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Biochemical Changes of Potato Cultivars Due to Infection by Dry Rot Disease

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Twenty one *Fusarium* spp. isolates, collected from potato tubers showing typical dry rot symptoms, taken from three regions in Egypt, were found to belonging to four species, *i.e. F. sambucinum*, *F. solani*, *F. oxysporum* and *F. culmorum*. The pathogenic ability of these isolates on healthy potato tubers (cv. Spunta) revealed that 17 ones were pathogenic and 4 were non-pathogenic. The most aggressive isolate of each *Fusarium* species was chosen for further studies.

Host range studies revealed that carrot is not susceptible for infection; meanwhile taro, eggplant and sweet potato were susceptible for infection by *Fusarium* spp.

Eight potato cultivars were evaluated for their reaction to dry rot disease infection. Obtained results showed significant differences among tested cultivars. Valor cultivar recorded the highest level of resistance; meanwhile cv. Galactica was the most susceptible one. The rest of tested cultivars showed different levels of susceptibility.

The enzymatic activity in two potato cultivars, *i.e*. Galactica and Valor, as a response to dry rot infection, showed increments in peroxidase, polyphenol oxidase and phenylalanine ammonia lyase in the resistant cultivar (Valor) compared with the susceptible one (Galactica). These measurements could explain resistance and susceptibility in tested potato cultivars.

Keywords: Ammonia lyase, dry rot, *Fusarium* spp., peroxidase, phenylalanine, polyphenol-oxidase and potato.

Potato (*Solanum tuberosum* L.) and its products are known to be the most important source of food for human beings all over the world. According to the report of Anonymous (2010), the world production of potatoes reached about 324 million tonnes, of which 3.6 million tonnes are produced in Egypt.

Potato plants are vulnerable to attack by many pathogenic microorganisms, *i.e.* Fungi, bacteria and viruses, which cause serious diseases on potato tubers under field and/or storage conditions. Postharvest diseases in potato tubers, caused by fungal pathogens, resulted in significant economic losses in the yield quality and/or quantity during storage, transportation and marketing process (Eken *et al*., 2000).

Many *Fusarium* spp. are known as pathogens of economically important crops, causing different types of disease, *i.e.* vascular wilts and root, stalk, cob rots, collar rot of seedlings, and rots of tubers, bulbs and corms in a wide range of plants (Leslie and Summerell, 2006). Fusarium dry rot, caused by *Fusarium* spp., is considered as one of the most important potato storage diseases all over the world (Jensen *et al*., 2011) and causes extensive losses, reaching up to 25% of the stored tubers (Burkhart *et al*., 2007).

Du *et al*. (2012) identified thirteen different *Fusarium* species as agents responsible for potato dry rot disease. Moreover, Choiseul *et al*. (2007) reported that *Fusarium avenaceum* appeared to be the greatest cause of Fusarium dry rot, having a rot index at least twice as great as that for *F. solani* var. *coeruleum*. They added that infection by *F. sulphureum* was relatively uncommon. In the pathogenicity test, *F. avenaceum*, *F. solani* var. *coeruleum* and *F. sulphureum* produced rot of similar depths and widths and larger than those of *F. culmorum*.

The host range of *F. equiseti* included several members of the Leguminosae, in addition to some cereals. The fungus may be one of the potential causes of damping-off and root rot on these plant species (Goswami *et al*., 2008). *Fusarium sambucinum* have extremely wide host range, meanwhile *F. oxysporum* has broad host range (El-Kot, 2008). Host specialization of individual isolates is more circumscribed (Kim *et al*., 2001).

Potato cultivars differed in their degree of resistance to *Fusarium* spp. and many cultivars react differently to *F. solani* var. *coeruleum* and to *F. sulphureum*, even when similar methods of inoculation and incubation have been used (Esfahani, 2005). Moreover, it was reported that all commonly grown potato cultivars are susceptible to Fusarium dry rot (Chérif *et al*., 2002).

Disease resistance in plants associated with activation a wide array of defence responses that slow down or halt infection at certain stages of the host-pathogen interaction. The defence mechanisms include pre-existing physical and chemical barriers that interfere with pathogen establishment. Other methods of protection rely on inducible defence responses in the form of enzymes that are activated upon infection (Vanitha *et al*., 2009).

This study was designed to isolate and identify the causal pathogen of potato dry rot. Also, evaluation of some commercial cultivars to disease infection was studied. Moreover, changes associated with the disease development were taken in consideration.

Materials and Methods

All experiments of this study were conducted during potato storage seasons of 2010-2012 in the Lab. of Plant Pathol. Dept., Fac. of Agric., Cairo Univ., Giza, Egypt.

