelements in 2 M HNO₃ extracts were determined by atomic absorption spectrometry with acetylene-air flame, i.e. Fe, Mn, Zn and Cu (Zbiral, 1995). Soil analysis was conducted at the Desert Development Center, The American University in Cairo, Research Station at Sadat City.

2- Tuber periderm and flesh mineral elements analysis: Samples of potato peelings were obtained immediately after harvest. Tubers were washed in distilled water, rinsed in 1% HCl solution for 2 minutes and then rinsed in distilled water again. The tubers were

peeled with a standard potato peeler which produced a peel 1.5-2.0 mm thick containing periderm and several layers of cortical cells. Scabby periderm peeled from each tuber was collected separately. The tissue was dried, ground and analysed. Phosphorus content was determined by ammonium paramolybdate-vanadate method using spectronic 20 D spectrophotometer. Potassium was determined by using CORNING 400 flame measured by varian spectr 220 Atomic Absorption Spectrometer. Concerning nitrogen was measured by VELP scientifica UDK 127 Distillation Unit. The tested flesh and periderm potato tubers content was also conducted for N, P, K, Fe, Zn, and Cu according to Jones and Case, (1990) while, flesh moisture, protein, fat, fibers, carbohydrates, reducing sugars were determined according to A.O.A.C., (2000) as well as total phenols were determined according to Amerine and Ough, (1980).

Disease assessment:- Common scab incidence and severity were determined for the freshly harvested tubers collected from five fields for each surveyed region in twenty field tubers according to Wenzel and Demel (1976) with six ratings as follows:- 0 = no scabs; 1 = 20 % of the surface tuber with scab lesions; 2 = 40 % ; 3 = 60 % ; 4 = 80 %; 5 = 100 %. Scab index was calculated according to the following equation:-

$$\frac{\sum n \times R}{d \times N} \times 100$$

Where n = numerical value R = number tuber in each class.

d = degree of freedom, N = Total number of tuber in each sample.

Statistical analysis: The obtained data were statistically analysed using the American SAS program, means were compared by LSD (SAS Inc. 2000).

EXPERIMENTAL RESULTS

1- Survey of common scab:

During the 2009/2010 growing season incidence and severity of common scab differed in the three surveyed regions i.e. El-Nubaria, El-Salheya and El-Sheikh Zaied and on the two surveyed potato cultivars, i.e. the white skinned, cv Hermis, and red skinned, cv L.

rosetta, (Table 1). Incidence of common scab ranged between 35 % in El-Sheikh zaied region to 70 % for each of El-Salheya and El-Nubaria regions on the cv Hermis with the mean of 58.33 %. On the other hand incidence on cv L. rosetta was evidently lower being 10 % - 50 % on the surveyed regions with the highest incidence on El-Nubaria followed by El-Salheya, while El-Sheikh zaied showed the lowest disease incidence . This showed that cv L. rosetta was of low susceptibility as exhibited 31.66 % scab incidence compared to 58.33 % on the cv Hermis. Meanwhile, El-Nubaria region (El-Behera) exhibited the highest common scab incidence. This was followed by El-Salheya (El-Sharkia) where 35 % incidence was recorded while El-Sheikh zaied showed a significantly lower incidence of 10 %.

Concerning the severity of common scab, a similar trend was revealed in the three surveyed regions and on the two tested potato cultivars. El-Nubaria region exhibited the highest disease severity on both the tested cultivars, followed by El-Salheya, while, El-Sheikh zaied region (El-Ismailia) exhibited the lowest common scab severity on both cultivars. The overall mean of common scab severity in the surveyed regions was 19.99 %, while, the cv L. rosetta showed the lowest disease severity 10.33 % compared to 29.66 % for the cv Hermis.

Table (1): Incidence and severity of common scab in the three surveyed regions.

Disease parameter Regions	Incidence %			Severity %		
	cv Hermis	cv L. rosetta	Mean	cv Hermis	cv L. rosetta	Mean
El-Nubaria	70 _a	50 _a	60.0 A	39 _a	12.6 _a	25.8 A
El-Salheya	*70 _a	35 _b	52.5 A	34 _a	11.6 _a	22.8 A
El-Sheikh zaied	35 _b	10 _c	22.5 B	16 _b	6.8 _b	11.4 B
Mean	58.33 A	31.66 B		29.66 A	10.33 B	
	44.99			19.99		

* Means with the same letters are not significantly different. at P = 0.05.

