PLANT BREEDING AND SEED SCIENCE
Volume 65 2012

DOI: 10.2478/v10129-011-0050-x

Lech Boros

Plant Breeding and Acclimatization Institute – National Research Institute, Radzików,
05-870 Błonie, Poland, e-mail: l.boros@ihar.edu.pl

EVALUATION OF STABILITY OF FIELD PEA GENOTYPES IN RESPONSE TO *MYCOSPHAERELLA PINODES* INFECTION

ABSTRACT

Interaction of genotypes with environment for quantitative traits among them certain disease resistance makes difficult choice of proper genotypes for breeding proposes and may affects further cultivation effects. The aim of this study was assessment of stability of reaction to *Mycosphaerella pinodes* infection for the set of pea genotypes in four years field experiments with vary epidemic pressure. The Sheffé-Caliński mixed model and the Caliński-Kaczmarek joint regression model for genotype-environment interaction analysis was applied. Tested pea genotypes were grouped into two categories; responding stable to *M. pinodes* (reacting proportionally to changed environment) and unstable ones (showing significant interaction with environment). The unstable genotypes reacted irregularly to environments (not able to describe the reaction to *M. pinodes* by any linear regression function). Pea genotypes PI 142441, PI 142442, PI 404221, PI 413691, cv. Radley and Bohun were characterized by high negative main effects (most resistant) for disease severity and showed stable response to *M. pinodes* infection. Stability of mycosphareallа blight reactions was not associated with the level of resistance in the cultivars tested.

Key words: field pea, genotype-environment interaction, Mycosphareallа blight, stability

INTRODUCTION

Mycosphareallа blight is an important yield constrains of pea worldwide. According to Marcinkowska (1996 and 2002) *M. pinodes* was prevalent on pea in several regions of Poland. The disease is apparent as a severe foliar blight and foot rot, causing yield losses. The yield losses in commercial pea fields were estimated from 10% to 20%, but in some trials were also over 50% (Xue *et al.*, 1997; Xue and Warkentin, 2001; Boros and Wawer, 2007). Using host resis-

---

Communicated by Henryk J. Czembor

tance is the most economical means in managing the disease. No complete resistance to *M. pinodes* has been identified in peas; however sources of partial resistance have been identified and are being used in breeding programme (Tivoli *et al.* 2006). In field pea, Bretag *et al.* (2000) found that disease severity varied considerably between years, regions and fields in the same region and was attributed to differences in climatic conditions and in the availability of inoculum.

Since the inheritance of resistance to *M. pinodes* is quantitative traits controlled by multiple genes (Pirioul-Gervais *et al.* 2007; Zhang *et al.* 2007), and expression of resistance is substantially influenced by environment (Worth 1999; Zhang and Gossen 2007) we decided to assess stability of reaction to *M. pinodes* infection of some partial resistant accessions in comparison with some commercial pea cultivars under field conditions with vary epidemic pressure.

MATERIALS AND METHODS

Field studies were conducted in 2005-2008. Twenty one field pea genotypes, among them commercial cultivars, partially resistant accessions from USDA-ARS collection (PI 142441, PI 142442, PI 381132, PI 404221 and PI 413691) and cv. Radley were used for these tests. Peas were grown on two–row 20 cm spaced plots, 1.5 m long with 100 plants per plot and 50 cm between plot spacing with three replications. Prior to flowering plants were inoculated with *M. pinodes* ($2 \times 10^6 \times ml^{-1}$). Control plots were sprayed with fungicide Bravo. Disease severity was assessed with 0-9 scale (Xue *et al.* 1996) where increasing scores represent higher disease severity and disease development higher in the plant canopy. The Sheffé-Caliński mixed model and the Caliński-Kaczmarek joint regression model for genotype-environment interaction analysis was applied (Madry and Kang 2005). Statistical analysis were performed with statistical package SERGEN 3 (Caliński *et al.* 1998).

