Comparison of disease resistance to chemical control in preventing yield losses from powdery mildew in peas

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Abstract

In the present study, we determined the effect of genetic resistance, compared to chemical treatment, on preventing yield reductions due to powdery mildew caused by Erysiphe polygoni DC; Syn. E. pisi DC. Pea near isogenic lines with the er gene for resistance to powdery mildew were compared to their susceptible counterparts over two year period (1986 and 1987) at Pullman, Washington. Powdery mildew occurred naturally and caused serious damage in the non treated plots of the susceptible lines. Resistant lines and chemically treated lines remained free of the disease. Resistant near isogenic lines yielded 11 to 44 % more than the susceptible lines. Disease resistance controlled powdery mildew as effectively as fungicide applications and was equivalent to chemical control in preventing yield losses resulting from the disease.

Keys Words : powdery mildew of peas, near-isogenic lines, genetic resistance, yield loss assessment

Résumé : Comparaison de la résistance génétique au contrôle chimique dans la prévention des pertes de rendement par l'oïdium du pois

Dans la présente étude, nous avons déterminé l'effet de la résistance génétique, comparée au traitement chimique, sur la prévention des pertes en rendement du pois dues aux attaques par l'oïdium causé par Erysiphe polygoni DC ; Syn. E. pisi DC. Des lignées presque iso-géniques contenant le gène er de résistance à l'oïdium ont été comparées à des lignées homologues sensibles. La maladie qui a apparu naturellement avait causé d'importants dégâts dans les parcelles non traitées des lignées sensibles. Par contre, les lignées résistantes ainsi que les lignées sensibles traitées par le fongicide Bayleton restaient très propres. Les lignées résistantes

ont produit 11 à 44 % plus que les lignées sensibles non-traitées. La résistance génétique a contrôlé la maladie aussi efficacement que le traitement chimique.

Mots clés : oïdium du pois, *Erysiphe polygoni pisi,* lignées presque iso-géniques, résistance génétique, estimation des pertes.

ملخص : مقارنة المقاومة الوراثية و المكافحة الكيماوية في الحد من أثر مرض البياض الدقيقي على إنتاج البازلاء (الجلبان)

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تبين من خلال هذه الدراسة أن المقاومة الوراثية للنبات، مقارنة مع المكافحة الكيماوية، تحد بشكل فعال من الإتلاف الذي يسببه مرض البياض الدقيقي (*Erysiphe polygoni* DC.*E.pisi* DC) في إنتاج البازلاء (*Pisum sativum*). عندما قارنا سلالات تحمل المورث er الخاص بمقاومة البياض الدقيقي مع سلالات شبه موازية لها وراثيا (near-isogeniques) و لكن حساسة لنفس المرض، ظهر أن المرض قد أصاب القطع الأرضية المزروعة بالسلالات الحساسة الغير المحمية كيماويا، بينما ظلت كل القطع سليمة التي تحمل السلالات المقاومة أو السلالات الحساسة المحمية بالمبيد الفطري بايلتون (Bayleton) كما أن السلالات المقاومة قد أنتجت من 11 إلى 44 % أكثر من السلالات الحساسة الغير المحمية.
و هكذا فإن المقاومة الوراثية تحمي النبات من الإصابة بالمرض بنفس الفعالية التي توفرها المكافحة الكيماوية.

الكلمات المفتاحية : البياض الدقيقي، المقاومة الوراثية، المكافحة الكيماوية

Introduction

Powdery mildew, caused by *Erysiphe polygoni* DC (syn. *E. pisi* DC) is an important disease in many pea producing countries including the USA (Muehlbauer, 1987) and Morocco (El Guili, 1987). Seed yields and quality can be severely reduced, especially in late maturing and late planted crops. In Wisconsin, USA, yields of unprotected plots were reduced by 44 to 71 % when compared to plots protected with a fungicide (Gritton and Ebert, 1975). Before the use of powdery mildew resistant cultivars, the disease was the principal factor limiting the development of late-planted peas in France (Cousin, 1965).

The use of resistant cultivars constitutes the least expensive, easiest, and most environmentally sound means of controlling powdery mildew of pea, in addition to the great beneficial effect in improving yield. Increase in seed yield of up to 96 % can be obtained with genetic resistance (Gritton, 1972).

Resistance to powdery mildew has been widely investigated (Harland, 1948 ; and Marx, 1971, 1974 and 1986) and several sources of resistance have been identified. These include the cultivars 'Strategem' (Pierce, 1948) and 'Mexique 4' (Harland, 1948). Resistance was first

described as being controlled by a single recessive gene (Harland, 1948) ; however, later evidence suggested that two genes might be involved in resistance (Heringa et al., 1969). Gritton (1972) and Gritton and Ebert (1975), using isogenic lines, demonstrated the benefit of resistance in preventing yield and quality losses. The objectives of this study were : (1) to determine the effects of genetic resistance on yield and (2) to compare chemical control with disease resistance for preventing losses from the disease.