The causal bacteria:- Isolation trails yielded fifteen isolates of *Streptomyces scabies*. Three isolates (one for each surveyed region) were randomly chosen and subjected to the morphological and

physiological tests. Data presented in (Table 2) revealed that all the isolates exhibited negative reaction in case of motility and growth at pH 5, however, showed positive reaction in case of gram staining, catalase activity, starch hydrolysis, casein hydrolysis, gelatin liquefaction, tolerance to Nacl 5 %, 6 % and 7 %, growth at 20 °C, 25 °C and 30 °C, growth at 7 pH and 9. All the isolates exhibited grey color in colony and spore mass, spiral spore chain and were positive to melanin production.

Table (2): Morphological, biochemical and physiological traits of *Streptomyces scabies* isolates recovered from scabby potato tubers collected during 2009/2010.

Characteristics	Bacterial isolates		
	St1	St2	St3
Motility	-	-	-
Gram staining	+	+	+
Catalase activity	+	+	+
Starch hydrolysis	+	+	+
Casein hydrolysis	+	+	+
Gelatin hydrolysis	+	+	+
Tolerance to Nacl 5 %	+	+	+
6 %	+	+	+
7 %	+	+	+
Growth at 20 °C	+	+	+
25 °C	+	+	+
30 °C	+	+	+
Growth at pH 5	-	-	-
7	+	+	+
9	+	+	+
Melanin production	+	+	+
Colony color	grey	grey	grey
Spore chain morphology	Spiral	Spiral	Spiral
Spore chain color	grey	grey	grey

+ = Positive reaction

- = Negative reaction

Pathogenicity test and varietal reaction: Two distinct lesion phenotypes were recognized in the tested isolates of *S. scabies* recovered in the conducted survey (Fig1). Phenotype1 (Phn.1) was characterized by the little brown flecks while the second phenotype (phn.2) was characterized by the brown black necrosis (Fig1). Data

presented in (Table 3) revealed that all the three isolates tested were moderately virulent on potato, cv Hermis, as the necrotic areas developed with the three isolates ranged between 40.25 % and 68.75 %. On the other hand L.rosetta exhibited the highest tolerance as 21.16 % necrotic area was developed compared to 54.83 % necrotic area in cv Hermis. Meantime, the two potato varieties tested were all susceptible to different degrees.

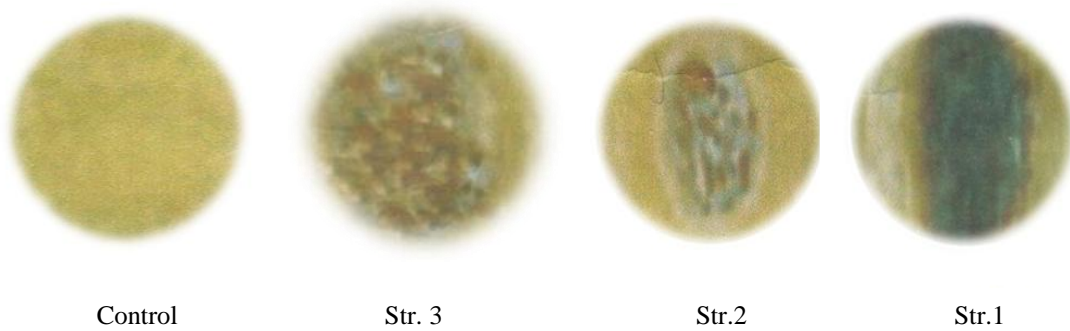


Fig (1): Pathogenicity of the three isolates of *S. scabies* 1 to 3 assessed as percentages of necrosis on tuber slices.

Table (3): Pathogenicity and varietal reaction of isolates of *Streptomyces scabies* isolates on potato tuber slices of the red-skinned, cv L.rosetta, and white-skinned, cv Hermis.