RESULTS AND DISCUSSION

Analysis of variance of pea accessions across environments for major agronomic traits revealed significant differences among cultivars, environments, and their interactions (G × E). Table 1 contains a summary of the mean cultivar values across four environments for major agronomic traits among them infection with *M. pinodes* and corresponding to infection scores, seed yield reduction. In each environment, significant differences among cultivars were found for all parameters measured. The environmental diversity is shown in the disease score means (Table 1) among four environments which ranged from 3.09 in 2008 to 4.93 in 2007 growing season. Significant differences among environments indicate that the cultivars were exposed to and evaluated at significantly different disease levels. A mean yield losses ranged from 8.7 to 14.5% in comparison to fungicide protected combination. An average seed yield reduction due to *M. pinodes* in this study was lower than that of previous experiments (Boros and Marcinkowska 2010).

Table 1

Environment mean values over cultivars and replications for disease severity and agronomic parameters from 2005-2008.

Years	Vegetation [days]	Plant height [cm]	Lodging [0-9 scale]	Disease severity [0-9 scale]	Seed yield/ plot [g]	Seed yield reduction [%]
2005	98	75.8	6.57	4.22	0.37	12.08
2006	89	75.3	5.52	4.83	0.31	14.46
2007	90	67.5	4.55	4.93	0.23	11.16
2008	89	62.6	5.42	3.09	0.27	8.71
LSD $_{0.05}$	0,5	2.4	0.28	0.17	0.01	1.82

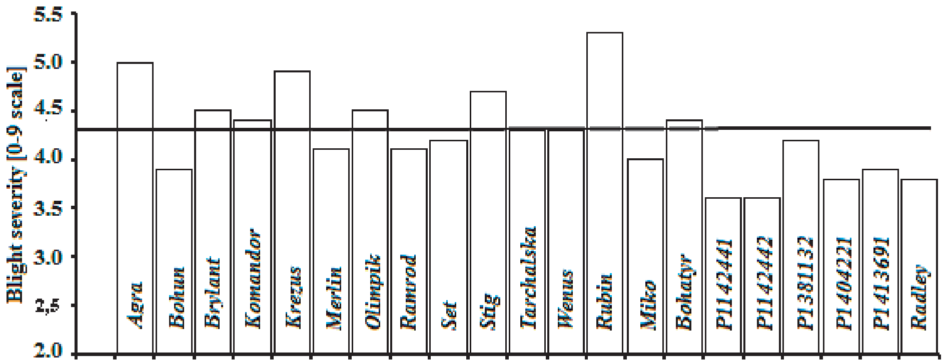

Fig. 1. Mean infection score of field pea genotypes inoculated with *M. pinodes* assessed in field trials

The genetic diversity among genotypes in their reaction to *M. pinodes* infection is shown in the Fg. 1. The *M. pinodes* infection score means among tested genotypes ranged form 3.6 for PI 142441, PI 142442 pea lines to 5.3 for cultivar Rubin. The four out of five accessions (PI 142441, PI 142442, PI 404221 and PI 419641) with partial resistance to *M. pinodes* identified by Kraft *et al.* (1998) from USDA –ARS collection of pea germplasm along with Radley, Bohun and Miko cultivars were the most resistant genotypes also in current study confirming previous reports (Boros and Wawer 2007). Similarly to other reports (Zhong *et al.* 2006; Xue and Warkentin 2001; Fondevilla *et al.* 2005; Boros and Wawer 2007; Boros and Marcinkowska 2010) differences in susceptibility among cultivars have been demonstrated but no strong resistance are known in *Pisum sativum*.

Table 2

Results of stability analysis of response to *M. pinodes* infection among field pea genotypes

Cultivar	Estimation of main effect	F-statistics			
		For main effect	For G × E interactions	For regression of interaction of G vs. E	For deviations from regression of interaction
Agra	0.692	133.08**	0.19	-	-
Bohun	-0.341	5.43	1.14	-	-
Brylant	0.259	1.93	1.86	-	-
Komandor	0.117	0.18	4.16**	0.00	6.23**
Krezus	0.676	5.65	4.31**	0.00	6.46**
Merlin	-0.174	0.24	6.86**	1.58	5.74**
Olimpik	0.226	3.19	0.85	-	-
Ramrod	-0.166	1.74	0.84	-	-
Set	-0.041	0.32	0.28	-	-
Stig	0.401	2.01	4.27**	0.32	5.52**
Tarchalska	0.076	0.32	0.97	-	-
Wenus	0.059	0.70	0.27	-	-
Rubin	1.067	17.52*	2.47	-	-
Miko	-0.224	0.69	3.88*	0.62	4.44*
Bohatyr	0.151	0.90	1.35	-	-
PI142441	-0.633	10.95*	2.14	-	-
PI142442	-0.683	20.11*	1.24	-	-
PI381132	-0.074	0.14	2.03	-	-
PI404221	-0.508	75.95**	0.18	-	-
PI413691	-0.391	12.26*	0.66	-	-
Radley	-0.491	37.45**	0.34	-	-