Material and methods

Near-isogenic lines development

Isogenic lines were developed using individual heterozygous selections up to the F4. Selfing of individual heterozygous F4 plants produced progenies in the F5 that segregated for resistance to powdery mildew. Selections were then made, on an individual plant basis, for lines resistant or susceptible to the fungus. Uniformity of resistance or susceptibility was verified by F6 progeny tests. Lines uniformly resistant were considered near isogenic to susceptible lines chosen from the same F5 segregating progenies.

Field experiment

An experiment comparing near-isogenic lines within five crosses for resistance to *E. pisi* (Table 1) was conducted at the Washington State University Spillman Farm during 1986 and 1987. A split-plot randomized complete block design with two replications in 1986 and 4 replications in 1987 was used. The five crosses were considered the main plot factor, while the sub-plots consisted of four combinations of isogenic lines and fungicide applications using Bayleton (common name Triadomifor, Mobay Chemical Co.). These combinations are as follows : SU : susceptible lines without chemical treatment, ST : susceptible lines with chemical treatment, RU : resistant lines without treatment, and RT : resistant lines with treatment. The effect of genetic resistance on powdery mildew was estimated by comparing RU to SU, while comparison of ST with SU was used to estimate the depressing effect of powdery mildew on yield. RU and ST served to compare genetic resistance to chemical treatment in controlling powdery mildew. RT with ST served to determine if genetic resistance had any adverse effect on yield.

The experiment was planted relatively late (1 June, 1986 and 4 May, 1987) to improve the likelihood of uniform disease development. Days to flowering and days to maturity were recorded. The first fungicide treatment was applied at the rate of 0.15 kg a.i./ha on 22 July and 7 July in 1986 and 1987, respectively. Subsequent applications were made 10 days later in both years. Powdery mildew incidence was evaluated visually using the scale of 0 (healthy) to 5 (100 % infected) developed by Munjal et al. (1963). Plots were harvested for seed yield and data were subjected to analysis of variance. Treatment means were compared at the 0.05 and

0.01 probability levels using the orthogonal contrasts. For the crosses having more than one resistant or susceptible line (Table 1), only the mean values of those lines were considered in the data analysis.

Table 1. Near-isogenic lines and corresponding parents

	Near-isogenic lines			
	Line	Disease*	Parents	
Crosses	Number	reaction	Resistant	Susceptible
XB80F042	PS5101344	R	WV341F	Grenada
(C1)	PS510583	R		
	PS414010	S		
	PS510587	S		
XB80F044	PS5101261	R	WV341F	WA77-1
(C2)	PS5101252	S		
XB80FO47	PS410134	R	WV341F	AG264C
(C3)	PS314175	S		
	PS510153	S		
XB78F108	PS410017	R	WV341F	IMPCS
(C4)	PS410014	S		
XS76F038	PS410042	R	WV341F	WA110-42
(C5)	PS312027	R		
	PS010420	S		

* R : Resistant, S : Susceptible

Results and discussion

Disease development

Powdery mildew began to develop in both years when the plants were in the early pod-filling stage. Symptoms on susceptible non protected plants first appeared as small whitish spots on the upper surface of the lower leaves. The disease soon spread to upper parts of the plants including leaves, stems, pods and flowers causing a heavy infection. The untreated susceptible near-isogenic lines became heavily infected with *E. pisi.* They received disease scores as high as 5, especially in crosses C2, C3, and C4 (Table 2), while the resistant and chemically-protected lines remained free of the disease or showed only a few small lesions which later disappeared. Their scores did not exceed 1 (Table 2), which confirms the effectiveness of genetic resistance and chemical treatment in controlling the disease. Because of their early

maturity, the susceptible lines of crosses C1 and C5 did not show heavy disease infection as compared to those of C2, C3 and C4 (Table 2).

Table 2. Average disease score and reaction of treated and untreated near-isogenic lines of pea to *Erysiphe pisi* infection in 1986 and 1987

Cross	Near-isogenic lines	Disease[1] reaction	Parents		Average Disease Score[2]			
			Resist.	Suscept.	Treated		Untreated	
					1986	1987	1986	1987
C1	PS5101344	R	WV341F	Grenada	0.3	0.2	1.1	0.1
	PS510583	R			0.1	0.2	0.5	0.3
	PS414010	S			1.0	1.1	2.1	3.2
	PS510587	S			0.9	0.8	1.7	3.1
C2	PS5101261	R	WV341F	WA77-1	0.1	0.2	0.6	0.9
	PS5101252	S			0.8	1.1	4.8	4.9
C3	PS410134	R	WV341F	AG264C	0.2	0.8	1.0	1.0
	PS314175	S			0.8	1.0	5.0	4.9
	PS510153	S			0.2	0.8	4.1	5.0
	PS410017	R	WV341F	IMPCS	0.5	0.1	1.5	1.1
	PS410014	S			1.0	1.1	4.9	5.0
C5	PS410042	R	WV341F	WA110-42	0.0	0.1	0.2	0.2
	PS312027	R			0.2	0.0	0.1	0.1
	PS010420	S			0.1	0.1	3.2	2.3
Average		R			0.2	0.3	0.6	0.5
		S			0.7	0.7	3.8	3.8

[1] R = Resistant, S = Susceptible (based on previous field studies)

[2] Disease scored on a scale from 0 = no infection to 5 = severe infection ; 1 = trace infection with less than 10 % of the leaves, stems and pod surfaces covered with mycelia ; 2 = occasional infection with 10 % of leaf area covered with mycelia ; 3 = mycelia covering up to 50 % of the surfaces of leaves, stems and pods ; 4 = mycelia covering from 50-80 % of the surfaces of leaves, stems and pods, obvious damage to the plants ; 5 = all surfaces of leaves, stems and pods covered with mycelia, severely damaged plants.

