Losses in potato caused by *Potato leaf roll virus* (*PLRV*), *Potato virus Y* (*PVY*) and *Alfalfa mosaic virus* (*AMV*)

Zaied, M. A. A.[1], H. A. Younes[2], G. I. Fegla[3], A. A. El Gamal[4] and Mervat M. Fathalla

1- Dept. of plant protection, Fac. of Agric., Tripoli Univ., Libya

2- Dept. of Agricultural Botany, Fac. of Agric, Saba Basha, Alex. Univ., Egypt

3- Dept. of Agricultural Botany, Fac. of Agric, Alex. Univ., Egypt

4- Dept. of Plant production, Fac. of Agric, Saba Basha, Alex. Univ.,

5- Plant Pathology Institute., Agric. Res. Center, Alex.

ABSTRACT

Using indirect ELISA and five antisera specific to important potato viruses, potato plants of cv. Spunta naturally infected singly with *Alfalfa mosaic virus* (*AMV*), *Potato leaf roll virus* (*PLRV*) and *Potato virus Y* (*PVY*) at two stages of plant development were chosen and targeted in the field to determine the effect of such virus infection on the vegetative growth and productivity of the infected plants. Vegetative growth parameters represented by plant height, average number of leaves per plant, fresh and dry weight of root and shoot systems were significantly reduced by virus infection. Great reduction was observed with plants infected at 5-6 leaf stage with *AMV*, *PLRV* and *PVY*. The same trend was also observed with productivity parameters represented by number of tubers per plant, weight of tubers per plant, dry matter and tuber size. Weight of tubers per plant was reduced by 66.2 and 48.1%, 69.9 and 39.8%, 63.6 and 23.3% in naturally infected plants, at 5-6 leaf stage and 8-9 leaf stage of development with *AMV*, *PLRV* and *PVY*, respectively.

On the other hand, chemical components of tubers of infected plants such as reducing and non reducing sugars, starch and vitamin C were not significantly affected.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a perennial plant of Solanaceae and the world's most widely grown tuber crop ranking fourth in the world after rice, wheat and maize. 40% of the world potatoes are grown in Europe, 35% in other developed countries and 25% in rest of the world. (Langer, 1975 and Yvon *et al.*, 2000).

Several distinct viruses are known to infect potatoes under field conditions. Among the most important of these in Egypt are *Potato leaf roll viruses* (*PLRV*), *Potato virus Y* (*PVY*), *Potato virus X* (*PVX*) (Shalaby, 1993; Gamal El-Din *et al.*, 1997 and Amer, 1999)

Little work has been done on potato viruses in northern Egypt. However, our limited surveys in some potato producing regions of Alexandria and El Behira governorates revealed the occurrence of *AMV*, *PLRV* and *PVY* in higher frequencies than other viruses.

This paper presents some morphological effects of *AMV*, *PLRV* and *PVY* on potato cv. Spunta and the rate of yield reduction due to these

viruses when infection occurred naturally at different stages of plant development.

MATERIALS AND METHOTDS

1. Field experiment

Open field experiment was conducted during spring season 2012, at Etai El Baroud Al-Khawalid – El-Behira. The experiment was carried out on March 5, 2012. Plants of potato cv. Spunta grown in the field were left for natural infection with potato viruses and plants infected singly with each *AMV, PLRV* and *PVY* were recognized in samples collected from such plants by indirect ELISA using specific antisera. Stages of plants at which symptoms appeared were also determined. Plants on which symptoms of *AMV, PLRV* and *PVY* appeared at different stages of plant development were chosen. Virus free plants were used as control. Five replicates were used for each treatment. Potato plants were weekly sprayed with Malathione 0.1 % to minimize infection of selected plants with other viruses.

2. Virus detection

2.1. Source of antisera

Antisera for *AMV, PLRV, PVY, PVX, PVS* and *PVM* were provided by Dr. Gaber Fegla, Plant Virology Lab., Plant Pathology Dept., Faculty of Agriculture, Alexandria University.

2.2. ELISA

The indirect ELISA first reported by Koenig (1981) and modified by Fegla *et al.* (1997) was used. The ELISA values were measured by Sunrise ELISA reader and expressed as absorbance at 405 nm. Absorbance values if at least double that of the healthy control were considered positive.

3. Effect of virus infection on vegetative growth and productivity

Potato plants were individually collected with their tubers in plastic bags at the end of experiment and used to study the effect of natural infection with *AMV, PLRV* and *PVY* on vegetative growth as well as productivity and some chemical components of tubers. Obtained results were statistically analyzed according to Duncan's multiple range test procedure at $p < 0.05$ level of significance, as illustrated by Snedecor and Cochran (1980).