Isolates	Phenotypes of necrosis developed	Lady rosetta		Hermis	
		Necrosis developed(%)	Cultivar susceptibility	Necrosis developed(%)	Cultivar susceptibility
St1	Phn.1	20.5 *	L.S	55.5	MS
St2	Phn.2	18.75	L.S	40.25	MS
St3	Phn.2	24.25	L.S	68.75	MS
Mean		21.16		54.83	

* Data are mean percentages of the necrotic area developed on tuber slices data are the average of 5 replicates determined 10 days after inoculation and incubation at 28 °C.

LS = low susceptible (tolerant), i.e. necrosis covered ≤ 25 % of tuber slice.

MS = moderately susceptible, i.e. necrosis < 75 % - > 25 % of tuber slice diameter.

Relationship between the soil content of mineral elements and naturally occurred common scab severity: Data tabulated in (Table

4), presented and analysed in (Figs 2 and 3) showed that severity of the common scab disease was correlated with the mineral element concentrations of the soil where potato was grown in the three surveyed regions as well as with the cation exchange capacity (CEC) of these elements. The calcium content of the soil exhibited the highest correlation factor ($r = 0.745 - 0.949$) in positive relationship over the three surveyed regions according to the common scab severity. This was followed by magnesium (Mg), potassium (K), manganese (Mn) and copper (Cu) where these elements positively correlated with common scab severity in two out of the three surveyed regions with correlation of $r = 0.837 - 0.936$, $r = 0.766 - 0.691$, $r = 0.552 - 0.892$ and $r = 0.625 - 0.739$, respectively. The third region, however, showed negative correlation being $r = 0.129$, 0.685 , 0.010 and 0.828 , for the same elements, respectively. Concerning nitrogen (N), phosphorus (P) and zinc (Z) negative correlations were detected being $r = 0.520 - 0.591$, $r = 0.299 - 0.673$ and $r = 0.053$ to 0.695 for these elements respectively in two regions, while the third exhibited positive correlations being $r = 0.290$, 0.945 and 0.469 , respectively. Moreover, the soil content of the iron (Fe) showed negative reaction being $r = 0.187$, 0.247 and 0.527 , respectively, in the three surveyed regions. In addition Ca/P ration was positively correlated with common scab severity in two out of the three regions ($r = 0.824$ and 0.952) while, a negative correlation ($r = 0.893$) was recorded in the third region. The CEC exhibited positive correlation with common scab severity i.e. $r = 0.718$, 0.957 and 0.933 at El-Salheya, El-Nubaria and El-Sheikh Zaied, respectively.

Table (4): Severity of common scab in three regions surveyed during 2009 / 2010 growing season as affected by the soil content of minerals.

Region	Field	Severity %	Soil content of minerals (p.p.m)									Ca/P	CEC meq/100g
			N	P	K	Ca	Mg	Fe	Zn	Mn	Cu		
El-Salheya	1	20	8	17	423	4048	445	4.7	0.4	1.6	2.1	238	25.3
	2	28	62	19	244	6155	258	2.6	0.3	3.3	0.9	323.9	34.4
	3	23	40	11	195	4031	339	704	0.5	8.6	1.0	366.5	23.9
	4	25	8	11	149	3946	307	4.1	0.3	3.6	0.4	358.7	23.1
	5	18	46	42	330	3745	217	3.9	0.5	5.5	1.9	89.2	23.82
	Mean	22.8	32.8	20	268.2	438.5	313.2	3.14	0.4	4.52	1.26	275.26	26.1
El-Nubaria	1	19	1	2	43	1488	78	3.9	0.4	0.5	0.4	744	8.4
	2	29	1	12	67	2181	110	3.7	0.2	1.3	0.4	181.8	12.2
	3	20	15	4	33	1505	73	3.4	0.6	1.1	0.5	376.25	8.5
	4	32	1	25	72	2545	113	3.7	0.7	2.3	0.7	101.8	14.4
	5	29	3	19	127	2643	94	2.8	0.3	0.4	0.6	139.1	14.6
	Mean	25.8	4.2	12.4	68.4	2072.4	93.6	3.5	0.44	1.12	0.52	308.59	11.62
El-Sheikh Zaied	1	3	0.0	9	41	202	40	3.5	0.1	0.5	0.1	22.4	1.6
	2	10	1	4	68	465	62	3.6	0.1	0.6	0.1	116.3	3.3
	3	18	0.0	3	43	1446	60	4.0	0.2	0.7	0.1	422	8.1
	4	24	0.0	4	97	3005	155	2.9	0.2	1.0	0.2	721.3	17.3
	5	2	4	2	47	244	45	4.5	0.2	0.8	0.2	172.5	2.8
	Mean	11.4	1.0	4.4	59.2	1072.4	72.4	3.7	0.16	0.72	0.14	302.9	6.62