*, ** indicate significance at P=0.05 and P=0.01 respectively

Genotype-environment interaction (G × E) has been important issue for plant breeders in developing improved varieties. Several methods are available for analysis GxE interaction and to assess genotype stability (Becker and Leon 1988; Fuentes *et al.* 2005; Mądry and Kang 2005; Letta and Tilahum 2007).

The results of applied statistical model of analysis of stability in response to *M. pinodes* infection among field pea genotypes are presented in Table 2. Tested pea genotypes were grouped into two classes; responding stable to *M. pinodes* (reacting proportionally to changed environment) and unstable ones (showing significant interaction with environment). The unstable genotypes can be divided in two subgroups: predictable and non predictable - reacted irregularly to environments (not able to describe the reaction to *M. pinodes* by any linear regression function). Within the first class cv. Agra and Rubin had high mean values for disease severity (highest and significant main effect) and non-significant G x E indicating that they are stable susceptible cultivars while PI 142441, PI 142442, PI 381132, PI 404241, cv. Radley, Bohun and Ramrod had low mean values for disease severity (lowest negative, significant main effect), were the most resistant, stable in response to *M. pinodes* infection among tested genotypes (Table 3). Also in seedling test and detached leaf assessment they were the most resistant genotypes tested (data not included). Results from stability analysis revealed stability for *M. pinodes* response in moderately resistant, moderately susceptible and susceptible pea genotypes (Table 3). Our results are in agreement with that of Fuentes *et al.* (2005) as well as with that of Letta and Tilahum (2007) who concluded that stability for *Fusarium head blight* (FBH) reaction in spring wheat and stem rust resistance in durum wheat varieties respectively, was not associated with the level of resistance in the cultivars tested. Similarly in potato association between stability for *Phytophthora infestans* resistance with the level of cultivars resistance has not been observed (Tatarowska *et al.* 2003).

Table 3

Genotypes grouping according to their stability in reaction to *M.pinodes* under field conditions

Resistance group	Genotypes stable	Genotypes unstable	
		Predictable	Unpredictable
Susceptible	Agra, Rubin	-	Krezus Stig
Moderately susceptible	Brylant , Olimpik, Set, Tarchalska, Wenus, PI 381132, Bohatyr	-	Komandor,
Moderately resistant	PI 142441, PI 142442, PI404221, PI 413691, Radley, Bohun, Ramrod	-	Merlin, Miko

CONCLUSION

Ideally, resistant cultivars should possess significant negative major effect (low mean values) for parameters of disease severity and not showing significant interaction with environment. The conidial-spray inoculation method provided disease levels sufficient to differentiate resistant and susceptible cultivars.

When breeding for mycosphaerella blight resistance, it is crucial to evaluate lines with resistant and susceptible check cultivars known to be stable in their disease response. Stability of mycosphareалla blight reactions was not associated with the level of resistance in the cultivars tested. The stability and level of the resistance reported in this study indicated that some accessions may be a good sources of resistance needed to improve the level of resistance to *M. inodes* in pea crop.

REFERENCES

Bretag T. W., Keane P. J., Price T. V. (2000). Effect of sowing date on the severity of ascochyta blight in field peas (*Pisum sativum* L.) grown in Wimmera region of Victoria. Australian Journal of Experimental Agriculture, 40, 1113–1119.

Boros L., Wawer A. (2007). Response of pea cultivars to *M. pinodes* in tests under controlled conditions and in field with controlled infection. Zeszyty Problemowe Postepów Nauk Rolniczych 522: 157 -165 [in Polish with English summary]

Boros L., Marcinkowska J. 2010. Assessment of selected pea genotypes reaction to ascochyta blight under field conditions and the impact of disease severity on yield components. Journal of Agricultural Science 2: 84 – 91.

