Menoufia J. Plant Prot., Vol. 5 December (2020): 169–183 https://mjpam.journals.ekb.eg/

CONTROL OF POTATO TUBER DRY ROT DISEASE DURING STORAGE

M. A. Awad, G.A. Amer and A.H. Farag
Agricultural Botany Dept., Fac. of Agric., Menoufia Univ., Shibin El-Kom, Egypt.

Received: Dec. 30 , 2020 Accepted: Dec. 31 , 2020

ABSTRACT: The dry rot disease incidence was affected by the different storage temperature degrees of both cultivations (Nili and Summer) during two tested seasons. The least periods of storage with least temperature degrees of storage (15 days at 3 – 5°C) decreased dry rot disease incidence % in both lasted seasons. Significant differences were notice between periods of storage which combined with different temperature degrees.

Eight plant extracts were tested against dry rot disease in potato tubers. Three concentrations of each plant extract were used i.e. 3, 5 and 10%. Garlic and cinnamon extracts were tested against the most aggressive fungal isolates, under storage conditions on potato tubers cv. Spunta. Both plant extracts were effective on disease index and minimized potato dry rot disease symptoms. Biological control using biological agents were effective in disease control both in laboratory and under storage conditions. Also, Tachigaren plus 600 SL fungicide at 100 ppm was the most effective one in controlling the dry rot disease incidence.

Key words: Potato – dry rot disease – *Fusarium solani* – disease control.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important crops in the world. Diseases caused by fungi and pseudo-fungi are important and require a variety of management practices to reduce them to tolerable economic level. These fungi are common in most soils where potatoes are grown and survive as free resistant spores in the soil or within decayed plant tissues. Pathogens attack potato plants during different stages, of their growth as well as after harvest during storage and marketing. Fusarium dry rot is one of the most important post-harvest diseases of potato occurring worldwide. Its infects tubers in storage and tuber pieces after planting. Yield losses attributed to dry rot in storage ranged from 6 to 25% with up to 60% of tubers affected in some cases. Also, the dry rot of potato caused by *Fusarium solani* resulted in significant yield loss in stores and may produce mycotoxins (Abo El-Seoud *et al.,* 2010). Although some infections may develop on tubers before harvest, most infections occur as the fungus enters tubers through harvest wounds. Small, brown lesions appear at wound sites 3 – 4 weeks after harvest and continue to enlarge during storage, taking several months to develop fully. The disease develops fairly rapidly at temperatures above 10°C, but lesions will cause enlarging below 40°C. The fungus is only dormant at these low temperatures, however, and will resume growth when tubers are warmed (Rowe *et al.,* 1995). Rafiq *et al.* (1995) found that eighty isolates belonging to *Fusarium oxysporum, F. solani, F. roseum, Rhizoctonia solani, Geotrichum candidum, Cephalosporium* and Verticillium were obtained from rotted tubers and all except V. sp. were pathogenic when inoculated on tubers.

Taskeen-un-Nisa *et al.* (2011) found that potato tubers in storage are attacked

Fusarium rot of potato caused by *Fusarium solani* Mart. Filippov *et al.* (1996) and Daami Remadi *et al.* (2006) found that several fungicides are tested individually or in dual combination against four *Fusarium* species causing potato tuber dry rot in Tunisia.

The biological control agents *B. subtilis* and *T. harzianum* provided good control of sprout rot and seed piece decay caused by *F. sambucinum,* when seed was re-stored under optimal conditions or not re-stored at all.

Zaker (2014) tested that five, ten and fifteen percent methanolic extracts (ME) and aqueous extracts (AE) of six plants namely, Lavender, Eucalyptus, Artemisia, Thyme, Savory and Datura were evaluated for their antifungal effect against *Fusarium solani*, the causal agent of potato dry rot under lab. condition and also for their efficacy in reducing dry rot development in potato tubers during 2013. Methanolic extracts of all tested plants exhibited better antifungal activity compared to their corresponding aqueous extracts against *F. solani in vitro* and *in vivo*.

The present study aimed to investigate the following:

- **Effect of some treatments on management of tuber diseases i.e., Temperature, Humidity, Fundgicides, Plant extract and Bioagents.**

MATERIALS AND METHODS

1. Storage time correlated with different temperature degrees:

Four storage periods corrected with four temperature degrees were tested for their effect on dry rot disease incidence, these periods of storage were (15) days, (30) days, (60) days and (90) days with four temperature degrees of cold storage (3 – 5°C), (8 – 10°C), (13 – 15°C) and (18 – 20°C).

Five replicates were used for each treatment. Ten inoculated potato tubers in each replicate were stored in sterilized packing (carton box) under cold condition RH = 90%. Effects of the four temperature degrees of storage on the disease incidence were assessed as percentages of the disease severity index after each period of storage. Parameters of dry rot inducted depth of rotting and maximum width (W) and depth (D) are scored.

The pathogen penetration into tuber is calculated using a formula developed for this purpose as mentioned before.

The obtained data were recorded and statistically analyzed (Fisher's L.S.D at l and 5%).

