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Chlorophyll fluorescence measurements as indicators of fusariosis severity in tomato plants

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Abstract. In these experiments the pathogenicity of *Fusarium oxysporum* populations was investigated. Disease index for inoculated plants was compared to chlorophyll fluorescence parameters measured with the fluorometer PAM. For most of the isolates of higher pathogenicity, the disease index was correlated with the decrease of photosynthetic activity of plants. However, in some cases the damage to the photosystem was more severe than external disease symptoms indicated, suggesting that chlorophyll fluorescence measurements might be helpful in early evaluation of the severity of *F. oxysporum*.

Key words: *Fusarium oxysporum*, tomato, chlorophyll fluorescence

INTRODUCTION

Fusarium oxysporum is one of the most important pathogens of tomato grown in fields and under cover. The chemical control of this pathogen is difficult, so other methods inducing soil suppression are recommended. One method is growing vegetables with cover crops, especially in the form of mulches, as they can have an inhibitory effect on soil-borne disease occurrence (Wyland et al., 1996). The increase in soil suppression can also be the result of changes in pathogenicity of *F. oxysporum* populations (Jamiolkowska & Wagner, 2003). Therefore we estimated pathogenic abilities of populations isolated from fields with and without cover crops.

The severity of fusariosis does not always manifest itself in the form of necrosis or wilting, especially at early stages of plant growth, but can affect the process of photosynthesis (Pospieszny & Struszczyk, 2003). Chlorophyll fluorescence is an indicator of photosynthetic performance of plants (Maxwell & Johnson, 2000). The aim of our trials was to determine correlations between pathogenic abilities of tested isolates and the photosynthetic capacity of infected plants, determined with the values of effective quantum yield of PSII.

MATERIALS AND METHODS

Inoculation tests of *F. oxysporum* isolates were carried out in 2003 and 2004 in a growth chamber at a temperature of 23–24°C and 85% air humidity. The first

experiment consisted of 23 and the second, of 27 combinations (including controls), with 20 seedlings in each combination. Seedlings were inoculated with individual isolates according to Manka's method (1989). After four weeks the disease index was computed with McKinney's formula (Lacicowa, 1968) and analysed with Duncan's test.

The effective quantum yields of PSII (ΔF/Fm) were measured with the PAM – 2000 fluorometer (Walz GmbH, Germany). For this test, living leaves with the same orientation to light and the same position on plants were selected. Results were analysed with Duncan's test.

RESULTS AND DISCUSSION

In all the combinations with *F. oxysporum* the seedlings showed some disease symptoms. Some plants were stunted, with yellowing, reduced leaves and necrotic spots on stem base and roots. There were differences in disease index values between the first and second experiment.

In the first experiment the disease index was as high as 100 for the isolates K41, K127 and K27. Those isolates caused pre-emergence damping-off of all the seedlings. All isolates were pathogenic to tomato plants, many showing very high pathogenicity. The isolates collected from the soil with rye mulch amendment were slightly less pathogenic (Table 1).

In the experiment carried out the next year the differences in pathogenicity between the isolates were less pronounced. No isolate caused 100% pre-emergence damping-off and the highest disease index reached 92%. The disease index of two isolates did not differ significantly from that the control combination. Similarly, more isolates from the conventionally cultivated soil were more pathogenic (Table 1).

Measurements of chlorophyll fluorescence indicated a negative effect of pathogens on the photosynthesis process. However, in the first experiment the values of effective quantum yield of PSII (ΔF/Fm) did not differ significantly from the control in the combinations with the isolates R12 and R18, even if there were differences in disease index. For isolates of disease index amounting to 87% or higher, the values of ΔF/Fm were zero on the fluorometer scale, which meant that the photosystem was destroyed and these plants had no chance of recovery. In the second experiment all values of photochemical quantum yield were significantly different from that of control, indicating more severe damage to plants than was manifested by disease symptoms. In one case (isolate R19) ΔF/Fm was significantly higher than that of other isolates of similar disease index, which may suggest that the pathogen caused only superficial lesions and the seedlings would be able to recover.

Results showed that *F. oxysporum* populations from fields with rye mulch were less pathogenic; that was also confirmed by chlorophyll fluorescence measurements. Other reports also describe the negative effect of fungal infection on fluorescence parameters (Paulech & Bacigalova, 1978, Bowden et al., 1990). Root pathogens can affect several physiological processes, such as water absorption or gas exchange, resulting in the decrease of the photosynthetic capacity of the plant. Chlorophyll fluorescence measurements can help in determining the health status of a plant before any disease symptoms appear (Santos et al., 2000).

Table 1. Effect of *F. oxysporum* on health status and chlorophyll fluorescence in tomato.

1st experiment			2nd experiment		
Isolate	Disease index	ΔF/Fm	Isolate	Disease index	ΔF/Fm
Control	3	0,790	Control	0	0,770
R12	45	0,769	R38	11	0,601
R18	46	0,765	R77	14,5	0,637
R2	68	0,738	R8	21,5	0,662
K44	69	0,752	R4	26,5	0,696
R28	76,5	0,738	R33	34	0,682
R7	77,5	0,707	K1	43	0,585
K14	80,2	0,654	R66	44	0,551
R52	84,2	0,602	R11	44,2	0,538
R35	85,7	0,434	K102	45	0,547
R17*	87		K5	45	0,538
K55	89		K81	46	0,557
R47	90,5		K111	46	0,539
K28	91		R19	46	0,599
R57	92		R22	50	0,566
R59	92,5		R13	51,2	0,537
R43	94,5		K103	58,5	0,538
K62	94,7		K6	70,5	0,530
K78	95		R11	71	0,567
K66	97,5		K77	72	0,435
K41	100		R12	75,5	0,452
K127	100		K22	76	0,410
K27	100		R5	79	0,456
			K104	83,5	0,418
			K13	86	0,399
			K19	87,5	0,354
			K10	92	0,343
	$LSD_{0,05}$ - 8,53	$LSD_{0,05}$ - 0,035		$LSD_{0,05}$ - 12,57	$LSD_{0,05}$ - 0,061

*For isolates from R17 through K27 the fluorometer did not to show any values
K – isolates obtained from soil cultivated conventionally
R – isolates obtained from soil with rye mulch
ΔF/Fm – quantum yield of PSII

CONCLUSIONS

The differences in pathogenic abilities of tested isolates confirm the biodiversity of *Fusarium oxysporum* populations. On average, the isolates from the first experiment showed higher pathogenicity than those from the second one.

The values of the quantum yield of PSII were negatively correlated to disease index in most combinations, proving that the pathogen had a damaging effect on the photosystems of the plants. The values of ΔF/Fm decreased significantly even in plants with low or medium disease index, suggestingthat chlorophyll fluorescence measurements might be used for early detection of fungal infection.

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