Effect of powdery mildew on yield

Comparisons of fungicide-treated plots with the untreated plots of the susceptible lines (ST - SU) indicated significant yield reductions as a result of the disease (Table 3). Except for C1 in 1986 and C5 in 1987, powdery mildew infection reduced yields significantly in the untreated susceptible lines in both years and for all crosses. Yield reductions ranged from 11 to 44 % in 1986 and from 21 to 41 % in 1987, with an average of 27 % over the two years. Larger yield reductions were observed with late maturing crosses ; C3 and C4. This pronounced effect of powdery mildew on the late maturing material was similar in magnitude to that found by Gritton and Ebert (1975).

The effect of genetic resistance

The comparison of resistant and susceptible near-isogenic lines (RU - SU) served to estimate the effect of genetic resistance on preventing yield losses from powdery infection. Mean yields of the resistant lines were 720 kg/ha (29 %) and 1012 kg/ha (41 %) greater than their susceptible counterparts in 1986 and 1987, respectively (Table 3). The largest yield increases were obtained from resistant lines of C3 and C4 for which the untreated susceptible lines were heavily affected by the disease.

Table 3. Yield (kg/ha) of resistant and susceptible pea lines near-isogenic for resistance to E. *pisi* at Pullman, Washington, in 1986 and 1987

	Crosses					
Treatment	C1	C2	C3	C4	C5	Mean
			1986			
Susceptible lines :						
- Treated (ST)	2903	3444	3614	3189	3756	3381
- Untreated (SU)	2519	2566	2011	2006	3350	2490
ST - SU	384	878**	1603**	1183**	406**	891**
% Reduction	13	25	44	37	11	26
Resistant lines :						
- Treated (RT)	2763	3405	3521	3222	3783	3339
- Untreated (RU)	2897	2938	3666	2849	3700	3210
Difference (RT - RU)	-134	467	-145	373	83	129
RT - ST	-140	-39	-93	33	27	-42
RU - SU	378	372**	1655**	843**	350**	720*
% Reduction	15	15	83	42	10	29
			1987			
Susceptible lines :						
- Treated (ST)	3030	3320	3575	3367	3906	3439
- Untreated (SU)	2091	2558	2562	2018	3054	2456
Difference (ST - SU)	939**	762**	1013**	1349**	852	983**
% Reduction	31	22	28	41	21	28
Resistant lines :						
- Treated (RT)	2717	3065	3751	3505	4396	3502
- Untreated (RU)	2989	2998	3883	3628	3848	3469
Difference (RT - RU)	-272	67	-132	-123	548	33
RT - ST	-313	-255	176	138	490	63
RU - SU	898**	440	1321**	1610**	794	1013**
% Reduction	43	17	52	80	26	41

*, **: Significant at 5 %, significant at 1 % probability levels, respectively.

When yields of resistant lines (ST) were compared to chemically protected susceptible lines (RU), no significant differences were observed (Table 3), indicating that resistance has controlled the disease as effectively as the chemical treatment. Also, no significant differences in yield

were observed when resistant near-isogenic lines and their susceptible counterparts were compared under disease-free conditions (RT - ST). This indicates that yield in the absence of powdery mildew was not depressed through pleiotrophic gene action or undesirable genetic linkages, and is in agreement with results of Gritton (1972).

The marked effect of powdery mildew on pea yields in late maturing peas reported by other investigators (Gritton and Ebert, 1972 and Laxman et al., 1978) was confirmed in the present study where yields of untreated plots of the late maturing lines were reduced 44% as compared to only 11 % of the untreated plots of the early maturing lines (Table 3). Although powdery mildew of pea can be controlled through early planting of late maturing peas, it is not always possible to plant pea crops that early because of either the unfavorable climatic conditions or other factors such as the need for planting other priority crops. In addition, late maturity characteristics, cool seasons and good moisture conditions often combine to delay maturity and help to bring about the onset of powdery mildew when inoculum is present.

Conclusion

Based on the results of this study, resistance to *E. pisi* can control powdery mildew and consequently improve yields substantially without adverse effects. The comparison of fungicidal control with genetic resistance indicated that both methods were essentially equivalent in preventing yield reductions from the disease. Because of the effectiveness and multiple advantages of resistance over chemical applications, it should be the preferred means of control of powdery mildew. Resistance was effective both for early and late maturing genotypes, but, more beneficial for the latter.

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