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Effect of late blight caused by *Phytophthora infestans* (Mont.) de Bary on calcium content in leaves of advanced potato lines/cultivars

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Minerals are the crucial part of plant nutrition and their presence in excess or deficiencies may cause certain maladies in the plants either through disturbing metabolism or plant physiology abnormally by favoring the plant pathogens or discouraging the plant growth. Potassium provides, stress such as frost and disease tolerance ability to potato plants. Calcium content was tested from three different samples taken at different times, first after 50 days of planting of the crop when there was no disease appeared while second samples were taken from healthy and diseased plant individually, almost 30 days after the first appearance of the symptoms on late blight. Results of present study revealed that there was an overall increase in the quantity of calcium in all tested lines after disease appearance. This increase was ranged from 0.4 to 45.5 percent over the healthy plants of that same age group. Maximum increase of 45.5 percent in calcium content after disease appearance was observed in potato line FD 70-1, while 0.4 percent decrease of calcium content was observed in line FD 35-36. Increase in calcium content was also observed in the healthy plants of all potato lines/cultivars which were not infected by the disease but this increase might be due to aging factor and was quit insignificant and unnoticeable. This increase in calcium content of diseased plant in all lines/cultivars was statistically significant. All though the calcium content was slightly increased in the plants which were not diseased than that of healthy plants which were tested at the time when disease was not appeared. It is apparent from the above figures that the increase in calcium content was more pronounced in moderately resistant to moderately susceptible plants as compared to highly susceptible plants.

Key Words: Potato, late blight, resistance, Calcium, *Phytophthora infestans,* mineral content, disease severity

INTRODUCTION

Solanum tuberosum is generally believed to have originated in the Andes region from central Peru to central Bolivia. From there, potato reached Europe, Asia and Africa (Poehlman and Slepper, 1995). Today potatoes have become an integral part of world's food and it became world's fourth largest food item after rice, wheat, and maize (Hijmans and Spooner, 2001). The average tuber yield of potatoes in the Pakistan is only 22.17 t/ha which is very low as compared to the developed countries of the world e.g. Netherlands 46.7, USA 46.27, UK 41.43 and Australia 36.18 t/ha (Swaminathan, 2000). Several factors can be responsible for low potato production in Pakistan including diseases and insect pests. Among diseases late blight is the most important one affecting potatoes (Dowley and O'Sullivan. 1994; Agrios, 2005). *Phytophthora infestans* (Mont.) de Bary, the causal organisms of the late blight disease of potato and tomato is the most important worldwide factor, limiting the production of potatoes worldwide.

Macro- and microelements have been known to be associated yield of crops both quantitatively and qualitatively and also changes the level of disease incidence (Rush *et al*., 1997). Late blight of potato not only causes the yield losses but also affect the accumulation/ depletion of different minerals from the foliage of the plants. The pathogen *Phytophthora infestans* (Mont.) de Bary is very aggressive and hinders the uptake of minerals from soil but also increase the accumulation/depletion of these minerals in the foliage. Minerals are the crucial part of plant nutrition and their presence in excess or deficiencies may cause certain maladies in the plants either through disturbing metabolism or plant physiology abnormally by favoring the plant pathogens or discouraging the plant growth (Sahi *et al.,* 2010). Phosphate application significantly increased the ground cover and leaf area index of potato plant (Ali and Anjum, 2004). Powdery mildew disease on *Dalberigia sissoo* seriously effects uptake potential and accumulation of these mineral nutrients nitrogen, phosphorus, magnesium, sulphur, zinc, ferrous, manganese and molybdenum (Thite, 2013). This study was carried out to assess the effect of late blight on the uptake and accumulation/depletion of calcium in foliage of potato lines/cultivars.