Relationship between mineral element contents of potato tuber periderm and naturally occurred common scab severity: In both healthy and scabby tubers periderm contents of N, P, K and Cu were found to be higher in the less susceptible (tolerant) red-skinned, cv L. rosetta, compared to the high susceptible white-skinned, cv Hermis, (Table 5) the more susceptible in all the analysed healthy potato tubers. On the other hand, the periderm nitrogen (N) content and Zn did not differ significantly in the two cultivars (Table 5). While, Fe and Mn content of periderm showed an opposite relationship as the cv Hermis, had higher content than the less susceptible, cv L-rosetta, with significant differences were observed. Concerning the naturally infected tubers, a similar trend was revealed with no significant differences for N, P, K and Mn and significant differences were observed in case of Zn and Cu. However, Fe showed higher content in case of Hermis than L-rosetta. Comparing the mineral elements content of periderm in healthy and naturally infected tubers of the cv Hermis, data revealed that the P, K, contents were higher in healthy potato periderm than the infected, but significant differences were not observed. However, N and Cu contents had an opposite trend. Also, Fe, Mn and Zn contents were higher in healthy tubers than infected ones, and significant differences were detected. In case of L-

rosetta, P and K contents were higher in healthy periderm than infected tubers as well as Mn, Zn and Cu. But significant differences were not noticed, however, N content showed an opposite trend. Additionally, Fe content was higher in healthy than infected tubers and significant difference was observed.

Relationship between tuber flesh mineral element contents and natural incidence of common scab: Flesh contents of N, K, Fe, Zn, Mn, and Cu were found to be higher in the less susceptible red-skinned, cv L.rosetta, compared to the white-skinned, cv Hermis, the more susceptible in the analysed healthy tubers but P showed an opposite trend. The K, Fe, Mn and Cu content exhibited significant differences in case of L. rosetta. However, N, P, and Zn content did not significantly differ among the two cultivars tested. Concerning the naturally infected tubers, the P, Fe and Cu contents were higher in Hermis than L. rosetta, but significant differences were not detected. While the N, K, Mn and Zn contents were higher in L. rosetta than that in Hermis and significant differences were found. Comparing the mineral elements content of flesh in healthy and naturally infected tubers of the cv Hermis, data presented in (Table 6) showed that N, Fe, Mn and Cu contents were higher in infected tubers than healthy ones, and significant differences were observed while P and Zn content found to be more in healthy than infected tubers and significant differences was found in Zn content. In case of, L. rosetta, N, K, and Mn contents were higher in infected tubers than in healthy and significant differences were noticed. In contrast, P, Fe, Zn and Cu contents were higher in healthy tubers than in infected ones, and significant differences were observed.

Relationship between type of chemical component of tubers and the common scab disease: Data presented in (Table 7) showed that protein, fiber, carbohydrate and total phenol percentages were found to be more in the less susceptible, cv L-rosetta, than the more susceptible, cv Hermis, while moisture, fat and reducing sugars showed an opposite trend in the all analysed healthy tubers. Concerning the naturally infected tubers, protein fiber and carbohydrate percentages were more in the less susceptible, cv L-rosetta, than that of more susceptible, Hermis, however, moisture, fats, reducing sugars, and total phenols revealed an opposite trend in the naturally infected tubers. Significant differences were observed in moisture, proteins, fats, fibers, carbohydrates, reducing sugars and total phenols between the two cultivars.