Source of infected potato tubers:

Samples of potato tubers, showing typical symptoms of dry rot disease, collected from several markets located in Giza Governorate as well as from storages in Behera (Nobariya) and in Fayoum Governorates, were used for isolation of causal agent.

Disease incidence:

Potato dry rot incidence (DI) was evaluated in samples, each containing 20 tubers, as the incidence (%) of any signs and/or symptoms of Fusarium dry rot, *i.e.* sporulation and surface discoloration. Also, tubers with blackened and/or dead sprout were considered as infected. At the end of storage period, disease incidence was calculated as the number of diseased tubers in relative to the total number of stored tubers x 100 (Townsend and Heuberger, 1943).

Isolation, purification and identification of the causal fungus:

Diseased potato tuber samples were thoroughly washed under tab water, cut into small pieces (1.5 cm), surface sterilized by soaking in sodium hydrochloride (1%) for 2 min., followed by washing in three changes of sterilized water then left on folds of sterilized filter papers to remove excess water. Sterilized pieces were aseptically transferred into Petri dishes (9-cm-diam.), each containing 20 ml of potato dextrose agar (PDA) medium, and incubated at 25±1°C for 48 h. when conidia were easily picked off, under a dissecting microscope, using sterile needle and carefully placed into new PDA plates. Pure cultures were maintained on PDA slants at 4°C for further studies. Purified fungal isolates were identified microscopically in Mycol. and Plant Dis. Survey Res. Dept., Plant Pathol. Res. Inst., ARC, according to the morphological characteristics, *i.e.* growth ratio, culture pigment and shape of conidia, as described by Leslie and Summerell (2006).

Pathogenicity tests:

Apparently healthy potato tubers (cv. Spunta) were used in this experiment. Initially, tubers uniformed in size and weight (100-120 g) were washed to remove adhering soil, surface sterilized in 1% sodium hypochlorite solution for 2 min. and rinsed in 3 changes of sterile distilled water (Lui and Kushalappa, 2002), then left on folds of sterilized filter papers to remove excess water. Tested tubers were wounded with a cork borer (7-mm-diam. x 7-mm-depth) (Peters *et al*., 2008) and individually inoculated, under aseptic conditions, in the prepared holes with a disk (5-cm-diam.) taken from the edge of 7-day-old tested *Fusarium* spp. cultures. A set of tubers inoculated with pathogen-free PDA disks were kept as check. Four tubers were used as replicates for each tested isolate. Tested potato tubers were wrapped in paper bags (Lui and Kushalappa, 2002) and incubated in the dark at 25±1°C for 10-14 days.

Disease assessment:

At the end of incubation period, tested potato tubers were cut through the inoculated site and the depth and width of the rotted area were measured. The following numerical rates were suggested to facilitate visual determination and to give a satisfactory comparison:

0= no symptoms.
1= less than ¼ of the tuber is covered by the symptoms.
2= about ¼ to ½ of the tuber is covered by the symptoms.
3= about ½ to ¾ of the tuber is covered by the symptoms.
4= more than ¾ of the tuber is covered by the symptoms.

Readings were converted to disease index according to the equation suggested by Townsend and Heuberger (1943), as follows:

$$\text{Disease severity (\%)} = \frac{\Sigma (n \times r)}{NR} \times 100$$

Whereas: (n) is the number of tested tubers in each numerical rate (r), and (N) is the total number of tested tubers multiplied by the highest numerical rate (R).

Among the 21 tested isolates, four *Fusarium* species, *i.e. Fusarium solani* (FSO1), *F. sambucinum* (FSA3), *F. culmorum* (FCU2) and *F. oxysporum* (FOX1), were chosen on base of their pathogenic ability to represent the most aggressive isolate of each tested species and used in further studies.

Host range:

Five plant species, *i.e.* eggplant (cv. Balady), sweet potato (cv. Apes), carrot (cv. Danvers), taro (cv. American taro) and potato (cv. Spunta) were evaluated for their susceptibility to Fusarium dry rot disease. Each tested plant material was artificially inoculated as abovementioned in the pathogenicity test section. Four replicates were used for each tested isolate.