MATERIALS AND METHODS

Total 50 potato genotypes including 8 cultivars and 42 lines were grown under field conditions in during 2009-10 and 2010-11 seasons Department of Plant Pathology, University of Agriculture, Faisalabad, Punjab, Pakistan. The trial was conducted with plot of four rows of six meter length with 20 cm plant to plant and 60 cm row to row distance, in RCBD with four replications in winter season of 2009-10 and was repeated in 2010-11. Field was fertilized @ 250: 125: 125 NPK Kg h-1. First sampling was done 50 days after plantation of crop when there was no symptoms of disease, while second sampling was done around 30 days after the first appearance of the symptoms of late blight. In the second sampling healthy and diseased plants of each line/cultivars were collected and tagged separately. Collected samples were washed in 0.2 percent detergent solution to remove dirt from the leaf surfaces followed by washing in 0.8 percent HCl to remove metallic contaminants and deionized water to wash out remains of detergent and HCl solutions. These samples were air-dried for 2-3 days in the shade on the paper towels and then placed in paper bags. These air-dried samples were dried in an oven at 70 °C for 72 hours to get constant weight, and were ground with Buhler sample grinder and then processed for the determination of calcium content in leaf samples of potato lines, following protocol described earlier (Bhargava and Raghupathi, 1995). Calcium content was recorded as percentage of leaf dry weight.

RESULTS

The data regarding the change in the calcium content in the leaves of 50 potato lines/cultivars is given in Table 1. Results of present study revealed that there was an overall increase in the quantity of calcium in all tested lines after disease appearance. This increase was ranged from 0.4 to 45.5 percent over the healthy plants of that same age group. Maximum increase of 45.5 percent in calcium content after disease appearance was observed in potato line FD 70-1, while 0.4 percent decrease of calcium content was observed in line FD 35-36. Increase in calcium content was also observed in the healthy plants of all potato lines/cultivars which were not infected by the disease but this increase might be due to aging factor and was quit insignificant and unnoticeable. This increase in calcium content of diseased plant in all lines/cultivars was statistically significant. All though the calcium content was slightly increased in the plants which were not diseased than that of healthy plants which were tested at the time when disease was not appeared. It is apparent from the above figures that the increase in calcium content was more pronounced due to the effect of disease and there was no or very slight effect of aging was observed.

DISCUSSION

Although the mineral content was assayed for the whole shoot, yet it seems that if only topmost foliage would have been assayed, this would have given a clearer concept of the picture. Calcium is mainly important as a constituent of plant cell wall in the form of clacium pectate. If partly removed from the middle lamella, the cell plasticity is increased (Devlin and Witham, 1983). Lecourieux *et al*. (2006) reported that calcium plays important role in plant defence-signalling pathways which is not specific only to potato but described in all plants generally. It is then evident that plant deficient in calcium would have more plastic cells, which may render them more susceptible to different biotic as well as abiotic stresses. Increased cell plasticity may ease the entry of the pathogen into the host cells. The calcium content of