Table (7): Chemical constituents of healthy and naturally infected potato tubers with common scab of the tolerant red-skinned, cv Lady rosetta, and the susceptible white-skinned, cv Hermis.

Cultivar	Moistures %		Proteins %		Fats %		Fibers %		Carbohydrates %		Reducing sugars %		Total phenols	
	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.
Lady Rosetta	73.94	75.64	2.66 ^b	3.43 ^a	0.270 ^c	0.213 ^d	1.347	1.213	20.82 ^a	16.99 ^b	0.23 ^d	0.47 ^c	84.33 ^a	51.33 ^c
Hermis	77.89	79.98	1.84 ^d	2.04 ^c	0.327 ^a	0.303 ^b	1.237	1.123	17.77 ^b	15.40 ^c	1.05 ^b	1.57 ^a	72.0 ^b	54.0 ^c
Mean	75.92 ^b	77.81 ^a	2.25 ^b	2.73 ^a	0.298 ^a	0.258 ^b	1.292 ^a	1.168 ^b	19.30 ^a	16.20 ^b	0.64 ^b	1.02 ^a	78.17 ^a	52.67 ^b
L.S.D _{0.05} infection	0.55		0.14		0.015		0.067		0.65		0.11		3.98	
L.S.D _{0.05} cultivar	0.55		0.14		0.015		0.067		0.65		0.11		3.98	
Inf. + cultivar	N.S		0.20		0.019		N.S		0.92		0.16		5.62	

** H = Healthy, I = Infected, N.S = not significant

** Means followed with the same letters are not significantly different at P=0.05 probability.

DISCUSSION

On the basis of the results obtained, the common scab of potato was found to occur in the potato growing regions surveyed in different degrees. This represented 22.5 %, 52.5 % and 60.0 % in El-Sheikh-zaied, El-Salheya and El-Nubaria, respectively. Meantime, severity of scab recorded in the different regions was the highest (25.8%) in El-Nubaria, while, in the two other regions, i.e. El-Salheya and El-Sheikh Zaied, scab severities were 22.8 % and 11.4 % respectively. Our study showed that the field isolates of *S. scabies* differed in their virulence on the white skinned susceptible, c.v Hermis, and this is in agreement with Loria *et al.*, (1997). Also, the isolates tested were totally monomorphic for the morphological and physiological investigations conducted. However, two distinct necrosis phenotypes were recorded. The phenotype1 (Phn1) was characterized with the little brown flecks. On the other hand, the second phenotype (Phn2), however, was characterized by the brown black necrosis. The red skinned, cv L.rosetta, exhibited low susceptibility (tolerant) to the tested isolates of *S. scabies* as 21.16 % necrotic area was developed, while, the white skinned, cv Hermis, was moderately susceptible as 54.83 % necrotic area was developed. These findings were in harmony with a number of reports in Australia, Greece, Czech Republic and U.S.A. (Wiechel and Crump, 2010; Dordas, 2008; Kristufek, *et al.*, 2000 and Lambert *et al.*, 2005). The nutritional management is considered a new approach for plant diseases control (Lambert *et al.*, 2005). Several investigators reported that the soil content of the mineral elements as well as the plant constituents of the mineral elements, sugars, proteins and phenols play an important part in plant diseases incidence and severity (Walworth and Muniz, 1993; Kristufek *et al.*, 2000; Natsume *et al.*, 2001 and Lambert *et al.*, 2005). In the present study, the macronutrients content of the soil where potato is grown were correlated to disease incidence and severity by varying degrees. Calcium content of the soil was positively highly correlated with the common scab severity ($r = 0.745$ to 0.949) over the three surveyed regions as the scab severity increased with increasing calcium content in the soil surveyed. This was in agreement with the results of (Goto, 1985; Kristufek *et al.*,