According to the obtained data from the laboratory experiments, the most effective antagonists used in this experiment. These biological agents are *Trichoderma harzianum* (1), *Trichoderma harzianum* (2), *Trichoderma harzianum* (3), *Trichoderma hamatum* (1), *Trichoderma hamatum* (2), *Trichoderma viride, Trichoderma koningii* (1), *Trichoderma koningii* (2), *Trichoderma pseudokoningii* (1) and *Trichoderma pseudokoningii* (2).

The potato tubers were stored for two years and two successive seasons of planting summer and Nili. In the two seasons the storage potato tubers (Spunta cv.) were prepared as follows, potato tubers were surface sterilized by immersing in 0.25% sodium hypochlorite solution for 5 minutes and then washed several time with sterilized distilled water and then left to dry. Inoculation technique was achieved by injuring the tested sterilized tubers using sterile blade and then the tubers were soaked in the prepared solution of tested bioagents for 48 hours.

Five replicates were used for each treatment. Ten inoculated potato tubers

in each replicate were stored in sterilized packing (carton box 25 × 25 cm) under cold condition (13 – 15°C) and RH = 90%, ten sterilized potato tubers were stored in sterilized packing (carton box 25 × 25 cm) as control. The obtained data were recorded and statistically analyzed (Fisher's L.S.D at 1 and 5%).

2. Plant extracts:

The effect of eight aqueous plant extracts on dry rot of tubers incidence of the causal organism of potato under laboratory conditions.

In this study, different preparations of plant extracts were used. All powder plant materials involved in this study were collected and identified as shown in Table (1).

Powders of eight plant samples were used in this study. One hundred (100) grams of dry powder of each plant material was added to 1000 ml distilled water and mixed thoroughly then autoclaved with steam under pressure at 120°C for 20 minutes. Three concentrations of each aqueous extracts, i.e. 3, 5 and 10% were used.

The adjusted aqueous extracts were kept in dark glass bottles in refrigerator for further studies.

Each concentration was used in three replicates by provide 5 cm disc sprayed with plant extract. Another replicate from each concentration was left as control provided with clear disc sprayed with distilled water.

The plant extracts were adopted with 3 ml from each extract individual at (3, 5 and 10%) to the solid media on the surface tell complete absorption into media. The plates were inoculated with the inoculum disk (4 mm) of the tested fungal pathogen at the centre of the dish.

Two plants extracts were prepared and adjusted at the three tested concentrations (3, 5 and 10%) in deep jars, i.e. garlic and clove. The un-wounded (healthy) potato tubers Spunta cv. were soaked individually in the target concentration for five minutes, then raised and leaved for air drying. The dry treated tubers were inoculated on the surface with disk (4 mm) of the pathogen inoculum and left in foam plates and covered with stretch film for symptom appearance and noticed daily twice.

Table (1). Plant materials used in aqueous extracts for control of dry rot disease of potato tubers.

No.	English name	Scientific name	Used parts
1	Cinnamon	*Cinnamon zeylanicum* L.	Cortex
2	Ginger	*Zingiber officinalis* L.	Rhizome
3	Thyme	*Thymus vulgaris* L.	Leaves
4	Marjoram	*Majorana hortensis* L.	Leaves
5	Clove	*Dianthus caryphlus* L.	Cloves
6	Garlic	*Allium sativum* L.	Cloves
7	Galls	*Quercus infectoria* L.	Fruits
8	Nigella	*Nigella sativa* L.	Seeds

3. Biological control of dry rot pathogens by *Trichoderma* spp. under storage conditions:

Ten Trichoderma isolates (that mentioned above in laboratory tests) were selected to study their effects as biocontrol agent against dry rot pathogen under laboratory conditions.

Potato tubers Spunta cv. were carefully chosen free from mechanical injury or diseases as far as possible. Wounded and unwounded tubers were then surface sterilized and inoculated with agar discs (5 mm in diameter) from cultures of each of the selected pathogenic fungi grown on PDA medium (7 days old). Four replicates, 3 tubers of each, were used for each treatment. Each replicate was covered with stretch film in foam plate 5 × 15 × 25 cm in diameter. The inoculated tubers were incubated at room temperature of about 22 – 25°C. The control treatment was left without fungal inoculation. Percentages and disease index of rotted tubers were recorded, 5 days after inoculation.

4. Chemical control of potato dry rot incidence under storage conditions:

Table (2) Five fungicides were tested for control of dry rot disease incidence of potato tubers cv. Spunta. The tested fungicides were Tachigaren plus 600 SL, Uniform 390.39% SE, Redomil M 2587, Aleet Express 80% and Rizolex-T in Table (2).

The above mentioned five fungicides were involved in storage studies. In two seasons, the stored potato tubers cv. Spunta were prepared as follows: potato tubers were surface sterilized by immersing in 0.255 sodium hypochlrite solution for 3 minutes and then washed several times with sterilized distilled water and then left to dry. Inoculation technique was achieved by injuring the tested sterilized tubers using sterile blade and then the tubers were soaked in the prepared solution of *F. solani* isolate (10) spore suspension and then left to ear dry. The infected tubers were incubated for storage in sterilized packing (carton box 25 × 25 × 20 cm) for 48 hours. Then each box was treated with one of five selected fungicides by spraying by fungicidal solution (100 ppm) and stored at 15°C, 90% relative humidity and noticed weekly to the end of experiment.

The disease incidence was calculated % and the reduction of the dry rot disease was calculated and recorded in comparing to control treatment.