In this experiment, each tested plant material was artificially inoculated by 7-mm-disc taken from 7-day-old *Fusarium* spp. cultures and incubated at 25±1°C. A set of each tested materials was inoculated with pathogen-free PDA disks and kept as control (check). Four replicates were used for each tested isolate. All tested plant materials were wrapped in paper bags (Lui and Kushalappa, 2002) and incubated in the dark at 25±1°C for 10-14 days, and then the average of rotted tissue area had been measured. Tested tubers were wounded using a cork borer (7-mm-diam. x 7-mm-depth) (Peters *et al*., 2008) and individually inoculated, under aseptic conditions, in the prepared holes with a disk (5-cm-diam.) taken from the edge of 7-day-old tested *Fusarium* spp. cultures. A set of tubers inoculated with pathogen-free PDA disks were kept as control (check). Four replicated tubers were used for each treatment. All tested potato tubers were wrapped in paper bags (Lui and Kushalappa, 2002) and incubated in the dark at 25±1°C for 10-14 days.

Cultivar reaction:

Apparently healthy potato tubers representing eight cultivars, *i.e.* Banba, Burren, Slaney, Galactica, Spunta, Valor, Cara, Lady Rosetta, were evaluated for their susceptibility to dry rot disease. Tested tubers (each weighed from 100 to 120 g.) were surface-sterilized with 1% sodium hypochlorite solution for 10 min and then wounded using the same method described above. The inoculated tubers, three replication of each cultivar, were incubated in the dark at 25±2 °C for 30 days. Data collection and analysis were similar to those used in the pathogenicity test.

Biochemical changes associated with disease development:

The enzymes changes of two potato cultivars, *i.e*. Galactica (susceptible) and Valor (tolerant) in response to dry rot infection was determined. Peroxidase activity was estimated according to method of Kochba *et al*. (1977). One gram of extracted enzyme sample was crushed well in sodium phosphate buffer. Density was read in absorbance spectrophotometer (Miltonroy spectronic 601) at 425 nm every 30 second for 10 reads. Peroxidase activity was calculated as mg/g fresh weight.

Polyphenol oxidase activity was also estimated according to method of Kochba *et al*. (1977). One tenth extracted sample was added to 0.5 ml sodium phosphate buffer 0.1 ml at pH 7and 0.5 ml catechol 0.001 N**.** The mixture was completed to distilled water and colour density was read in spectrophotometer Miltonroy spectronic 601at 495 nm every 30 second for 10 reads (Lisker *et al*., 1983).

Phenylalanine ammonia lyase (PAL) activity was estimated, The enzyme preparation was obtained from acetone powders of sweet potato tuber roots. Enzyme estimated according to the method described by Lisker *et al*. (1983).

Statistical analysis:

Obtained data were subjected to statistical analysis of variance, whenever needed, according to Rafter *et al.* (2002). Mean of treatments were compared by Duncan's multiple range test at level of 0.05% (Duncan, 1955).

Results

1. Disease incidence:

The incidence of potato dry rot caused by *Fusarium* spp. varied by region and period of storage. Data in Table(1) showed that the highest records of disease incidence were found on collected tubers from Nobariya followed by Fayoum, meanwhile the least infection was recorded on tubers collected from Giza Governorate.

Table 1. Dry rot incidence on potato tubers collected from three Egyptian Governorates

Governorate	Disease incidence (%)
Giza	5
Behera (Nobariya)	20
Fayoum	15

2. Isolation and identification of causal agent:

Various *Fusarium* spp. were isolated from naturally infected potato tubers showing typical symptoms of dry rot. A total of twenty one isolates of various *Fusarium* spp. were established in pure cultures. *Fusarium* spp. were identified on the basis of their cultural, morphological and microscopical characteristics. The main isolates of potato tuber belonged to four species of genus *Fusarium*, *i.e*. *F. sambucinum*, *F. solani*, *F. oxysporum* and *F. culmorum*. Frequency of isolates indicate that *F. solani* was most dominant species (38%), followed by *F. culmorum* (33.3%), *F. sambucinum* (19%) and *F. oxysporum* (9.5%).

3. Pathogenicity tests:

Pathogenicity of 21 Fusarium isolates was carried out by using potato tubers (cv. Spunta). Results presented in Table (2) indicate that there is an obvious variation in pathogenicity of *Fusarium* spp. isolates to potato tubers. *Fusarium* species differed in their pathogenicity, when four isolates were found to be non-pathogenic, meanwhile seventeen isolates were found pathogenic. Moreover, the most

Table 2. Average lesion size on potato tubers after inoculation with one of four *Fusarium* species