3.1. Vegetative growth

Vegetative growth parameters of potato cv. Spunta such as plant height, number of leaves per plant, fresh and dry weights of shoot and root systems were determined.

3.2. Productivity and some chemical components of tubers

3.2.1. Productivity

The number and weight of potato tubers per plant, dry matter, tuber shape index and tuber size of healthy and infected plants with *AMV, PLRV* or *PVY* were determined.

3.2.2. Chemical components

The following chemical components were determined in tubers of healthy and infected plants.

3.2.2.1. Reducing and non-reducing sugars content

A known mass (5g) of fresh tuber was taken to estimate reducing and non- reducing sugars, using sulphuric acid and phenol (5%), and then they were calorimetrically determined, according to the method of Dubios *et. al.* (1956).

3.2.2.2. Starch content

Tuber starch content was determined by using a sample of 1 g of fresh tuber, according to the method described in AOAC (1970).

3.2.2.3. Vitamin C

Vitamin C was determined by titration with 2, 6-di-chlorophenol-indophenol blue dye, according to the method of Jacobs (1951).

RESULTS

1. Effect of virus infection on vegetative growth and productivity

Alfalfa mosaic virus (AMV)

Data presented in Table (1) indicate that height and average of leaves per plant of plants infected with *AMV* at 5-6 leaf stage of development were reduced by about 21.8 and 68.1%, respectively. The reduction reached 4.4 and 50.4%, respectively when infection occurred at 8-9 leaf stage. Fresh and dry weights of shoot system were also reduced and the reduction was greater in plants infected at early infection date (5-6 leaf stage) being 56.1 and 59.5%, respectively. The same trend was observed with fresh and dry weight of root system.

Reduction in vegetative growth parameters reflected on productivity (Table 2). Number of tubers and weight of tuber per plant were decreased by 61.7 and 69.9% in plants infected at 5-6 leaf stage of development and by 42.5 and 39.8 in plants infected at 8-9 leaf stage, respectively Comparing with control treatment, dry matter of tubers and tuber size reduction were 52.7 and 73.2%, respectively when infection occurred at 5-6 leaf stage and reached 37 and 49.1% when infection happened at 8-9 leaf stage of development, respectively.

Tuber shape index was not significantly affected by virus infection either at 5-6 leaf stage or at 8-9 leaf stage of development.

Potato leaf roll virus (PLRV)

The height and average number of leaves per plant of potato plants infected with *PLRV* were reduced by 42 and 72.5%, respectively in 5-6 leaf stage infected plants and reduction reached 13.4 and 48.1% in 8-9 leaf stage infected one. Fresh and dry weights of shoot system were also decreased and the reduction reached 72.8 and 34.6% in early infected plants and 37.6 and 22.9% in late infected one, respectively. The same

trend was observed with fresh and dry weights of root system, higher reduction was also observed in root system of early infected plants.

Parameters of productivity were greatly affected. Number and weight of tubers per plant were reduced by 63.7 and 66.2% in 5-6 leaf stage infected plants and by 15.2 and 48.1%, in 8-9 leaf infected one, respectively.

Dry matter of tubers and tuber size were reduced by 60.17, 68% and 54.7, 45% in plants infected at 5-6 and 8-9 leaf stages of development, respectively.

Tuber shape index was not significantly affected by virus infection either at 5-6 leaf stage or at 8-9 leaf stage of development.

Potato virus Y (PVY)

Plant height and average number of leaves per plant were significantly reduced by virus infection and the reduction was greater in plants infected with *PVY* at the early stage (5-6 leaf stage) of plant development (Table 7). Shoot system was also affected. Virus infection at 5-6 and 8-9 leaf stages decreased significantly shoot system in terms of fresh weight by 85.1 and 54% and of dry weight by 81.84 and 41.0%, respectively. The same trend was observed with fresh and dry weights of root system, the reduction was greater in plants infected earlier (at 5-6 leaf stage) being 75.5 and 75.7%, respectively as compared with control.

Studying productivity showed that there were significant reduction in number of tubers per plant and weight of tubers by about 60.7 and 63.6%, respectively in plants infected at 5-6 leaf stage and the reduction reached 24.3 and 23.3% in plants infected at 8-9 leaf stage. Dry matter of tubers and tuber size were significantly decreased by 57.3 and 67.6% in early infected plants and by 39 and 25.8% in late infected ones.

Tuber shape index was not significantly affected by virus infection either at 5-6 leaf stage or at 8-9 leaf stage of development.