Table (2). Fungicides used in dry rot of potato tubers control.

Trade name	Conc.	Common name	Active ingredients	Company
Tachigaren plus 600 SL	1 cm^3/L	Metalaxyl hemexazol	Hemexazol 40% + Metalaxyl 20% + inert material 40%	Syngenta, USA
Uniform 390.39% SE	650 cm^3/Fed.	Azoxystrobin Minfinoxam	Minfinoxam + Azoxystrobin	Syngenta, Switherland
Redomil M 2587	2 gm/L	Mithoxy Metalaxyl + Mancozib	N-2, 4 Dimethyl N-2-cety-Dit-alanin methyl-ester	Nepon Soda, Japan
Aleet Express 80%	1 cm^3/L	Fosetyl Aluminum 80% WP	Organophosphate	Payer Crop Science, France
Rizolex-T	1 gm/L	Tolcofos-methyl + Thiram (50% WP)	20% Tolcofos-methyl: 0.0 Dimethyl-o-(4 methyl-2, 6 dichlorophenyl) thiophophat + 30% thiram (TMTD): Tetramethyl thiuramdisulfid	Sumitomo chem. Ltd., Japan

After inocubation period, tubers were cut longitudinally via sites of inoculations and the rotted tissues were weighted. Parameters of inducted dry rot depth of rotting are scored. The obtained data were recorded and statistically analyzed.

RESULTS

1. Effect of storage periods combined with different storage temperature degrees on potato dry rot infection:

Four storage periods combined with five storage temperature degrees were applied the two summer and Nili seasons. The four periods of storage were applied with 15 days intervals.

Data in Table (3) indicate that the dry rot disease incidence was affected with combined with the different storage temperature degrees of both cultivations during the two tested seasons, 2015 and 2016.

Data in Table (3) show that the least periods of storage with the least temperature degrees of storage (15 days at 3 – 5°C) decreased the dry rot disease incidence % in both tested seasons.

Significant differences were noticed between periods of storage which combined with different temperature degrees as shown in Table (3).

Table (3). Effect of different temperatures with storage periods of *F. solani* (F10) on potato Spunta c.v. under storage condition during (2015 – 2016) seasons.

Storage periods	Temperature	Disease incidence (DI) (%)				
		2015		2016		Mean
		Nili	Summer	Nili	Summer	
15 days	3 – 5°C	0.32^{i}	0.34^{i}	0.32^{o}	0.33^{o}	0.33
	8 – 10°C	1.42^{hi}	1.62^{hi}	1.47^{n}	1.45^{m}	1.49
	13 – 15°C	5.834^{g}	5.724^{gh}	5.84^{k}	5.82^{k}	5.80
	Up to 25°C	13.24^{f}	13.02^{f}	13.19^{h}	13.05^{h}	13.13
30 days	3 – 5°C	1.532^{hi}	1.57^{hi}	1.65^{n}	1.56^{n}	1.58
	8 – 10°C	4.80^{gh}	6.744^{g}	7.08^{j}	6.91^{j}	6.89
	13 – 15°C	24.99^{d}	24.85^{d}	24.92^{f}	24.80^{f}	24.89
	Up to 25°C	35.72^{c}	35.59^{c}	35.52^{d}	35.53^{d}	35.59
60 days	3 – 5°C	2.79^{ghi}	2.86^{ghi}	2.53^{m}	2.73^{m}	2.73
	8 – 10°C	11.24^{f}	11.18^{f}	11.24^{i}	11.21^{i}	11.22
	13 – 15°C	31.78^{c}	25.86^{d}	31.47^{e}	29.58^{e}	31.17
	Up to 25°C	44.19^{b}	44.33^{b}	44.62^{b}	44.63^{b}	44.44
90 days	3 – 5°C	4.96^{gh}	4.70^{ghi}	4.68^{l}	4.87^{l}	4.80
	8 – 10°C	18.90^{e}	18.96^{e}	19.00^{g}	18.92^{g}	18.94
	13 – 15°C	40.99^{b}	40.81^{b}	41.19^{c}	41.02^{b}	41.01
	Up to 25°C	52.24^{a}	52.62^{a}	52.43^{a}	52.96^{a}	52.56
L.S.D. at 5%		4.28	4.38	0.83	0.93	–

2. Disease control:

A. Plant extracts:

Eight plant extract materials were tested against disease in potato tubers, i.e. Cinnamon, Ginger, Thyme, Marjoram, Clove, Garlic, Galls and Nigella. The most aggressive fungal pathogen isolates from the three major pathogenic fungi that were isolated from dry rotted potato tubers were tested in these trials, i.e. *Fusarium solani* three isolates, i.e. isolate (Fs10).

Three concentrations of each plant extract were used in these experiments, i.e. 3, 5 and 10%.

Plant extracts at 3% concentration:

Data presented in Table (4) indicated that all tested plant extracts were effective on inhibition fungal growth in Petri dishes for all five tested isolates.

The least effective plant extract at 3% concentration on fungal growth was Galls, followed by Ginger, while the most effective plant extract at 3% was Garlic followed by clove and Marjorum.

Plant extracts at 5% concentration:

Data presented in Table (5) indicated that all tested plant extracts were effective on inhibition fungal growth in Petri dishes in all tested isolates.