Tested isolate	Isolate code	Governorate	Rotted area (cm)		Average lesion size (cm)
			Width	Depth	
F. culmorum	FCU1	Giza	1.30	1.80	1.55 bc
	FCU2	Nobariya	2.10	2.13	2.11 a
	FCU3	Fayoum	1.53	1.68	1.60 bc
	FCU4	Nobariya	0.00	0.00	0.00 f
	FCU5	Giza	2.08	2.10	2.09 a
	FCU6	Fayoum	1.33	1.18	1.25 cd
	FCU7	Nobariya	1.58	1.80	1.69 b
F. sambucinum	FSA1	Giza	0.75	0.90	0.83 e
	FSA2	Giza	0.93	0.93	0.93 de
	FSA3	Nobariya	1.25	1.80	1.53 bc
	FSA4	Fayoum	0.00	0.00	0.00 f
F. solani	FSO1	Fayoum	1.25	1.63	1.44 bc
	FSO2	Giza	0.00	0.00	0.00 f
	FSO3	Nobariya	0.88	0.88	0.88 de
	FSO4	Giza	0.00	0.00	0.00 f
	FSO5	Fayoum	0.80	0.78	0.79 e
	FSO6	Nobariya	1.45	1.38	1.41 bc
	FSO7	Giza	1.18	1.50	1.34 bc
	FSO8	Nobariya	0.73	1.18	0.95 de
F. oxysporum	FOX1	Fayoum	1.43	1.63	1.53 bc
	FOX2	Giza	0.75	0.00	0.88 de

The same letter means no significant at level α=0.05.

pathogenic isolates caused about double size of lesions comparing with that of the least pathogenic one. On the base of statistical analysis, tested Fusarium species were divided into two groups. The most pathogenic isolate is *F. culmorum* (FCU2) followed by *F. culmorum* (FCU5), while the less pathogenic isolate is *F. sambucinum* (FSA1).

4. Host range:

Four *Fusarium* spp. were used to test their reaction against other crops. Results in Table (3) and Fig. (1) indicate that roots of sweet potato and potato tubers were more susceptible than those of taro corms and eggplants fruits. On the other hand, carrot roots showed no susceptibility to the infection with any of tested fungi.

Table 3. Relative reaction of some crops to the infection with *Fusarium* spp.

Tested plant	*F. culmorum*	*F. sambucinum*	*F. solani*	*F. oxysporum*
Sweet potato	1.58	1.48	2.40	1.82
Eggplant	0.18	0.22	0.88	1.30
Carrot	0.00	0.00	0.00	0.00
Taro	1.52	0.25	1.32	0.97
Potato	2.11	0.93	1.44	1.53

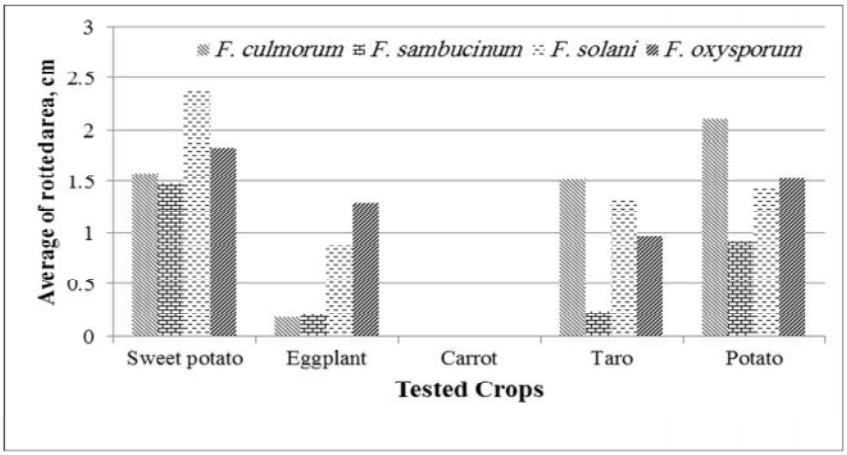

Fig. 1. Relative reaction of some crops to the infection with *Fusarium* spp.

5. Cultivar reaction:

All tested potato cultivars were susceptible, with different degrees, to tested *Fusarium* spp. Results presented in Table (4) show that lesion sizes ranged from 1.1 to 2.42 cm. Also, data revealed that there are significant differences in susceptibility of tested cultivars, *i.e.* Banba, Burren, Slaney, Cara and Galactica, against infection with *Fusarium* spp. Meanwhile, there are no differences among tested *Fusarium* spp. in this concern. On the other hand, *F. sambucinum* and *F. oxysporum* resulted in significant bigger size of lesions comparing with those caused by *F. culmorum* and *F. solani* on cvs. Lady Rosita and Valor, respectively. Galactica showed the biggest lesions size by *Fusarium* spp. Meanwhile, cv. Valor showed smallest lesions size.

Table 4. Potato cultivar reaction to the infection with *Fusarium* spp.