2000; Lacey and Wilson, 2001; Lambert *et al.*, 2005 and Datnoff *et al.*, 2007). On the contrary, our results were contradictory with Tanii, (1985) and Lambert and Manzer (1991) where they found that scab incidence was not correlated with calcium concentration. Concerning the macronutrients and micronutrients effect, the mineral elements content in the soil was found to have a role on both percentage of infection and severity on potato common scab. The Mg, K, Mn and Cu were positively correlated ($r = 0.837$ to 0.936), ($r = 0.677$ to 0.691), ($r = 0.552$ to 0.892) and ($r = 0.625$ to 0.739), respectively, with common scab in two of the three surveyed regions, while the third region exhibited negative correlation ($r = -0.129$, -0.685 , -0.010 and -0.828), respectively. In case of N and P a negative correlation ($r = -0.520$ to -0.591 and $r = -0.673$ to -0.289) was observed in two of the three regions while the third region showed positive correlation ($r = 0.290$ and $r = 0.945$), respectively. On the other hand Zn exhibited positive correlation in two of the three regions, however, negative correlation was observed in the third region. Besides, the Fe showed negative correlation in the three surveyed regions. In this concern our results are in harmony with Wiechel and Crump (2010), where they found that the increased availability of Mn has been shown to reduce common scab in some trails but not in others. Also, with Dordas, (2008) how reported that Zn was found to have different effects. The cation exchange capacity (CEC) determines the supply of nutrients to plants from the soil and influences movement of calcium in soil is limited (Simmons and Kelling, 1987). The importance of CEC in soil to the incidence of common scab in potato has not been sufficiently investigated. However, Kristufek *et al.*, (2000) revealed that CEC was significantly lower at the less susceptible site and was positively correlated with common scab severity. Our study supports these results and concluded that the CEC was positively correlated ($r = 0.718$, 0.957 and 0.933) with common scab severity in the three tested regions. Also, our results revealed that Ca/P was positively correlated with common scab severity in two of the three regions ($r = 0.824$ and 0.952), while, a negative correlation was observed in the third region ($r = -0.893$). Results about the mineral elements content of periderm, showed that N, P, K did not significantly differ between healthy and

infected potato tubers, however, Fe, Mn and Zn were higher in healthy tubers than infected in the susceptible cv Hermis. In case of the tolerant cv L. rosetta, the same trend was observed. The previous results were partially in agreement with the findings of Kristufek *et al.*, (2000), Wiechel *et al.*, (2007), Dordas, (2008), and Wiechel and Crump (2010). Comparing the mineral elements content of flesh tissue in healthy and infected potato tubers, the results showed that N, K, Fe, Mn, Zn and Cu were found to be higher in the more tolerant red-skinned cv L. rosetta compared to the susceptible white-skinned cv Hermis. These results were in agreement with those reported by Kristufek *et al.*, (2000) and Dordas, (2008). Our results proved that cultivars of potato differed in relative susceptibility, tuber content of elements and biochemical constituents differed in the tolerant, cv L. rosetta, than the susceptible white-skinned, cv Hermis, where protein, fiber, carbohydrate and total phenol percentages were found to be more in the less susceptible (tolerant), cv L. rosetta, than the more susceptible, cv Hermis. However, moisture, fat and reducing sugars had a reverse tendency in the all analysed healthy tubers. The tolerance of cv L. rosetta may be due to the fact that phenolic compounds play important role in inducing resistance against plant diseases. This is in agreement with Hiltunen *et al.*, (2005) and Lambert *et al.*, (2006). However, the obtained results disagree in some cases with Kristufek *et al.*, (2000) and Wiechel and Crump (2010). This may be due to various factors including planting date, site, maturity, cultivar susceptibility, the age of tissue, and metabolic components in tuber periderm and inner tissues (flesh). Changes in incidence from year to year could be attributed to the differences in pathogen inoculum potential in the soil as a consequence of weather changes in soil ecology leading to alteration in populations of pathogenic streptomycetes and/or competitors. Another possibility is the appearance of new scab-causing species or strains better adapted to new conditions or potato cultivars, or that have acquired different virulence characteristics (Wanner, 2006). Soil characteristics greatly affect the severity of potato scab in soils with pH 7 (Wiechel and Crump, 2010). Finally, it could be recommended that the growers must be avoid planting of potato in calcarious soils, or liming the

potato growing fields. In addition, the use of acidifying fertilizers such as ammonium sulfate or diammonium phosphate or applications of sulfur that reduce the soil pH can induce control of common scab disease. Also, control of common scab is mainly focused on soil amendments, and foliar spray of micronutrients based on a soil test where potatoes are grown.