Table 1. Calcium (percent dry weight) contents of Potato lines/cultivars

Calcium							**Per cent increase over healthy plants**
Lines/ Cultivars	**Before disease appearance**		**After disease appearance**				
	Healthy Plants		**Healthy Plants**		**Diseased Plants**		
9619	0.45	ijklmno	0.47	fghijkl	0.60	abcd	22.1
CARDINAL	0.48	hijklmno	0.50	fghijkl	0.62	abcd	20.3
FD 1-10	0.61	abcdefghij	0.65	abcdefgh	0.68	abcd	3.4
FD 1-3	0.73	ab	0.74	abcd	0.77	abcd	3.5
FD 3-10	0.37	no	0.39	l	0.52	cd	24.4
FD 32-2	0.56	bcdefghijkl	0.59	bcdefghijk	0.63	abcd	7.4
FD 35-25	0.51	fghijklmno	0.53	defghijkl	0.58	bcd	8.6
FD 35-36	0.71	abcd	0.76	ab	0.77	abcd	0.4
FD 37-13	0.60	abcdefghik	0.63	abcdefgh	0.65	abcd	3.1
FD 3-9	0.56	cdefghijklm	0.60	bcdefghijk	0.68	abcd	12.3
FD 48-54	0.50	ghijklmno	0.53	efghijkl	0.62	abcd	14.5
FD 49-28	0.47	abcdefgh	0.49	abcde	0.62	abcd	20.0
FD 49-62	0.58	abcdefghijkl	0.61	abcdefghijk	0.71	abcd	14.2
FD 51-5	0.55	ijklmno	0.58	fghijkl	0.68	abcd	14.6
FD 51-6	0.54	defghijklm	0.59	abcdefghijk	0.68	abcd	14.1
FD 52-2	0.64	abcdefghi	0.67	abcdefg	0.79	abcd	14.8
FD 53-6	0.65	abcdefgh	0.68	abcdef	0.71	abcd	5.1
FD 56-1	0.41	abcde	0.45	abc	0.50	abcd	8.7
FD 53-7	0.69	lmno	0.62	ijkl	0.66	abcd	5.6
FD 61-3	0.46	ijklmno	0.49	fghijkl	0.59	bcd	15.9
FD 63-2	0.47	ijklmno	0.52	efghijkl	0.72	abcd	20.5
FD 63-4	0.65	a	0.69	a	0.78	a	12.0
FD 64-2	0.46	ijklmno	0.48	ghijkl	0.60	abcd	20.4
FD 65-4	0.62	abcdefghij	0.65	abcdefgh	0.73	abcd	11.4
FD 65-6	0.58	abcdefghijkl	0.64	abcdefghi	0.78	abcd	18.4
FD 69-1	0.66	abcdefg	0.68	abcdef	0.80	ab	14.6
FD 70-1	0.35	o	0.40	l	0.74	abcd	45.5
FD 71-1	0.72	abc	0.74	abcd	0.77	abcd	3.9
FD 76-59	0.45	jklmno	0.48	ghijkl	0.60	abcd	20.0
FD 8-1	0.59	abcdefghik	0.64	abcdefghi	0.70	abcd	8.1
FD 8-3	0.54	cdefghijklm	0.59	abcdefghijk	0.65	abcd	9.7
FSD RED	0.64	abcdefgh	0.69	abcde	0.76	abcd	9.2
FSD White	0.46	ijklmno	0.48	ghijkl	0.61	abcd	21.0
KARODA	0.38	mno	0.43	kl	0.54	bcd	27.9
MARATO	0.52	efghijklmn	0.57	defghijkl	0.68	abcd	15.8
N- 18	0.55	cdefghijklm	0.59	abcdefghijk	0.76	abcd	21.6
N- 22	0.68	abcdefgh	0.70	abcdef	0.80	ab	12.9
N- 30	0.74	abcdef	0.78	abcde	0.87	ab	10.4
N- 37	0.42	klmno	0.44	jkl	0.59	bcd	25.4
N- 8	0.64	abcdefghi	0.66	abcdefg	0.77	abcd	14.2
N-13	0.59	abcdefghijkl	0.62	abcdefghij	0.69	abcd	9.7
N-34	0.47	jklmno	0.49	hijkl	0.63	abcd	21.7
N-39	0.51	fghijklmno	0.53	efghijkl	0.81	ab	34.3
RODIO	0.62	abcdefghij	0.66	abcdefgh	0.77	abcd	14.7
SH- 692	0.56	abcdefghijkl	0.59	abcdefghijk	0.79	abc	24.6
SH 788	0.65	bcdefghijkl	0.68	abcdefghijk	0.81	abcd	15.7
SH-5	0.49	ghijklmno	0.55	efghijkl	0.80	ab	31.5
SH-704	0.41	lmno	0.44	jkl	0.59	bcd	25.0
SHANAN	0.57	bcdefghijkl	0.62	abcdefghij	0.72	abcd	13.5
SIPLY RED	0.57	bcdefghijkl	0.62	abcdefghij	0.72	abcd	13.5
CV	10.210%		10.215%		11.944%		

potato varieties/lines susceptible to blight was significantly lower than the resistant ones, which supports the above hypothesis. Same response in the lentil cultivars has already been reported against rust (Reddy and Khare, 1984). The pronounced increase in the calcium content of susceptible varieties/lines may be attributed to rapid and extensive growth, multiplication and sporulation of *P. infestans* in the susceptible potato varieties/lines as compared with the resistant ones.

The pronounced decrease in the calcium content of moderately resistant to moderately susceptible FD 70-1, N 34 and FD 63-2 lines may be attributed to rapid and extensive response ofplant to the growth and sporulation of *P. infestans* as compared to susceptible potato varieties/lines like FD 35-36 and N 39. More the quantity of Calcium present in the foliage more will be the resistance of the plant against the late blight of potato caused by *Phytophthora infestans* (Mont.) de Bary.

CONCLUSION

Calcium is the crucial part of plant nutrition and its presence deficiencies cause certain maladies in the plants either through disturbing metabolism or plant physiology abnormally by favoring the plant pathogens or discouraging the plant growth and its excess or optimum quantity enables the potato plant to tolerate frost and diseases stresses.

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