The least effective plant extract at 5% concentration on fungal growth was Galls, followed by Ginger.

The most effective plant extract at 5% was Garlic, followed by cinnamon.

The most effective plant extract of 5% on *F. solani* (isolates F10, 4 and 1) was Garlic, followed by Clove. These results were similar to the plant extracts at 3% but with low percentages as shown in Table (5).

Table (4). Effect of different plant extracts at concentration (3%) on *F. solani* growth under laboratory conditions.

Plant extract / Isolates	Linear growth (mm)								Mean
	Cinnamon	Ginger	Thyme	Marjoram	Clove	Garlic	Galls	Nigella	
F. solani F10	78.49[a]	85.83[a]	78.16[c]	76.23[a]	73.07[a]	69.11[a]	88.93[a]	80.81[a]	78.83
F. solani F4	79.65[a]	86.74[a]	82.55[a]	78.72[a]	75.15[a]	73.22[a]	86.51[a]	79.98[a]	80.32
F. solani F1	78.28[a]	79.16[a]	80.23[b]	73.14[a]	72.74[a]	70.89[a]	87.43[a]	83.12[a]	78.12
F. oxysporum F19	71.55[a]	85.41[a]	73.14[d]	69.12[a]	68.12[a]	67.13[a]	79.66[a]	86.50[a]	75.08
F. avenaceum F20	74.28[a]	83.89[a]	78.25[c]	73.46[a]	71.65[a]	70.29[a]	84.26[a]	82.01[a]	77.26
Mean	76.45	84.21	78.47	74.13	72.15	70.13	85.36	82.48	–
L.S.D. at 5%	15.69	8.23	1.41	11.52	11.52	11.52	11.52	11.52	–

Table (5). Effect of different plant extracts at concentration (5%) on *F. solani* growth under laboratory conditions.

Plant extract / Isolates	Linear growth (mm)								Mean
	Cinnamon	Ginger	Thyme	Marjoram	Clove	Garlic	Galls	Nigella	
F. solani F10	65.43^{a}	70.54^{a}	64.12^{a}	63.66^{a}	67.35^{a}	65.73^{a}	73.11^{a}	72.23^{a}	67.77
F. solani F4	65.28^{a}	75.36^{a}	60.12^{b}	66.93^{a}	63.12^{ab}	58.18^{ab}	76.45^{a}	69.11^{a}	66.82
F. solani F1	60.12^{a}	73.12^{a}	63.33^{ab}	68.11^{a}	60.08^{b}	60.69^{ab}	74.29^{ab}	70.12^{a}	66.23
F. oxysporum F19	63.64^{a}	63.20^{b}	72.27^{a}	64.12^{b}	71.18^{a}	54.20^{b}	68.44^{b}	65.61^{b}	65.33
F. avenaceum F20	63.29^{a}	61.11^{b}	70.21^{a}	63.57^{a}	69.22^{a}	60.11^{ab}	66.18^{b}	65.04^{b}	64.84
Mean	63.55	68.66	66.01	65.28	66.19	59.78	71.69	68.42	–
L.S.D. at 5%	11.51	11.52	9.12	9.12	9.12	9.12	9.12	9.12	–

Plant extracts at 10% concentration:

Data presented in Table (6) indicated that all tested plant extracts were effective on inhibition fungal growth in Petri dishes in the five tested isolates.

All tested plant extracts were affective on the same trend of all extracts that obtained in 3 and 5% concentrations.

The least effect of the tested plant extracts at 10% concentration on fungal growth was Galls, followed by Ginger.

The most effective plant extract at 10% was Garlic, followed by Clove.

The same trend was repeated on the tested fungi.

Data in Table (6) also indicated that were significant differences between all tested plant extracts and their concentrations. Also, there were significant differences between the five tested fungal isolates.

B. Control of potato dry rot disease incidence using the most effective two plant extracts in laboratory against five *Fusairum* spp. Under storage condition of potato tubers cv. Spounta:

Data in Table (7) indicated that both tested plant extracts, i.e. Garlic and Cinnamon, the most effective in laboratory tested eight plant extracts. Potato tubers cv. Spunta were treated with spore suspension of one the five species of fusarium individually and treated after air drying by one the three concentrations of both tested plant extracts the stored as mentioned above and tested for linear growth (mm).

Both plant extracts were effective on disease index and minimized potato dry rot linear growth with all tested isolates.

The least effective plant extract concentration was Clove (3%), followed by Garlic (3%). They reacted by 24.15 and 22.34% DI, respectively.

Table (6). Effect of different plant extracts at concentration (10%) on *F. solani* growth under laboratory conditions.