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الملخص العربي

الجرب العادي في البطاطس وعلاقة حدوثه بالعناصر المعدنية ومحتوى الدرنه من المكونات الكيميائية .

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- تم إجراء حصر خلال الموسم 2009 / 2010 في ثلاث مناطق حيث تزرع البطاطس بكثافة في ثلاث محافظات مختلفة وكانت المناطق هي النوبارية في محافظة البحيرة ، والصالحية في محافظة الشرقية والشيخ زايد في محافظة الإسماعيلية.
- وقد تم عزل البكتيرية ستريتومايسز سكايبس مسبب مرض الجرب العادي من درنات بطاطس يظهر عليها أعراض مختلفة للجرب العادي وثبت أن هذه العزلات متماثلة في صفاتها المورفولوجية والبيوكيميائية والفسولوجية. وفي اختبار القدرة المرضية تبين وجود مظهرين من الموت الموضعي نتيجة للاختبار، المظهر الأول تم تشخيصه وتمييزه بظهور بقع وقرح بنية قليلة بينما المظهر الثاني يتميز بموت موضعي بني أسود.
 - وقد أسفرت الدراسات عن ان نسبة حدوث المرض الأعلى كانت في النوبارية بنسبة 60% يليها الصالحية 52,5% ، 22,5% في منطقة الشيخ زايد.
 - وقد لوحظ نفس التوجه في حالة شدة المرض حيث كانت أعلى شدة المرض في النوبارية 25,8% يليها الصالحية بنسبة 22,8% ثم الشيخ زايد بنسبة 11,4% .
 - وقد وجد ان شدة مرض الجرب العادي كانت مرتبطة بمحتوى التربة من العناصر المعدنية علاوة على محتوى الدرنات من العناصر المعدنية والمركبات الكيميائية .
 - كما وجدت علاقة ارتباط موجبة قوية بين تركيز عنصر الكالسيوم في التربة وشدة مرض الجرب العادي حيث ان قيمة r تراوحت بين 0,941- 0,949 وذلك في المناطق الثلاثة. كما أن عنصر النيتروجين والفوسفور اظهر علاقة ارتباط ضعيفة الى متوسطة غالبا في منطقتين من الثلاث مناطق المختبرة حيث أن قيمة r تراوحت بين 0,289 – 0,591 . وفي نفس الوقت فإن محتوى التربة من البوتاسيوم والمغنسيوم قد اظهر علاقة ارتباط موجبة تراوحت بين 0,677 – 0,936 بينها وبين شدة مرض الجرب العادي غالبا في منطقتين من الثلاث مناطق.
 - من ناحية أخرى فإن محتوى التربة من العناصر الصغرى مثل الحديد والزنك والمنجنيز والنحاس قد أظهر غالبا علاقة ارتباط طردية موجبة في حالة المنجنيز والنحاس بينها وبين شدة الجرب العادي حيث r تراوحت بين 0,187 – 0,695 .
 - علاوة على ذلك فإن نسبة الكالسيوم / الفوسفور قد أظهرت بصورة رئيسية علاقة موجبة قوية بينها وبين شدة المرض حيث ان r تراوحت بين 0,824 – 0,952 .
 - وقد توصلت النتائج في ما يتعلق بالسعة التبادلية الكاتيونية CEC أنها قد أظهرت علاقة ارتباط قوية بينها وبين مرض الجرب العادي حيث r تراوحت بين 0,824 – 0,952 في الثلاث مناطق .