Chemical components of tubers

Data concerning chemical components of tubers collected from healthy and naturally infected plants are presented in Tables (3, 6 and 9). Results indicate that virus infection with either *AMV, PLRV* and *PVY* had no apparent effect on total sugars, reducing sugars, starch content and vitamin c. Values of these components varied according to plant stage at which infection occurred by decrease or increase as compared with control, but the differences were not significant.

Table (1): Growth parameters of potato cv. Spunta plants naturally infected with *AMV* at two different stages of development

Time of symptoms appearance	Period from symptoms appearance to yield harvest (days)	Plant height (cm)		Average No. of leaves/plant		Fresh weight				Dry weight			
						Shoot		Root		Shoot		Root	
		cm.	reduction %	No.	reduction %	g	reduction %	g	reduction %	g	reduction %	g	reduction %
Five to six leaf stage	58	90[c]	21.8	80.4[c]	68.1	304[c]	66.15	11.1[c]	57.18	31[c]	59.5	1.4[c]	66.9
Eight to nine leaf stage	40	110[b]	4.4	125[b]	50.4	459[b]	35.5	10.7[b]	31.5	50.4[b]	34.2	2.77[b]	32.5
Control	—	115[a]	—	252[a]	—	709.4[a]	—	26.9[a]	—	76.5[a]	—	4.1[a]	—
LSD (0.05)		4.1		30.30		100		4.2		10.2		0.44	

Table (2): Productivity of potato cv. Spunta plants naturally infected with *AMV* at two different stages of development

Time of symptoms appearance	Period from symptoms appearance to yield harvest (days)	No. of Tubers Per plant		Tubers weight per plant		Mean tuber weight		Dry matter(g)		Tuber shape index	Tuber size (Cm^3)			
											Per plant		Single tuber	
		No.	reduction %	g	reduction %	g	reduction %	g	reduction %		Cm^3	reduction %	Cm^3	reduction %
Five to six leaf stage	58	2.6[c]	61.7	253[c]	68.9	98.2[b]	51.1	163[c]	52.7	1.96[a]	202[c]	73.2	77.6[c]	32
Eight to nine leaf stage	40	3.8[b]	42.5	506[b]	39.8	164[a]	6.82	217[b]	37	1.58[b]	384[b]	49.1	101[b]	11.5
Control	—	6.6[a]	—	840[a]	—	176[a]	—	344[a]	—	1.84[a]	754[a]	—	114[a]	—
LSD (0.05)		0.9		147.7		52.6		1.18		n.s	115.4		9.9	

Table (3): Chemical component of tubers of Spunta plants naturally infected with *AMV*

Time of symptoms appearance	Period from symptoms appearance to yield harvest (days)	Total sugars (%)	Reducing sugars (%)	Starch content (%)	Vitamin C (mg/100 g)
Five to six leaf stage	58	5.2[b]	3.1[b]	13[b]	10.2[b]
Eight to nine leaf stage	40	6.6[b]	4[b]	14.5[b]	12.9[b]
Control	—	6.8[a]	5.5[a]	13.6[a]	11.2[a]
LSD (0.05)		25.4		6.9	12.7

Table (4): Growth parameters of potato cv. Spunta plants naturally infected with *PLRV* at two different stages of development

Time of symptoms appearance	Period from symptoms appearance to yield harvest (days)	Plant height (cm)		Average No. of leaves/plant		Fresh weight				Dry weight			
						Shoot		Root		Shoot		Root	
		cm.	reduction %	No	reduction %	g	reduction %	g	reduction %	g	reduction %	g	reduction %
Five to six leaf stage	58	67[b]	42	69.4[c]	72.5	193.2[c]	72.8	8.8[c]	67.2	27.14[b]	34.6	2[c]	51.3
Eight to nine leaf stage	40	99[b]	13.4	130.8[b]	48.1	443.2[b]	37.6	17.8[b]	34.7	59[b]	22.9	3.22[b]	22.3
Control	—	115[a]	—	252[a]	—	709.4[a]	—	26.9[a]	—	76.5[a]	—	4.1[a]	—
LSD (0.05)		1.61		30.5		124.3		6.25		13		0.6	

Table (5): Productivity of potato cv. Spunta plants naturally infected with *PLRV* at two different stages of development