Tested *Fusarium* spp.	Banba	Burren	Spunta	Slaney	Cara	Galactica	Lady Rosita	Valor	Mean
F. culmorum	2.4 a	2.0 a	2.1 a	1.7 a	1.6 a	2.4 a	2.0 a	1.5 a	2.0
F. sambucinum	1.3 b	1.7 a	1.5 b	1.9 a	1.9 a	1.9 a	1.3 b	1.2 ab	1.6
F. solani	1.5 b	1.6 a	1.9 a	1.5 a	1.9 a	2.0 a	1.5 b	1.3 ab	1.6
F. oxysporum	1.5 ab	1.8 a	1.2 b	1.8 a	1.4 a	1.8 a	1.2 b	1.1 b	1.5

The same letter in each column means no significant at level α=0.05.

6. Biochemical changes associated with disease development:

Two cultivars, *i.e.* Valor (resistant) and Galactica (susceptible), were selected to test their ability to stimulate enzymes production (Peroxidase, Phenylalaninne amonia lyase and Polyphenol oxidase) when inoculated with the highly virulent *Fusarium culmorum* isolate.

Data presented in Table (5) and Fig. (2) clearly indicate presence of a difference of all enzymes in both cultivars comparison with their control, noticeable increasing with three enzymes in Valor (resistant cultivar) comparison with Galactica (sensitive cultivar), in addition to marked increasing for Peroxidase in Valor compared with Galactica.

Table 5. Enzymes activities from treated or untreated two potato cultivars by *F. culmorum*

Tested potato cultivar	Enzymes activity		
	Peroxidase	Phenylalaninne amonia lyase	Polyphenol oxidase
Valor (Resistant)	2.266	1.094	0.191
Valor - Control*	1.346	0.542	0.059
Galactica (Susceptible)	1.581	0.998	0.063
Galactica - Control**	1.446	0.853	0.057

***** Resistant control and ** Susceptible control.

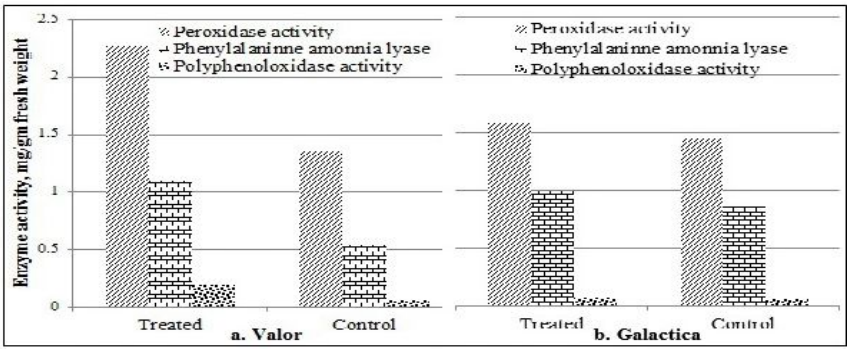

Fig. 2. Enzymes activities in two potato cultivars treated or not with *F. culmorum*.

Discussion

Dry rot caused by *Fusarium* species is considered as one of the important potato disease all over the world. It causes post-harvest rotting and seed piece decay after planting. (Du *et al*., 2012).

Disease incidence of *Fusarium* spp. varied by region and period of storage. This fact found to be in harmony with that of Ronald (2005) who indicated that dry rot incidence and severity was lowered when potatoes were harvested under 4-week dead vines compared to 2-week dead vines or green dug.

At least thirteen *Fusarium* species have been worldwide considered as causal agents of dry rot of potato (Cullen *et al*., 2005). In this concern, four *Fusarium* spp., *i.e. F. sambucinum*, *F. culmorum*, *F. oxysporum* and *F. solani*, were identified in the present study.

Results of the present study indicated that *F. culmorum* and *F. solani* are the major *Fusarium* species that associated with dry rot disease. Meanwhile, two additional species, *i.e. F. equiseti* and *F. semitectum*, previously reported with *F. sambucinum* were found to be associated with potato dry rot in Egypt and being the most frequently species (El-Hassan, 2008).

Fusarium culmorum isolates were found to cause extensive rotting (width and depth) of potato tubers compared with other *Fusarium* species. These results disagree with those of many other researchers (Choiseul *et al*., 2007 and Du *et al*., 2012) who found that *F. avenaceum* was the most common species of Fusarium that causes dry rot in the tested samples. Moreover, Chehri *et al*. (2011) reported that *F. solani* was recorded in the virulent group.

