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

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Total phosphorus 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 revealed that there was an overall increase in the quantity of phosphorus in all tested lines after disease appearance. This increase was ranged from 6.0 to 41.8 percent over the healthy plants of that same age group. Maximum increase of 41.8 percent in phosphorus content after disease appearance was observed potato line FD 64-3, while 6.0 percent increase of phosphorus content was observed in line SH 704. Increase in phosphorus 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. All though the phosphorus 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 phosphorus content was more pronounced due to the effect of late blight of potato and there was no or very slight effect of aging was observed.

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

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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 phosphorusin foliage of potato lines/cultivars.

MATERIALS AND METHODS

Total phosphorus 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. Potato leaf samples comprising of shoots from healthy plants were taken after 50 days of sowing. Then waited for the appearance of the disease naturally and sampling was done 30 days of disease appearance both from diseased and healthy ones separately. They were washed in 0.2 percent detergent solution in order to remove any dirt from them followed by washing in 0.8 percent HCl to remove metallic contaminants from them and deionized water to remove the previous two solutions. The samples were air-dried in the shade on paper towels and then placed in paper bags. The samples were dried in an oven at 70 °C for 72 hours to get constant weight. The dried samples were ground with Buhler sample grinder and then processed for the determination of phosphorus content in leaf samples of potato lines, following (Bhargava and Raghupathi, 1995). Phosphorus content was recorded as percentage of dry.

RESULTS

The data regarding the change in the phosphorus 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 phosphorus in all tested lines after disease appearance. This increase was ranged from 6.0 to 41.8 percent over the healthy plants of that same age group. Maximum increase of 41.8 percent in phosphorus content after disease appearance was observed potato line FD 64-3, while 6.0 percent increase of phosphorus content was observed in line SH 704. Increase in phosphorus 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 quite insignificant and unnoticeable. Although the phosphorus 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 phosphorus content was more pronounced due to the effect of late blight of potato and there was no or very little change in phosphorus content of healthy plant was observed which may be due to the effect of aging.

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. Phosphorus is utilized by the plants for the formation of nucleic acids, phospholipids, the coenzymes NAD and NADP, ATP and other high-energy compounds (Devlin and Witham, 1983). The phosphorus content although higher in un-inoculated plants of susceptible potato varieties/lines than the resistant ones, yet it decreased, as a result of inoculation with *Phytophthora infestans* while it increased in the resistant potato lines. Depletion of phosphorus in susceptible potato lines may be due to increased but disrupted respiration. But the increase in phosphorus content in resistant potato lines indicates intact and consistent uptake and translocation of this mineral. Phosphate application significantly increased the ground cover and leaf area index of potato plant (Ali and Anjum, 2004). On the other hand, Reddy and Khare (1984) reported decreased phosphorus in lentil cultivars both

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

Percent Phosphorus						Per cent increase over healthy plants
Lines/ Cultivars	Before disease appearance		After disease appearance			
	Healthy Plants		Healthy Plants		Diseased Plants	
9619	0.26	abcde	0.25	a	0.31 ijklmn	19.3
CARDINAL	0.26	abc	0.25	a	0.34 no	27.9
FD 1-10	0.20	abcdefghi	0.21	a	0.29 ghijkl	25.6
FD 1-3	0.21	abcdefgh	0.21	a	0.28 bc	27.1
FD 3-10	0.18	bcdefghi	0.18	a	0.26 s	30.4
FD 32-2	0.25	abcde	0.25	a	0.33 fghi	22.4
FD 35-25	0.24	abcdefg	0.24	a	0.32 jklmn	23.2
FD 35-36	0.16	efghi	0.19	a	0.23 q	19.6
FD 37-13	0.17	defghi	0.18	a	0.25 ijklmn	27.0
FD 3-9	0.15	a	0.19	a	0.23 fghij	17.6
FD 48-54	0.16	efghi	0.18	a	0.23	20.6
FD 49-28	0.25	fghi	0.26	a	0.36 fghij	28.3
FD 49-62	0.25	abcde	0.23	a	0.34 b	31.4
FD 51-5	0.28	abcdef	0.24	a	0.38 defg	37.5
FD 51-6	0.26	abcd	0.22	a	0.33 d	32.4
FD 52-2	0.24	abcdefg	0.26	a	0.32 o	16.8
FD 53-6	0.20	abcdefghi	0.22	a	0.25 c	11.8
FD 56-1	0.15	bcdefghi	0.16	a	0.23 de	27.6
FD 53-7	0.19	fghi	0.20	a	0.27 r	25.0
FD 61-3	0.21	abcdefgh	0.19	a	0.32 ghijkl	40.0
FD 63-2	0.21	abcdefgh	0.20	a	0.28 efgh	27.4
FD 63-4	0.15	hi	0.20	a	0.25 b	18.9
FD 64-2	0.20	abcdefghi	0.18	a	0.30 q	41.8
FD 65-4	0.17	cdefghi	0.16	a	0.27 klmno	41.2
FD 65-6	0.27	ab	0.25	a	0.34 p	28.2
FD 69-1	0.15	ghi	0.19	a	0.21 def	12.5
FD 70-1	0.22	abcdefgh	0.21	a	0.30 r	29.7
FD 71-1	0.21	abcdefgh	0.24	a	0.28 a	13.0
FD 76-59	0.21	abcdefgh	0.22	a	0.29 de	24.1
FD 8-1	0.22	abcdefgh	0.20	a	0.30 klmno	32.6
FD 8-3	0.26	abcd	0.25	a	0.33 ijklmn	26.0
FSD RED	0.20	abcdefghi	0.20	a	0.27 def	28.0
FSD White	0.19	bcdefghi	0.21	a	0.25 o	18.4
KARODA	0.26	abcd	0.25	a	0.33 de	25.0
MARATO	0.19	abcdefghi	0.18	a	0.27 ghijk	32.7
N- 18	0.20	abcdefghi	0.22	a	0.28 defg	21.1
N- 22	0.20	bcdefghi	0.18	a	0.29 def	36.0
N- 30	0.14	abcdefghi	0.16	a	0.24 c	33.8
N- 37	0.17	bcdefghi	0.16	a	0.25 mno	35.3
N- 8	0.20	abcdefghi	0.19	a	0.27 no	27.3
N-13	0.18	bcdefghi	0.22	a	0.27 d	18.4
N-34	0.25	abcd	0.28	a	0.31 lmno	10.3
N-39	0.19	abcdefghi	0.21	a	0.25 r	18.0
RODIO	0.15	fghi	0.14	a	0.22 hijklm	35.4

Continuation of Table 1

SH- 692	0.19	bcdefghi	0.18	a	0.28	fghij	36.5
SH 788	0.18	fghi	0.20	a	0.25	fghi	18.9
SH-5	0.18	bcdefghi	0.19	a	0.25	s	26.3
SH-704	0.17	bcdefghi	0.21	a	0.22	no	6.0
SHANAN	0.22	abcdefgh	0.23	a	0.30	fghi	21.1
SIPLY RED	0.11	i	0.20	a	0.22	no	9.8
CV	14.382%		20.164%		1.645%		

resistant and susceptible to *Uromycesfabae* but Randhawa (1994) and Sahi*et al*., (2010) reported increase in phosphorus in case of chickpea cultivars both susceptible and resistant against infection by *Ascochytarabiei*.

In conclusion, although there was some changes in nitrogen content in foliage of healthy plants from first samples but these were not significant which may be due aging but the presence of much higher nitrogen content in the diseased foliage was definitely due to the presence of late blight infection which could be exploited for better disease management in future.

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