Plant extract / Isolates	Linear growth (mm)								Mean
	Cinnamon	Ginger	Thyme	Marjoram	Clove	Garlic	Galls	Nigella	
F. solani F10	40.20^{a}	50.11^{a}	46.67^{a}	38.31^{b}	24.00^{a}	25.36^{a}	50.12^{a}	49.33^{a}	40.51
F. solani F4	43.38^{a}	53.28^{a}	44.52^{a}	31.43^{c}	25.06^{a}	22.14^{a}	51.50^{a}	48.30^{a}	39.95
F. solani F1	45.00^{a}	55.14^{a}	48.23^{a}	37.50^{b}	29.28^{a}	23.19^{a}	54.70^{a}	43.20^{a}	42.03
F. oxysporum F19	44.16^{a}	52.19^{a}	50.12^{a}	48.11^{a}	31.64^{a}	24.71^{a}	56.44^{a}	47.75^{a}	44.39
F. avenaceum F20	46.73^{a}	50.31^{a}	49.14^{a}	47.92^{a}	28.11^{a}	22.08^{a}	49.38^{a}	41.18^{a}	41.86
Mean	43.89	52.21	47.74	40.65	27.61	23.49	52.43	45.95	–
L.S.D. at 5%	8.51	10.00	9.46	9.46	9.46	9.46	9.46	9.46	–

Table (7). Effect of different concentrations (3, 5 and 10%) of garlic and cinnamon on mycelial growth of *F. solani* under laboratory condition.

Concentration / Isolates	Linear growth (mm)						Control
	3%		5%		10%		
	Garlic	Cinnamon	Garlic	Cinnamon	Garlic	Cinnamon	
F. solani F10	18.46^{ab}	18.22^{b}	12.35^{bc}	12.03^{bc}	3.18^{a}	4.94^{a}	25.92^{ab}
F. solani F4	18.09^{ab}	20.58^{ab}	10.00^{bc}	10.18^{c}	3.09^{a}	3.88^{a}	28.15^{ab}
F. solani F1	16.45^{b}	17.84^{b}	8.11^{c}	9.26^{c}	2.44^{a}	3.04^{a}	30.75^{a}
F. oxysporum F19	20.59^{ab}	22.17^{ab}	15.18^{ab}	17.73^{ab}	5.77^{a}	6.54^{a}	27.00^{ab}
F. avenaceum F20	22.34^{a}	24.15^{a}	18.40^{a}	18.88^{a}	6.65^{a}	6.93^{a}	25.36^{b}
Mean	19.19	20.59	12.81	13.62	4.23	5.07	27.44
L.S.D. at 5%	5.24	4.92	5.24	6.17	4.66	5.24	5.24

2.1. Biological control:

Antagonistic activity of some biological control agents under laboratory conditions:

Data in Tables (8 a, b) indicated that *Fusarium solani* great affected by the various biocontrol agents in all calculated parameters. The highest linear growth of *F. solani* was recorded against *Trichoderma pseudoconingii* (1), followed by *T. pseudoconingii* (2) in the case of *F. solani* (isolate 1).

Table 8 a

Table 8 b

2.2. Chemical control:

Five fungicides were tested for control of *Fusarium solani* (the causal pathogen of dry rot disease of potato tubers). The tested fugnicides were: Tachigaren plus 600 SL, Uniform 390.39% se, Redomil M 2587, Aleet Express 80% and Rizolex-T (Table 9).

According to the obtained data from the laboratory experiments; (not mentioned data); the most effective concentration of each fungicide was selected for storage experiments. The effect of the above mentioned five fungicides on dry rot disease incidence under storage in cold conditions by using infected potato tubers in sterilized packing (carton box 25 × 25 × 20 cm) were conducted. The recommended dose of each of the five above mentioned fungicides were used in these experiments.

Data in Table (9) indicate that Tachigaren plus 600 SL fungicide at 100 ppm was the most effective one in controlling the dry rot disease incidence, followed by Uniform 390, 39% SE and Redomil M 2587 fungicides at 100 ppm..

Significant differences were recorded between the five tested fungicides as shown in Table (9).

DISCUSSION

Furasium dry rot is one of the most important postharvest diseases of potato tubers occurring worldwide. It infects tubers in storage, as well as tuber pieces underground after planting. Yield losses attributed to dry rot in storage ranged from 6 to 25% with up to 60% of tubers affected in some cases (Abo El-Seoud *et al.,* 2010).

In storage, many cavities happen on the surface tissues of tubers, then in these cavities many spore masses develop in these internal cavities with various colours. After storage in low temperature and cold conditions, internal tissues often will become firm and dry or even powdery (Rowe *et al.,* 1995).

The occurrence of dry rot disease in potato plants in Egypt varied between potato growing areas and potato varieties with significant differences. The variation between climate, environment and soil conditions may explain the variation between the various in disease incidences in the various governorates in Egypt. These results confirmed the findings of Cullen *et. al.* (2005), Wharton & Kirk (2007), Ocamb (2008) and Peters *et al.* (2008).

Table (9). Effect of different fungicides on *F. solani* of potato Spunta cv. under storage condition during (2015 – 2016) seasons.

Tested fungicides	Disease incidence DI (%)				Mean	Reduction %
	2014/2015		2015/2016			
	Nili	Summer	Nili	Summer		
Tachigaren plus 600 SL	5.28	5.09	4.11	5.35	4.96	82.54
Uniform 390.39% SE	7.38	7.64	8.02	7.48	7.63	73.13
Redomil M 2587	8.92	9.18	8.75	8.44	8.82	68.94
Aleet Express 80%	15.29	17.22	16.88	15.93	16.33	42.50
Rizolex-T	13.40	11.04	10.98	12.54	11.99	57.78
Control + Pathogen	28.86	29.73	26.11	28.91	28.40	–
Control	0.00	0.00	0.00	0.00	0.00	–
L.S.D. at 5%	0.22	0.30	0.29	0.26	–	–

Fusarium solani **was the main causal organism of dry rot disease of potato tubers in the Egyptian potato growing fields. In the last two decades, the incidence of dry rot in potato tubers were recorded high levels in sandy soils.**

Different control measures such as cultural practices, planting of tolerant resistant cultivars, clean seed, crop rotation and fungicides application are necessary for disease control (Rekamovic *et al.,* 2015).