In the present study, twenty one *Fusarium* spp. isolates collected from infected tubers were tested for their pathogenic ability on potato tubers (cv. Spunta). Obtained results showed a great variation among tested isolates. FCU2 and FCU5 isolates were highly pathogenic on potato tubers; meanwhile FSO2, FSO4 and FCU4 were avirulent. These results are in harmony with those of Peters *et al*. (2008). In fact, the observed differences in pathogenicity among the tested Fusarium isolates could be attributed to the differences in their aggressiveness that expressed as various given dry rot lesion caused by individual *Fusarium* sp., which supported this assumption (Esfahani, 2006). Moreover, several factors may explain why different *Fusarium* species were identified in the present survey compared to that implemented by Du *et al.* (2012), including use of different rotation patterns and different potato cultivars, as well as different environmental and/or edaphic conditions.

Host range studies were conducted to determine the ability of tested pathogen to infect four plant hosts, *i.e*. sweet potato roots, potato tubers, taro corms and eggplant fruits. Recorded results cleared that sweet potato roots and potato tubers were more susceptible than those of taro corms and eggplants fruits. On the other hand, carrot roots were completely resistant to the infection with any of tested fungi. These results are in agree with that recorded by Chavan (2007) who tested 16 different hosts to determine their susceptibility to *F. Solani*. He found that tomato, potato and guava were highly susceptible. Meanwhile, maize, sunflower, soybean and safflower were completely resistant.

The most effective and environmentally friendly approach to control dry rot is the utilization of resistant potato cultivars, although better handling of potatoes at harvest and during post-harvest operations would sensibly reduce the importance of such disease as well.

Tested clones, including commercial cultivars, show variable degrees of susceptibility to four *Fusarium* species (Du *et al*., 2012). However, potato cultivars generally show susceptibility to different *Fusarium* species worldwide.

In the present study, it was found that tested cultivars varied in their reactions against tested Fusarium isolates. Cultivars Valor and Lady Rosita were found to be highly resistant. Meanwhile, Galactica was the most susceptible cultivar.

On the other hand, tested Fusarium isolates, *i.e. F. sambucinum* and *F. oxysporum*, resulted in significant bigger size of lesions comparing with those caused by *F. culmorum* and *F. solani* on cvs. Lady Rosita and Valor, respectively. These results are in agreement with those of Saremi *et al.* (2011) who reported that tubers of potato cultivars differed in their susceptibility to *Fusarium* species and none certain tolerant cultivars were introduced. Some cultivars were tolerant to infection when harvested but develop susceptibility during storage. He concluded that the difference in cultivar reaction may be due to the genetic composition which regulate the physiological and morphological defense reaction of tubers against the pathogen, or may be as a result of different rates of wounds healing by periderm and of suberization formation.

It is well known that plants do not have specialized cells to carry out immune functions, however they have both structural and biochemical pre-formed barriers that present a first obstacle against pathogen attacks. When these constitutive defenses are overcome by a pathogen, recognition leads to a complex signaling cascade of inducible defense responses. These responses include cell wall strengthening, oxidative burst, metabolic changes and the expression of a large amount of defense related Genes (D'Ippólito *et al*., 2012).

Biochemical changes associated with inoculated and non-inoculated potato tubers by *Fusarium culmorum* were investigated. Obtained data indicated increments in the activity of PO, PPO and PAL enzymes more than non-inoculated control. These results are in harmony with those of Narayanasamy (2011) who stated that changes in the enzyme activities have been reported to be a reliable basis for detection of certain fungal pathogens, but the largest increase was observed in case of PO activity more than the PPO and PAL in inoculated tubers. Also, Graskova *et al*. (2004) reported that peroxidase is believed to be one of the most important factors of the plant biochemical defense against pathogenic microorganisms, which is actively involved in the self-regulation of plant metabolism after infection.

The role of PPO enzyme in disease resistance was postulated by many authors Graskova *et al*., 2004; Lozovaya *et al*., 2006 and Narayanasamy, 2011). Lozovaya *et al*. (2006) reported that resistance levels of crops to fungi could be increased by genetically manipulating metabolic events that lead to production of antimicrobial compounds that are toxic to pathogens or that can strengthen the barriers of plant cells to pathogen entry. They concluded that plant cell wall phenolics can play an important protective role against pathogen invasion.

References

Anonymous, 2010. Food and Agriculture Organization (FAOSTAT). FAO, Rome. http://faostat.fao.org/site/339/default.aspx.

Burkhart, C.R; Christ, B.J. and Haynes, K.G. 2007. Non-additive genetic variance governs resistance to Fusarium dry rot in a diploid hybrid potato population. *Amer. J. Potato Res*., **84**: 199-204.

Chavan, S.S. 2007. Studies on fungal diseases of patchouli with special reference to wilt caused by *Fusarium solani* (Mart.) Sacc. M.Sc. Thesis, College of Agric., Dharwad. 98pp.