Time of symptoms appearance	Period from symptoms appearance to yield harvest (days)	No. of tubers per plant		Tubers weight per plant		Mean tuber weight		Dry matter(g)		Tuber shape index	Tuber size (Cm^2)			
											Per plant		Single tuber	
		No	reduction %	g	reduction %	g	reduction %	g	reduction %		Cm^2	reduction %	Cm^2	reduction %
Five to six leaf stage	58	2.4[c]	83.7	284[c]	80.2	53.8 [b]	69.5	137[c]	60.17	2[a]	242[c]	68	101[c]	41.5
Eight to nine leaf stage	40	5.6[b]	15.2	436[b]	48.1	175[a]	0.6	156[b]	54.7	1.64[b]	415[b]	46	74[b]	34.1
control	—	6.6[a]	—	840[a]	—	178[a]	—	344[a]	—	1.64[b]	754[a]	—	114[a]	—
LSD (0.05)		0.58		126		97.8		1.18		n.s.	121.1		4.4	

Table (6): Chemical components of tubers of Spunta plants naturally infected with *PLRV*

Time of symptoms appearance	Period from symptoms appearance to yield harvest (days)	Total sugars (%)	Reducing sugars (%)	Starch content (%)	Vitamin C (mg/100 g)
Five to six leaf stage	58	5.4[a]	3[a]	12.86[a]	13.2[a]
Eight to nine leaf stage	40	6.6[a]	3.5[a]	14.7[a]	12.0[a]
Control	—	6.8[a]	3.5[a]	13.0[a]	11.2[a]

Table (7): Growth parameters of potato cv. Spunta plants naturally infected with *PVY* two different stages of development

Time of symptoms appearance	Period from symptoms appearance to yield harvest (days)	Plant height(cm)		Average No. of leaves/plant		Fresh weight				Dry weight			
						Shoot		Root		Shoot		Root	
		cm	reduction %	No	reduction %	g	reduction %	g	reduction %	g	reduction %	g	reduction %
Five to six leaf stage	58	68[c]	45.3	29.2[c]	58.5	106.9[c]	85.1	6.6[c]	75.5	13.9[c]	81.84	1[c]	75.7
Eight to nine leaf stage	40	84.2[b]	26.8	100.2[b]	40.3	326.4[b]	54	18.5[b]	31.1	45.1[b]	41	2.46[b]	40
Control	—	115[a]	—	252[a]	—	709.4[a]	—	26.9[a]	—	76.5[a]	—	4.1[a]	—
LSD (0.05)		28		34		115.7		5.6		19.7		0.64	

Table (8): Productivity of potato cv. Spunta plants naturally infected with *PVY* at two different stages of development

Time of symptoms appearance	Period from symptoms appearance to yield harvest (days)	No. of Tuber Per plant		Tubers weight per plant		Mean tuber weight		Dry matter(g)		Tuber shape index	Tuber size (Cm^3)			
											Per plant		Single tuber	
		No.	reduction %	g	reduction %	g	reduction %	g	reduction %		Cm^3	reduction %	Cm^3	reduction %
Five to six leaf stage	58	2.6[a]	60.7	308[c]	63.6	93.8[b]	46.7	147[c]	57.3	2[a]	245[c]	67.6	94.2[b]	17.4
Eight to nine leaf stage	40	5[b]	24.3	645[b]	23.3	172[a]	2.3	210[b]	39	1.68[a]	580[b]	25.8	112[a]	1.8
control		6.6[a]		840[a]		170[a]		344[a]		1.84[a]	754[a]		114[a]	
LSD (0.05)		1.15		166.1		46.7		1.182		3.04	188.2		3.7	

Table (9): Chemical component of tubers of Spunta plants naturally infected with *PVY*

Time of symptoms appearance	Period from symptoms appearance to yield harvest (days)	Total sugars (%)	Reducing sugars (%)	Starch content (%)	Vitamin C (mg/100 gm)
Five to six leaf stage	58	5[a]	2.96[a]	13[a]	9.3[a]
Eight to nine leaf stage	40	6.3[a]	3.7[a]	13.80[a]	11.6[a]
Control	—	6.8[a]	3.5[a]	13.6[a]	11.2[a]
LSD (0.05)		3.6	0.8	3.04	8.6

DISCUSSION

Several distinct viruses are known to infect potatoes under field conditions. Among the most important of these in Egypt are *Potato leaf roll virus (PLRV)*, *Potato virus Y (PVY)*, *Potato virus X (PVX)* (Shalaby, 1993, Gamal El-Din *et al.*, 1997 and Amer, 1999).

Limited surveys carried out in some potato producing regions of Alexandria and Bheira governorates revealed the occurrence of *Alfalfa mosaic virus (AMV)*, *Potato leaf roll virus (PLRV)* and *Potato virus Y (PVY)* in higher incidence than other viruses. Thus this work was directed to study the effect of infection with AMV, *PLRV* and *PVY* under field conditions on vegetative growth and productivity of potato cv. Spunta.

