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Genotypic variations in potassium contents of potato leaves infested with late blight of potato incited by *Phytophthora infestans* (Mont.) de Bary

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Abstract: 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. Potassium 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 decrease in the potassium concentration of leaves in all tested lines after disease appearance. This decrease was ranged from 2.8 to 13.6 percent over the healthy plants of that same age group. Genotypes FD 8-1 , N-22 and SH 788 proved to be most susceptible genotype in term reduction in leaf potassium concentration by losing 13.6, 13.5 and 13.4 percent of potassium due to late blight infestation, while 2.8 percent decrease of potassium content was observed in line FD 32-2. Decrease in potassium content was also observed in the healthy plants of all potato lines/cultivars which were not infected by the disease but this decrease might be due to aging factor and was quit insignificant over the plants on which disease was not appeared and unnoticeable. This decrease in potassium content of diseased plant in all lines/cultivars was statistically significant. Although the potassium content was slightly decreased in the plants which were not diseased than that of healthy plants which were tested at the time when disease was not appeared. Decrease in potassium content was more pronounced due to the effect of disease and there was no or negligible effect of aging was observed.

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1. Introduction

Potato (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-1 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 tha-1 (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 crucial one in term of affecting potato production (Dowley and O'Sullivan. 1994; Agrios, 2005). *Phytophthora infestans* (Mont.) de Bary, the causal organisms of the late blight disease in potato and tomato is the most devastating pathogen worldwide, limiting the production of potatoes worldwide.

Macro- and microelements have been known to be associated with the both qualitative and quantitative aspects of crop yield and are also associated with the level of disease incidence (Rush et al., 1997). Late blight of potato not only causes the yield losses but also affect the accumulation or depletion of different minerals from the foliage of the plants. The pathogen *P. infestans* is very aggressive in nature and hinders the uptake of minerals from soil, moreover it also enhanced the depletion of these minerals in the plant. Minerals are the crucial part of plant nutrition and their toxicity or deficiency may cause certain maladies in the plants either through disturbing metabolism or by altering physiological functions of plants and ultimately plant become more

susceptible by favorable conditions for the plant pathogens or distressed plant growth (Sahi et al., 2010). Potassium has an important role in the control of the plant water status and ionic concentrations inside plant tissues, including stomata. As a result of the improved cell strength that potassium provides, stress such as frost and diseases can be better tolerated. (Ali and Anjum, 2004). Powdery mildew disease on *Dalberigia sissoo* seriously effects uptake potential and accumulation of mineral nutrients including nitrogen, phosphorus, potassium, magnesium, sulphur, zinc, ferrous, manganese and molybdenum (Thite, 2013). Present study was carried out to assess the effect of late blight on the uptake and accumulation/depletion of potassium in foliage of potato cultivars and promising lines.

2. 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 potassium content in leaf samples of potato lines, following protocol described earlier (Bhargava and Raghupathi, 1995). Potassium content was recorded as percentage of leaf dry weight.

3. Results

The data regarding the changes in the leaf potassium content of 50 potato lines/cultivars is given in Table 1. Results presented revealed that there was an overall decreasing trend in the leaf potassium concentration in all the tested potato genotypes after the appearance of late blight. This decrease was ranged from 2.8 to 13.6 percent over the healthy plants of that same age group of each genotype. Maximum decrease of 13.6, 13.5 and 13.4 percent in FD 8-1, N-22 and SH 788 in potassium content after disease appearance was observed in susceptible lines, while 2.8 and 4.0 percent decrease of potassium content was observed in the line FD 32-2 and Fsd white which were moderately resistant or moderately susceptible. Although slight decrease in leaf potassium content was also observed in the healthy plants which were not infected by the disease but this decrease might be due to aging factor and was insignificant. Whereas strong and statistically significant decreasing potassium content was detected in the leaves of plants infected with late blight of potato and this reduction was observed in all lines/cultivars. Although the potassium content was slightly decreased 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 decrease in potassium content was more pronounced due to the effect of disease and there was insignificant effect of aging was observed.

4. 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. Potassium is important for plants for the processes such as respiration, photosynthesis and chlorophyll development and is also a part of some important enzymes and coenzymes. Un-inoculated plants of resistant potato varieties/lines contained almost 250 percent of the potassium as that of susceptible ones, which even increased in the inoculated plants. In case of susceptible varieties/lines, the increase in potash as a result of inoculation with the pathogen was more pronounced than in case of resistant potato varieties/lines. These results comply with those of Randhawa (1994) and Reddy and Khare (1984). Potassium silicate treatment of inoculated plants of pepper showed increased root dry weight and number of fruits as compared to non-inoculated, untreated control Lee et al. (2004). Silveira et al. (2008) studied the effect of potassium silicate alone and mixed with fungicide found no significant effect on disease control when used alone and any additional benefit when mixed with fungicides. The control of root rot

of lettuce by potassium phosphonate in hydroponic culture before infection was over 94%, while it was less than 35% when applied after infection Jee *et al*. (2002).