Eight plant extracts were involved in these studies, i.e. Cinnamon, Ginger, Thyme, Marjoram, Clove, Garlic, Galls and Nigella. Each of the extracts was prepared in three concentrations, i.e. 3, 5 and 10%.

All tested plant extracts were effective on inhibition fungal growth in Petri dishes for all five tested isolates (in 3% concentration).

The most effective plant extract at 5% was Garlic, followed by Cinnamon. On *F. solani* (the three tested isolates: F10, F4 and F1) were affected by Garlic, followed by Clove at 5%, and these results were similar to that noticed by 3% concentration, but with highly effect and low fungal growth.

As for plant extracts in 10% concentrations, all tested plant extracts were effective on inhibition fungal growth in Petri dishes and the effects were at the same trained of all extracts that obtained in 3 and 5% concentrations. Significant differences were noticed between all tested plant extracts, as well as their tested concentration (3, 5 and 10%).

These results are in accordance with those obtained by Dulli *et al.* (2011), Liximg Dong & Xue Huali (2014), Pagnussatt *et al.* (2014), Zaker (2014), Gonzalez-Alvarez *et al.* (2015), Mvuemba *et al.* (2015) and El-Sherbiny *et al.* (2016).

In storage conditions, the most effective plant extract was Garlic at 10% concentration, followed by Clove at the same concentration. The best control was obtained by Garlic 10% when treated on potato tubers infected with *F. solani* isolate 10, followed by Clove 10% against *F. solani* isolate 1.

All disease incidence (DI) were minimized by raising the plant extracts concentrations that treated on potato tubers cv. Spunta that infected with the tested five isolates of *Fusarium* spp.

These results were similar to the results obtained by Bahardwaj (2012), Zaker (2014) and Gonzalez-Alvarez *et al.* (2015).

Antagonistic activities of some biological control agents under laboratory conditions were conducted in Petri dishes on PDA medium against five isolates of fungal pathogens. The fungal pathogens were *Fusarium solani* (three isolates: 10, 4 and 1), one isolate of *F. oxysporum* (F19) and one isolate of *F. avenaceum* (F20). Ten isolates of *Trichoderma* spp., i.e. *T. harzianum* (three isolates: 1, 2 and 3), two isolates of *T. hamatum* (isolates 1 and 2), one isolate of *T. viride*, two isolates of *T. koningii* (isolates 1 and 2), and two isolates of *T. pseudokoningii* (isolates 1 and 2) were used for determination the antagonistic activities against the above mentioned fungal pathogens.

Fusarium solani **great affected by the various biological control agents in all calculated parameters. The highest linear growth of *F. solani* was achieved against *T. pseudokoningii* isolate (1), followed by *T. pseudokoningii* isolate (2). The best biological control was recorded by *T. harzianum* isolates (1, 2 and 3) against *F. solani* isolates (10, 4 and 1). All bioagent actions parameters were noticed by various eight *Trichoderma* spp. isolates against the five *Fusarium* spp. isolates, i.e. fungal growth contact, inhibition zone, as well as over growth.**

These results were similar to the results obtained by Pratella & Mari (1993), Gould *et al.* (2008), Gachango *et al.* (2012), Glez *et al.* (2013) and Krik *et al.* (2013).

Five fungicides were tested for control of *Fusarium solani*; the causal pathogen of dry rot disease of potato tubers; the most aggressive isolate in pathogenicity tests (F10). The tested fungicides were: Tachigaren plus 600 SL, Uniform 390, 39% SE, Redomil M 2587, Aleet Express 80% and Rizolex-T. The effect of these fungicides on dry rot disease incidence under storage in cold conditions by using infected potato tubers cv. Spunta stored in sterilized packing (carton boxes 25 × 25 × 20 cm) were conducted. The recommended dose of each of the fungicides were used.

Tachigaren at 100 ppm was the most effective one in controlling the incidence of dry rot disease, followed by Uniform and Redomil fungicides at 100 ppm also. The reduction of disease incidence was between 82 to 73% with these best three fungicides. Significant differences were noticed between the five tested fungicides.

Many investigators were studied the fungicidal effects on potato tubers and dry rot disease control, and they recommended they results for application as Bang (1992), Stachewicz *et al.* (1992), Idrees *et al.* (2009), Daami Remadi *et al.* (2010), Cwalina Ambroziak and Trrojak (2011), Gachango *et al.* (2011) and Taskeen-un-Nisa *et al.* (2011).

REFERENCES

Abo-El-Seoud, M.A.; Sarhan, M.M.; Galal, A.M. and Helal, M.M. (2010). Effect of gamma radiation and formulated essential oils on stored potato tubers. Proceeding, 2nd International conference on Radiation Sciences and Applications on 28 March, 1 April, 2010.

Bang, U. (1992). Influence of seed tuber infestation, chemical seed treatment and pre-harvest climate on incidence of gangrene and dry rot of potato (*Solanum tuberosum*). Potato Research. 35 (1): 3 – 15.