Chehri, K; Mohamed, N.F; Salleh, B. and Latiffah. Z. 2011. Occurrence and pathogenicity of *Fusarium* spp. on the potato tubers in Malaysia. *African J. Agric. Res*., **6**(16): 3706-3712.

Chérif, M.; Sadfi, N.; Benhamou, N.; Boudabbous, A.; Boubaker, A.; Hajlaoui, M.R. and Tirilly, Y. 2002. Ultrastructure and cytochemistry of *in vitro* interactions of the antagonistic bacteria *Bacillus cereus* x16 and *B. thuringiensis* 55t with *Fusarium roseum* var. *sambucinum*. *J. Plant Pathol*., **84** (2):83-93.

Choiseul, J.; Allen, L. and Carnegie, S.F. 2007. Fungi causing dry tuber rots of seed potatoes in storage in Scotland. *Potato Res*., **49**:241–253.

Cullen, D.W.; Toth, I.K.; Pitkin, Y.; Boonham, N.; Walsh, K.; Barker, I. and Lees, A.K. 2005. Use of quantitative molecular diagnostic assays to investigate Fusarium dry rot in potato stocks and soil. *Phytopathol*., **95**:1462–1471.

D'Ippólito, S.; Martín, M.L.; Salcedo, M.F.; Atencio, H.M.; Casalongué, C.A.; Godoy, A.V. and Fiol, D. 2012. Transcriptome profiling of *Fusarium solani* f.sp. *eumartii* infected potato tubers provides evidence of an inducible defence response. *Physiol. and Mole. Plant Pathol*., **75**: 3-12.

Du, M.; Ren, X.; Sun, Q; Wang, Y. and Zhang, R. 2012. Characterization of *Fusarium* spp. causing potato dry rot in China and susceptibility evaluation of Chinese potato germplasm to the pathogen. *Potato Res*., **55**:175-184.

Duncan, D.B. 1955. Multiple range and multiple F-test. *Biometrics*, **11**(1): 1-24.

Eken, C.; Demirci, E. and Sahin, F. 2000. Pathogenicity of the fungi determined on tubers from potato storages in Erzurum, Turk.. *J. Turkish Phytopathol*., **29**: 61-69.

El-Hassan, K.I. 2008. Studies on the pathogenesis mechanisms of *Fusarium* spp., the causal of potato tubers dry-rot disease. Ph.D. Thesis, Fac. Sci., Ain Shams Univ., 164pp.

El-Kot, G.A.N. 2008. Biological control of black scurf and dry rot of potato. *Egypt. J. Phytopathol*., **36**(1-2): 45-56.

Esfahani, M.N. 2005. Susceptibility assessment of potato cultivars to Fusarium dry rot species. *Potato Res*., **48**: 215-226.

Esfahani, M.N. 2006. Present status of Fusarium dry rot of potato tubers in Isfahan (Iran). *Indian Phytopathol*., **59**(2):142-147.

Goswami, R.S.; Dong, Y. and Punja, Z.K. 2008. Host range and mycotoxin production by *Fusarium equiseti* isolates originating from ginseng fields. *Can. J. Plant Pathol*., **30**: 155-160.

Graskova, A.; Romanenko, A.S.; Vladimirova, S.V. and Kolesnichenko, A.V. 2004. Changes in peroxidase activity during potato ring rot infection. *Russian J. Plant Physiol*., **51**(4): 476-479.

Jensen, P.H.; Brurberg, M.B. and Hermansen, A. 2011. Fusarium dry rot on potatoes in Norway: Identification of pathogenic *Fusarium* spp. and implementation of molecular diagnostic methods. *Bioforsk***, 6**(10):21.

Kim, J.T.; Park, I.H.; Hahm, Y.I.. and Yu, S.H. 2001. Crown and root rot of greenhouse tomato caused by *Fusarium oxysporum* f.sp. *radicis-lycopersici* in Korea. *Plant Pathol. J*. **17**(5): 290-294.

Kochba, J.; Lavee, S. and Spiege-Roy, P. 1977. Difference in peroxidase activity and isozymes in embryogenic and non-embryogenic 'sharr outi' orange ovular callus lines. *Plant and Cell Physiol.*, **18**(46):3- 7.

Leslie, J.F. and Summerell, B.A. 2006. *The Fusarium Laboratory Manual*. UK: Blackwell Publish Ltd. 388pp.

Lisker, N.; Cohen, L.; Chaluz, E. and Fuchs, Y. 1983. Fungi infection suppress ethylene-induced phenylalanine ammonia-lyase activity in grape fruit. *Physiol. Plant Pathol*., **22**(33): 331-338.