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

Lines/ Cultivars	Leaf Potassium Concentration (%)						Percent change over healthy plants
	Before disease appearance (50 days after plantation)		After disease appearance (80 days after plantation)				
	Healthy Plants		Healthy Plants		Diseased Plants		
9619	2.90	ijklm	2.92	jklmn	2.56	jklmn	12.4
CARDINAL	1.68	r	1.68	tu	1.55	t	7.4
FD 1-10	1.55	s	1.57	u	1.42	u	9.6
FD 1-3	2.78	fghij	2.80	fghijk	2.64	efgh	5.7
FD 3-10	2.63	ijklm	2.61	klmno	2.30	lmno	12.0
FD 32-2	2.84	efgh	2.83	efghi	2.75	de	2.8
FD 35-25	2.91	ef	2.91	ef	2.78	de	4.5
FD 35-36	3.20	c	3.20	c	3.04	ab	5.0
FD 37-13	2.22	p	2.23	r	2.08	qr	6.6
FD 3-9	2.86	ijklm	2.84	klmn	2.57	jklmn	9.5
FD 48-54	2.55	klmn	2.56	lmnop	2.23	mnopq	12.9
FD 49-28	2.64	no	2.65	opq	2.34	opqr	11.6
FD 49-62	2.96	de	2.98	de	2.66	defg	10.9
FD 51-5	2.62	a	2.62	a	2.35	a	10.4
FD 51-6	2.36	o	2.37	q	2.22	mnopq	6.3
FD 52-2	3.09	cd	3.10	cd	2.96	bc	4.5
FD 53-6	2.80	efghi	2.79	fghijk	2.65	defg	5.1
FD 56-1	2.11	o	2.12	q	1.86	mnopq	12.4
FD 53-7	2.37	p	2.38	r	2.22	s	6.6
FD 61-3	2.71	ghijk	2.73	ghijkl	2.41	ijklm	11.7
FD 63-2	2.87	efgh	2.87	efgh	2.76	de	3.7
FD 63-4	2.42	ijklm	2.43	klmn	2.14	jklmn	12.1
FD 64-2	2.53	klmno	2.54	mnopq	2.22	mnopq	12.5
FD 65-4	3.36	b	3.38	b	3.07	ab	9.1
FD 65-6	3.09	cd	3.10	cd	2.94	bc	5.2
FD 69-1	3.16	c	3.17	c	2.82	cd	10.8
FD 70-1	2.70	hijk	2.71	hijklm	2.56	fghi	5.4
FD 71-1	2.22	p	2.24	r	2.09	qr	7.0
FD 76-59	2.41	no	2.42	pq	2.09	qr	13.6
FD 8-1	1.76	r	1.77	t	1.62	t	8.8
FD 8-3	2.84	efgh	2.85	efghi	2.72	def	4.8
FSD RED	2.77	fghij	2.80	fghijk	2.63	efgh	6.0
FSD White	2.61	jklm	2.63	klmn	2.33	klmn	11.3
KARODA	2.60	jklm	2.61	klmno	2.46	hijkl	5.9
MARATO	2.66	ijklm	2.68	jklmn	2.51	ghijk	6.2
N- 18	2.87	efg	2.89	efg	2.75	de	4.6
N- 22	2.43	lmno	2.44	mnopq	2.11	nopqr	13.5
N- 30	2.63	no	2.63	opq	2.35	pqr	10.5
N- 37	2.16	p	2.13	r	2.04	r	4.5
N- 8	3.31	b	3.31	b	3.00	b	9.4
N-13	3.36	b	3.37	b	3.03	ab	10.1
N-34	3.50	ef	3.51	ef	3.18	fghi	9.5
N-39	2.96	de	2.94	ef	2.82	cd	4.0
RODIO	2.55	klmn	2.57	lmnop	2.42	ijklm	6.0
SH- 692	2.66	ijklm	2.66	jklmn	2.50	ghijk	6.0
SH 788	2.52	efgh	2.53	efghi	2.19	fghi	13.4
SH-5	2.47	mno	2.49	nopq	2.35	jklmn	5.6
SH-704	2.65	ijklm	2.66	jklmn	2.52	ghij	5.1
SHANAN	1.96	q	1.98	s	1.82	s	7.8
SIPLY RED	2.43	no	2.44	opq	2.29	lmno	6.2
CV	2.518%		2.554%		2.879%		

The pronounced decrease in the potash content of susceptible FD 8-1, N22 and SH 788 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 lines FD 32-2 and N 39. More the quantity of Potassium 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.

5. Conclusion

Potassium 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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