Growth and productivity parameters of potato plants were significantly reduced as a result of infection with *AMV, PLRV* and *PVY*.

The highest reduction in plant height was due to *PVY* infection and the lowest one was in plants infected with *PLRV*, Similar results were reported by Rahman *et al.* 2006, who found that the reduction in plant height ranged from 16.05-22.68 % and 27.87-35.12% for *PLRV* and *PVY* respectively.

The reductions in tuber number per plant were 61.7%, 63.7%, and 60.7% for *AMV, PLRV* and *PVY* respectively at 5-6 leaf stage while it was 15.2%, 4.5% and 24.3% at 8-9 leaf stage. Such results agreed with previous data of Rahman *et al.* 2006.

Tubers yield also was reduced in infected plants by 48.1-66.2%, 39.8-69.9% and 23.3-63.6% for *PLRV, AMV* and *PVY* respectively. These results are in line with those of Gupta *et al.* (1985) who found that yield infection with *PVY* and *PLRV* singly reduced potato yield up to 60-75% in India and Hoa *et al.* (1991) who reported that moderate infection and severe infection due to *PVY*, respectively, caused 49% and 61% yield loss in the Philippines under low land field condition. Also Hossain and Ali (1992) found that the yield loss due to *PVY* raised up to 95% with severe infection in Bangladesh. With 100% infection of *PLRV*, yield loss was recorded up to 78% (Hossain *et al.*, 1994) and only 30% infection with *PVY* in variety Cardinal may cause 35% yield loss (Hossain and Ali, 1993) in Bangladesh, while no significant change in tubers content of starch and total sugars. Our results also showed that infection with *AMV, PLRV* and *PVY* did not significantly reduce reducing and non-reducing sugars, starch and vitamin C contents of tubers.

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الملخص العربي

الفاقد الناتج عن الإصابة بفيروسات *Alfalfa mosaic virus (AMV)* ، *Potato leaf roll virus (PLRV)* و *Potato virus Y (PVY)* في البطاطس

محمد علي زاند[١] ، حسني علي يونس[٢] ، جابر إبراهيم فجلة[٣] ، أحمد محمود الجمل[٤] ، مرفت مصطفى فتح الله[٥]

١- قسم وقاية النبات ، كلية الزراعة ، جامعة طرابلس ، ليبيا
٢- قسم النبات الزراعي ، كلية الزراعة – سابا باشا ، جامعة الإسكندرية
٣- قسم أمراض النبات ، كلية الزراعة ، جامعة الإسكندرية.
٤- قسم النبات الزراعي ، كلية الزراعة – سابا باشا ، جامعة الإسكندرية.
٥- معهد أمراض النبات ، مركز البحوث الزراعية ، الإسكندرية.

باستخدام اختبار الإليزا غير المباشر وخمسة أمصال مضادة متخصصة لأهم فيروسات البطاطس ، تم اختبار وتحديد نباتات بطاطس صنف سبونتا مصابة طبيعياً بفيروس موزيك البرسيم *AMV* وفيروس إلتفاف أوراق البطاطس *PLRV* وفيروس البطاطس واي *PVY* في مرحلتين مختلفتين من النمو وذلك لدراسة تأثير العدوى بهذه الفيروسات على النمو الخضري والإنتاجية للنباتات المصابة .

كان هناك نقص معنوي وذلك بالنسبة للنمو الخضري من حيث متوسط ارتفاع النبات و متوسط عدد الأوراق بالنبات وكذلك متوسط الوزن الرطب والجاف للمجموع الخضري والجذري .

لوحظ نقص كبير في النباتات المصابة في مرحلة ٥-٦ أوراق وذلك بفيروس *AMV, PLRV* و *PVY* . وكذلك كان الأمر بالنسبة لدلائل الإنتاجية من حيث عدد الدرنات في النبات الواحد والمادة الجافة وحجم الدرنة.

كان انخفاض الوزن الجاف في الدرنات ٦٦,٢ و٤٨,١ % و ٦٩,٩ و٣٩,٨ % و ٦٣,٦ و ٢٣,٣ % في النباتات المصابة طبيعياً في مرحلة ٥-٦ أوراق و ٨-٩ أوراق على الفيروسات *PLRV, AMV* و *PVY* على التوالي .

لم يكن هناك أي أثر معنوي على المكونات الكيماوية للدرنات مثل السكريات المختزلة والغير مختزلة والنشا وفيتامين ج .