Becker H.C., Leon J. 1988. Stability analysis in plant breeding. Plant Breeding 101:1-23

Caliński T., Czajka S., Kaczmarek Z., Krajewski P., Siatkowski I. 1998. SERGEN – Analiza serii doświadczeń odmianowych i genetyczno hodowlanych. Program komputerowy, Poznań IGR.

Fondevilla S., Cubero J.I., Rubiales D. (2007). Inheritance of resistance to *Mycosphaerella pinodes* in two wild accessions of *Pisum*. Eur J Plant Pathol. 119: 53-58

Fondevilla S., Avila C.M., Cubero J.I., Rubiales D. (2005). Response to *Mycosphaerella pinodes* in a germplasm collection of *Pisum ssp.* Plant Breeding 124: 313-315

Fuentes R.G., Mickelson H.R., Busch R.H., Dill-Mackey R., Evans C.K., Thompson W.G., Viersma J.V., Xie W., Dong Z., Anderson J.A. 2005. Resource allocation and cultivar stability in breeding Fusarium head blight resistance in spring wheat. Crop Sci. 45:1965-1972

Kraft J.M., Dunne B., Goulden D., Armstrong S. (1998). A search for resistance in peas to *Mycosphaerella pinodes.* Plant Disease 82: 251-253.

Letta T., Tilahun A, 2007. Stability analysis for selecting stem rust resistance in some Ethiopian durum wheat varieties. African Crop Science Conference Proceedings 8: 853-856

Marcinkowska J.Z. (1996). Frequency of occurrence of *Ascochyta pisi* Libert, *Mycosphaerella pinodes* (Berk. et Blox.) Vestergren and *Phoma pinodella* (L.K.Jones) Morgan-Jones et Burch, the fungi responsible for ascochyta blight on peas. Phytopathologia Polonica 12: 15-33.

Marcinkowska J.Z. (2002). Foliar diseases of *Pisum stivum* L. in Poland. Plant Breeding and Seed Science 46: 49-54.

Mądry W., Kang M. 2005. Sheffé-Calinski and Shukla models; Their interpretation and usefulness in stability and adaptation analyses. Journal of Crop Improvement. 13(1/2) 325-369

Pirioul-Gervais S.A., Deniot G., Receveur E.M, Frankewitz A., Fourmann M., Rameau C., Pilet-Nayel M.L., Baranger A. 2007. Candidate genes for quantitative resistance to *Mycosphaerella pinodes* in pea (*Pisum sativum* L.). Theor. Appl. Genet. 114: 971- 984.

Tatarowska B., Flis B., Zimnoch-Guzowska E. 2003. Evaluation of potato cultivars stability in resistance to *Phytophthora infestans.* Biul. IHAR 228:291-304 [in Polish with English summary]

Tivoli B., Baranger A., Avila C.M., Banniza S., Barbetti M., Chen W., Davidson J., Lindeck K., Kharrat M., Rubiales D., Sadiki M., Sillero J.C., Sweetinghan M., Muehlbauer F.J. 2006. Screening techniques and sources of resistance to foliar diseases caused by the main world-wide necrotrophic fungi in grain legumes. Euphytica 147:223-253

Xue A.G., Warkentin T.D., Kenaschuk E.O. (1997). Effects of timings of inoculation with *Mycosphaerella pinodes* on yield and seed infection of field pea. Canadian Journal of Plant Science 77: 685-689.

Xue A.G., Warkentin T.D. (2001). Partial resistance to *Mycosphaerella pinodes* in field pea. Canadian Journal of Plant Science 81: 535-540.

Wroth J.M. (1999). Evidence suggests that *Mycosphareallа pinodes* infection of *Pisum sativum* is inherited as a quantitative trait. Euphytica, 107: 193-204

Zhang R., Hwang S.F., Chang K.F., Gossen B.D., Strelkov S.E., Turnbull G.D., Blade S.F. (2006). Genetic resistance to *Mycosphaerella pinodes* in 558 field pea accessions. Crop Sci. 46: 2409 - 2414

Zhang R.X., Gossen B.D. (2007). Heritability estimates and response to selection for resistance to *Mycosphaerella pinodes* in pea. Crop Sci. 47:2303-2307

Zhang R.X., Gossen B.D., Hwang S.F., Gossen B.D., Chang K.F., Turnbull G.D. (2007) A quantitative analysis of resistance to mycosphaerella blight in field pea. Crop Sci. 47: 162-167