- كما أظهرت النتائج أن محتوى القشرة (البريديرم) من عناصر النيتروجين والفوسفور والبوتاسيوم والنحاس أعلى في الصنف الأقل قابلية للإصابة ذا القشرة الحمراء ليدي روزيتا مقارنة بالصنف ذي القشرة البيضاء هيرمس.
- من ناحية أخرى فإن محتوى القشرة من N ، Zn لم تختلف معنويًا في كل من الصنفين، بينما محتوى القشرة من الحديد، والمنجنيز أظهر علاقة عكسية حيث أظهر الصنف هيرمس محتوى أعلى من هذين العنصرين أكثر من الصنف الأقل قابلية (المتحمل) مع وجود فروق معنوية. وفي حالة الصنف ليدي روزيتا فإن محتوى الدرنات من N ، P ، K لم تختلف معنويًا بين الدرنات السليمة والمصابة في نفس الصنف مثلما في عناصر المنجنيز والزنك والنحاس، إلا أن المحتوى من الحديد كان أعلى في الدرنات السليمة عن الدرنات المصابة مع وجود فروق معنوية.
- وقد وجد أن محتوى الدرنات من N ، P ، K ، Fe ، Zn ، Mn كان أعلى في الصنف الأقل قابلية للإصابة (متحمل) ليدي روزيتا مقارنة بالصنف ذي القشرة البيضاء هيرمس الأكثر قابلية للإصابة.
- كما أظهرت النتائج أن نسبة البروتين ، الألياف ، الكربوهيدرات ، الفينولات الكلية كانت أعلى في الصنف ليدي روزيتا الأقل قابلية للإصابة (المتحمل) عن الصنف الأكثر قابلية للإصابة "هيرمس" بينما نسبة الرطوبة والدهون والسكريات المختزلة أخذت اتجاهها عكسيًا في كل الدرنات السليمة.

Table (5): Mineral elements content of periderm in healthy and naturally infected potato tubers with common scab of the tolerant red-skinned, cv Lady rosetta, and the susceptible white-skinned, cv Hermis.

Cultivar	N		P		K		Fe		Mn		Zn		Cu	
	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.
Hermis	1.686	1.856	0.22	0.21	3.183	3.0	2975.3 ^a	2189.3 ^b	115 ^a	101.333 ^b	211.33 ^a	149.67 ^b	1033.3 ^c	1470 ^b
Lady Rosetta	1.783	2.083	0.31	0.29	3.766	3.5	1250.7 ^c	1100 ^d	104.67 ^b	104.6 ^b	205 ^a	195 ^a	1655 ^a	1610 ^a
Mean	1.735 ^b	1.97 ^a	0.265 ^a	0.251 ^a	3.475 ^b	3.25 ^b	2113 ^a	1644.7 ^b	109.833 ^a	102.667 ^b	208.17 ^a	172.33 ^b	1344.2 ^b	1540 ^b
L.S.D _{0.05} infection	0.181		N.S		0.215		89.33		4.738		13.93		33.67	
L.S.D _{0.05} cultivar	N.S		0.023		0.215		89.33		N.S		13.93		33.67	
Inf. + cultivar	N.S		N.S		N.S		126.33		6.701		19.70		47.62	

** H = Healthy, I = Infected, N.S = not significant ** Means followed with the same letter are not significantly different at P=0.05 of probability.

Table (6): Mineral elements content of flesh tissue in healthy and naturally infected potato tubers with common scab of the tolerant red-skinned, cv Lady rosetta, and the susceptible white-skinned, cv Hermis.

Cultivar	N		P		K		Fe		Mn		Zn		Cu	
	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.
Hermis	1.10	1.48	0.236	0.193	1.35	1.35	280.33 ^c	361.33 ^b	70.67	86.67	140.33 ^a	114.67 ^b	860 ^c	1190 ^b
Lady Rosetta	1.30	1.64	0.22	0.19	2.067	2.467	452 ^a	339 ^b	98.0	106.33	148.33 ^a	145 ^a	1360 ^a	113.33 ^b
Mean	1.20 ^b	1.56 ^a	0.228 ^a	0.191 ^b	1.708 ^a	1.908 ^a	366.17 ^a	350.17 ^a	84.5 ^b	96.5 ^a	144.83 ^a	129.83 ^b	1110 ^a	1151.67 ^a
L.S.D_{0.05} infection	0.16		0.027		N.S		N.S		5.93		8.91		N.S	
L.S.D_{0.05} cultivar	0.16		0.027		0.289		29.55		5.93		8.91		56.22	
Inf. + cultivar	N.S				N.S		41.79		N.S		12.60		79.51	

** H = Healthy, I = Infected, N.S = not significant
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** Means followed with the same letters are not significantly different at P=0.05