Bhardwaj, S.K. (2012). Evaluation of plant extracts as antifungal agents against *Fusarium solani* (Mart.) Sacc. World Journal of Agricultural Sciences, 8 (4): 385 – 388.

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. Phytopathology, 95 (12): 1462 – 1471.

Cwalina-Ambroziak, B. and Trojak, A. (2011). The effect of fungicides applied during the growing season on the health stales of potato tubers after storage. Polish Journal of Natural Sciences, 26 (3): 197 – 206.

Daami-Remadi, M.; Ayed, F.; Jabnoun-Khiareddine, H.; Hibar, K. and El-Mahjoub, M. (2006). *In vitro*, *in vivo* and in situ evaluation fungicides tested Individually or in combination for the control of the Fusarium dry rot of potato. International Journal of Agricultural Research, 1 (6): 564 – 572.

Daami-Remadi, M.; Ayed, F.; Jabnoun-Khiareddine, H.; Hibar, K. and El-Mahjoub, M. (2010). *In vitro*, *in vivo* and in situ evaluation of fungicides tested individually or in combination for the control of the Fusarium dry rot of potato. International Journal of Agricultural Research, 5 (11): 1039 – 1047.

Du LiLi; Wang XueZheng; Ma HongYan and Luan FeiShi (2011). Effect of potato-onion bulb extraction on *Fusarium oxysporum* f.sp. *niveum*. [Chinese] Dongbei Nongye Daxue Xuebao, 42 (1): 114 – 118.

El-Sherbiny, E.A.; Amin, B.H. and Baka, Z.A. (2016). Efficiency of pomegranate (*Ponica granatum* L.) peels extract as a high potential natural iooi towards Rosarium dry rot on potato tubers. Postharvest Biology and Technology, 111: 256 – 263.

Filippov, A.V.; Kuznetsova, M.A.; Barlyuk, T.I.; Rogozhin, A.N. and Pyushpeki, V.D. (1996). Influence of potato tuber treatments with fludioxonil on development of fungal diseases. Brighton Crop Protection Conference: Pests & Diseases. Volume 1. Proceedings of an International Conference, Brighton, UK, 18-21 November, pp. 269 – 274.

Gachango, E.; Kirk, W.; Hanson, L.; Rojas, A.; Tumbalam, P. and Shetty, K. (2011). First report of *in vitro* fludioxonil-resistant isolates of *Fusarium* spp., causing potato dry rot in Michigan. Plant Disease, 95 (2): 228.

Gachango, E.; Kirk, W.; Schafer, R. and Wharton, P. (2012). Evaluation and comparison of biocontrol and conventional fungicides for control of postharvest potato tuber diseases. Biological Control, 63 (2): 115 – 120.

Glez, V.M.; Derevyagina, M.K.; Sedova, V.I. and Vasil'eva, S.V. (2013). Prospects for use of Agat-25K on potato. [Russian]. Zashchita I Kaeantin Rastenii, 5: 27 – 29.

Gonzalez-Alvarez, M.; Moreno-Limcn, S.; Salcedo-Martinex, S.M. and Perez-Rodriguez, E.C. (2015). *In vitro* evaluation of antifungal activity of Agave (Agave scabra, Salm Dyck) extracts against post-harvest mushrooms. [Spanish]. Phyton Buenos Aires, 84 (2): 427 – 434.

Gould, M.; Nelson, L.M.; Waterer, D. and Hynes, R.K. (2008). Biocontrol of *Fusarium sambucinum*, dry rot of potato, by *Serratia plymuthica* 5-6. Biocontrol Science and Technology, 18 (10): 1005 – 1016.

Idrees, M.; Shaukat, Ali; Muhammad Ayub; Niaz, M.Z. and Qurban, Ali (2009). Impact of seed dressing on soil borne potato tubers diseases. Pakistan Journal of Phytopathology, 21 (1): 89 – 91.

Kirk, W.W.; Gachango, E.; Schafer, R. and Wharton, P.S. (2013). Effects of in-season crop-protection combined with postharvest applied fungicide on suppression of potato storage diseases caused by Fusarium pathogens. Crop Protection, 1: 77 – 84.

Lixing, D. and Xue, H. (2014). Antifungal activity of the essential oil of *Zanthoxylum bungeanum* and its major constituent an *Fusarium sulphureum* and dry rat of potato tubers. Phytoparasitica, 42 (4): 509 – 517.

Mvuemba, H.N.; Green, S.E.; Tsopmo, A. and Avis, T.J. (2015). Antimicrobial efficacy of cinnamon, ginger, horseradish and nutmeg extracts against spoilage pathogens. Phytoprotection, 90 (2): 65–70.

Ocamb, C.M. (2008). Potato (*Solanum tuberosum*) Fusarium dry rot. American Journal of Potato Research, 1: 642.

Pagnussatt, F.A.; Ponte, E.M. del; Garda-Buffon, J. and Badiale-Furlong, E. (2014). Inhibition of *Fusarium graminearum* growth and mycotoxin production by phenolic extract from *Spirulina* sp. Pesticide Biochemistry and Physiology, 108: 21 – 26.