Lozovaya, V.V.; Lygin, A.V.; Zernova, S.L.; Widholm, J.M. and Hartman, G.L. 2006. Lignin degradation by *Fusarium solani* f.sp. *glycines*. *Plant Dis.*, **90** (1): 77-82.

Lui, L.H. and Kushalappa, A.C. 2002. Response surface models to predict potato tuber infection by *Fusarium sambucinum* from duration of wetness and temperature, and dry rot lesion expansion from storage time and temperature. *Int. J. Food Microbiol*., **76**:19-25.

Narayanasamy, N. 2011. Microbial Plant Pathogens-Detection and Disease Diagnosis. *Fungal Pathogens*, 1: 256p.

Peters, R.D.; MacLeod, C.; Seifert, K.A.; Martin, R.A.; Hale, L.R.; Grau, C.R. and McInnis, S. 2008. Pathogenicity to potato tubers of *Fusarium* spp. isolated from potato, cereal and forage crops. *Amer. J. Potato Res*., **85**:367–374.

Rafter, J.A; Abell, M.L. and Braselton, J.P. 2002. Multiple Comparison Methods for Means. *Society for Industrial and Applied Mathematics*, **44** (2): 259-278.

Ronald, A.B. 2005. Effect of preharvest management on yield, process quality, and disease development in Russet Burbank potatoes. M.Sc. Thesis. Univ. Manitoba, Canada. 189pp.

Saremi, H.; Okhovvat, S.M. and Ashrafi, S.J. 2011. Fusarium diseases as the main soil borne fungal pathogen on plants and their control management with soil solarization in Iran. *African J. Biotechnol*., **10** (80): 18391-18398.

Townsend, G.R. and Heuberger, J.W. 1943. Methods for estimating losses caused by diseases in fungicide experiments. *Plant Dis. Repter.*, **27** (17): 340-343.

Vanitha, S.C.; Niranjana, S.R. and Umesha, S. 2009. Role of phenylalanine ammonia lyase and polyphenol oxidase in host resistance to bacterial wilt of tomato. *J. Phytopathol*., **157**:552-557.

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التغيرات البيوكيميائية لأصناف من البطاطس مصابة بمرض العفن الجاف

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تم عزل وتعريف ٢١ عزلة من فطر الفيوزاريوم الذي يصيب درنات البطاطس والتي تظهر عليها الأعراض النموذجية لمرض العفن الجاف، والتي جمعت من ثلاث مناطق من جمهورية مصر العربية، والتي صنفت إلى أربع أنواع مختلفة من الجنس فيوزاريوم هي: *F. sambucinum*, *F. solani*, *F. oxysporum* and *F. culmorum*، والتي استخدمت في إختبار القدرة المرضية بإستخدام درنات بطاطس سليمة من الصنف سبونتا. حيث أظهرت النتائج أن سبع عشرة عزلة منها كانت ممرضة، في حين أن أربع عزلات كانت غير ممرضة. وقد تم إختيار العزلة الأقوى من كل نوع من أنواع الفيوزاريوم الأربع في إختبارات المدى العوائلي وتقييم الأصناف.

تم عملية عدوى لكل من الباذنجان، البطاطا، الجزر، القلقاس والبطاطس لدراسة المدى العوائلي بإستخدام العزلات الأربع التي تم إختيارها. حيث أظهرت النتائج أن الجزر كان غير قابل للإصابة في حين كان الباذنجان والبطاطا والقلقاس قابلة للإصابة.

إختيرت ثمانية أصناف من البطاطس بغرض دراسة مدى قابليتها للإصابة أو مقاومتها لمرض العفن الجاف. وقد ظهرت فروق واضحة بين الأصناف، حيث أظهرت النتائج أن الصنف فالور كان أكثرها مقاومة في حين كان الصنف جلاكتيكا أكثرها قابلية للإصابة، وتباينت الأصناف الأخرى في مدى قابليتها للإصابة.

تم تقدير النشاط الأنزيمي لكل من البيروكسيديز، البولي فينول أوكسيداز والفينيل آلانين أمونيا لياز في صنفين من البطاطس أحدهما مقاوم والآخر حساس نتيجة لإصابتهما بمرض العفن الجاف. وقد أوضحت النتائج زيادة نشاط الأنزيمات الثلاثة في الصنفين مقارنة بالكنترول الغير معامل، ولوحظ زيادة لنشاط الأنزيمات الثلاثة في الصنف المقاوم مقارنة بالصنف الحساس، مما يوضح تفسير زيادة المقاومة في الصنف المقاوم والتي تعود الى نشاط الأنزيمات.