Peters, R.D.; Piatt, H.W.; Drake, K.A.; Coffin, R.H.; Moorehead, S.; Clark, M.M.; Al-Mughrabi, K.I. and Howard, R.J. (2008). First report of fludioxonil-resistant isolates of *Fusarinm* spp. causing potato seed-piece decay. Plant Disease, 92 (1): 172.

Rafiq, M.; Mirza, J.H.; Shakir, A.S. and Akhtar, K.P. (1995). Post-harvest fungal diseases of potato in Faisalabad and their chemical control. Pakistan Journal of Phytopathology, 7 (1): 44 – 46.

Rekanovic, E.; Potocnik, I.; Milijasevic-Marcic, S.; Slepanovic, M. and Todorovic, B. (2015). Fungal and pseudofungal diseases of potato (Serbian); Bilini lekar (plant doctor), 43 (6): 560 – 573.

Rowe, R.C.; Miller, S.A. and Riedel, R.M. (1995). Fusarium dry rot and seed piece decay of potato. The Ohio State University Extension Fact Sheet Plant Pathology, 35 (10): 77.

Stachewicz, H.; Burth, U. and Rathke, S. (1992). Fungicide resistance in Fusarium species causing dry rot of potato in the new federal Lander, [German]. Nachrichtenblatt des Deutschen Pflanzens-chutzdienstes, 44 (5): 97 – 100.

Taskeen-un-Nisa; Wani, A.H. and Mir, R. (2011). Fusarium rot of potato and its manager. Journal of Plant Disease Sciences, 6 (2): 107 – 113.

Wharnton, P.S.; Kirk, W.W.; Berry, D. and Tumbalam, P. (2007). Seed treatment application-timing options for control of Fusarium decay and sprout rot of cut seed pieces. American Journal of Potato Research, 84 (3): 237 – 244.

Wharton, P.S. and Kirk, W.W. (2014). Evaluation of biological seed treatments in carina, ioa with management practices for the control of Fusarium dry rot of potato. Biological Control, 73: 23 – 30.

Zaker, M. (2014). Antifungal evaluation of some plant extracts in controlling *Fusarium solani*, the causal agent of potato dry rot *in vitro* and *in vivo*. International Journal of Agriculture and Biosciences, 3 (4): 190 – 195.

مكافحة مرض تعفن درنات البطاطس أثناء التخزين

محمد أحمد عوض، جمعة عبد العليم عامر، أحمد حسن فرج

قسم النبات الزراعي – كلية الزراعة – جامعة المنوفية – شبين الكوم

الملخص العربى

تُصاب البطاطس في الحقل والمخزن بالعديد من الأمراض الفطرية مثل العفن الجاف. ويُمكن إيجاز نتائج البحث في التالي:

ثبت من التجارب أن التخزين على درجة حرارة 3 – 5°م قلَّل بشدة % للإصابة بالمرض، وعلى العكس من ذلك فإن التخزين على درجة 18 – 20°م ودرجة 25°م قد شجَّع حدوث العدوى وشدة الإصابة في درنات البطاطس. في تجارب مُقاومة حدوث مرض العفن الجاف في درنات البطاطس باستخدام مُستخلصات مائية لأنسجة نباتية مُختلفة، تم اختبار استخدام ثمانية مُستخلصات نباتية بتركيزات مُختلفة حيث تم الوصول إلى أن أفضل المُستخلصات النباتية في مُقاومة المرض على صنف البطاطس سبونتا كان مُستخلص الثوم بتركيز 3، 5، 10% هو أفضل المُستخلصات. تم اختبار تأثير المُستخلصات النباتية الثمانية مُنفردة وكل مُستخلص بثلاث تركيزات 3، 5، 10%، وكانت الاختبارات معملياً في عملية تضاد للفطر المُمرض على بيئة غذائية مُضاف إليها المُستخلص النباتي بتركيزٍ واحدٍ في أطباق بتري. تم اختبار مُستخلصات نباتين وهما الثوم والقرفة في ثلاث تركيزات 3، 5، 10% رشاً على درنات البطاطس التي تم عدواها بأقوى عزلات الفيوزاريوم سولاني F10. تم اختبار 10 كائنات تضاد حيوية من جنس الترايكودرما في مقدرتها على التضاد الحيوي مع أقوى العزلات الفطرية في أطباق بتري بالإضافة إلى عزلات الفيوزاريوم سولاني (F10 ، F4 ، F1) وعزلة من الفيوزاريوم أوكسيسبوريم (F19)، وعزلة من الفطر فيوزاريوم أفيناكيوم (F20). أثَّرت فطريات التضاد الحيوي بدرجةٍ كبيرةٍ على خفض نسبة الإصابة تحت ظروف التخزين العادية في حرارة 18 – 20°م وذلك بالمُقارنة بالدرنات المُعدية فقط دون المُعاملة بكائنات التضاد الحيوي. تم اختبار خمسة مُبيدات فطرية لمُعاملة الدرنات المُعدية بالفطر فيوزاريوم سولاني وذلك أثناء تخزين الدرنات في صناديق كرتون بالجرعة المُوصى بها (100 جزء في المليون).

السادة المحكمين

أ.د/ أحمد أبوريا الكفراوى — معهد بحوث أمراض النباتات – الجيزة

أ.د/ محمد محمد عمار — كلية الزراعة – جامعة المنوفية