

# The Genotype x Environment Study

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The following people have worked very hard in the GxE. There may be others at each site that have contributed greatly. To them, our thanks and apologies for missing their names this time. Denmark (H. G. Kirk); Argentina (M. Huarte); Scotland (G. Mackey, H. Stewart, R. Lowe, J. Duncan); USA, Cornell (W. E. Fry, H. Mayton); Canada (H. Platt, R. Tarn, G. MacKenzie); The Netherlands (L. Colon); France (D. Elliseche, D. Adrison) USA, Washington State (C. Brown, D. Inglis); Mexico (H. Lozoya-Saldaña); Ecuador (G. Chacón, O. Bastidas).

The planning of the G x E trial series began in 1993. Initial attempts to get funding failed, so a group of researchers worldwide agreed to fund their own participation. When CIP started the GILB initiative on late blight in 1996, the G x E study was given a high priority at the initial planning meeting (March 1996). Partial funding of the 10 sites was approved, using a contribution from DANIDA, Denmark. Eight countries are now participating in the field trial series: Canada (Agriculture Canada), the United States (Cornell and Washington St. Univs.), Denmark (LKF-from 1997), Ecuador (CIP), Argentina (INTA), Scotland (SCRI), The Netherlands (CPRO), and France (INRA), and Mexico (PICTIPAPA, from 1998).

The study is concentrated on varieties that possess different levels of quantitative resistance, which is believed to be durable. Anecdotal information indicated that some genotypes might be resistant wherever grown, while others are resistant only in certain locations. Because of a lack of information on the geographic

stability of quantitative resistance to late blight, CIP and a group of collaborators developed the G x E study. The main idea was to evaluate the level of resistance of a standard set of cultivars ranging from very susceptible to very resistant at different sites around the globe.

Field trials in the first year (1996) included eight cultivars. From CIP: CRUZA 148, Seseni, Monserrate, Yungay, Chata Blanca, and Alpha, and from CPRO: Bintje and Dutch Robijn. For the second year, SCRI supplied Pimpernel, Eigenheimer, Record, Stirling, Teena, and Torridon, bringing the total in the second year to 14. Two years of planning along with distribution and multiplication of seed preceded the first field trial in 1996.

The trials were normally fit into pre-existing resistance screening trials. Experimental designs have been similar, but with site-specific modifications. At all sites, a randomised block design was used with 2-4 replications. Disease was initiated by inoculation of spreader plants in between plots, direct inoculation of plots, or natural infection. The progression of disease symptoms was followed twice a week, and AUDPC's were calculated for each plot at each site.

The preliminary results, including years 1996 and 1997, were summarised in GILB newsletter no. 4. These results are presented here as well as newly collected results from 7 of the 10 trial sites in 1998. Also, selected results from Danish resistance screening trials are presented for an odd number of years.

So far, the statistical analysis indicates that cultivar differences were a greater source of variance than the

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genotype x environment interaction. There are, however, exceptions between varieties and sites. The resistant cultivar Cruza 148 was quite stable, expressing a high level of resistance at all sites. Stirling was very resistant at most sites with some exceptions—Holland in 1996; Washington State, USA, in 1997; and Argentina, in 1998—where it showed a susceptible to intermediate reaction. Torridon was resistant with the exception of Washington, USA, in 1997, and Argentina, in 1998, where it showed an intermediate reaction. Monserrate was scored resistant in all locations except Argentina, in 1998, where it was rather susceptible.

Yungay, Seseni and Teena expressed an intermediate resistance at all sites. The cultivar Bintje was very susceptible, and Eigenheimer was rather susceptible at all sites. Chata Blanca was mainly very susceptible with some exceptions (Argentina and USA) where it was measured to be resistant to intermediate. Dutch Robijn, Pimpernel, and Alpha varied from intermediate to susceptible. Record was scored resistant in Ecuador in 1997, and intermediately resistant elsewhere, but very susceptible at one site (Canada).

In routine resistance screening trials over several years in Denmark, Bintje was measured to be very susceptible in all years, and Eigenheimer and Pimpernel were stable as intermediate to rather susceptible. Results from the same trial series from 1985 to 1998 with other Danish and Swedish material illustrate that cultivars with expected quantitative resistance have a large year to year variation, and there are indications of resistance efficiency loss in some cultivars. The variety Danva, however, showed a resistant reaction over all years.

The experimental data so far indicates that horizontal resistance is relatively stable, irrespective of environment. Tropically resistant materials were found

to be resistant in the Temperate Zone, and vice versa. The cases of instability that have been found till now seem to be isolated events.

Judging from previous data, the cultivar Alpha was expected to have an intermediate resistance and to have interaction with the environments. This was not evident from the results.

Results from the long series of breeders' trials in Denmark clearly show that the year to year variation in climate, disease pressure and the *Phytophthora* population necessitates continuous observations of disease expression in key resistance sources.

There are several difficulties in the evaluation of a complex multi-site study like this, such as: Possible errors in local experimental procedures; many long day sites and few short day sites and problems of producing seeds because of short/long day adaptation. All these problems have to be overcome for proper evaluation of results.

Remaining data from 1998 are still to be collected, and a more thorough analysis of the full data set should be done before final conclusions and reports can be made. This should be done very soon.

The present GXE group was asked for its opinion about the future for this cooperative work, and most members of the group expressed an interest in continuing the cooperation, but with new goals. Some of the same sites should be included. Several proposals for a possible continuation have been put forward in the past and present— pathogenic and epidemiological studies, crossing populations studies (4x), as well as investigations of the most resistant cultivars. Additional funding will be needed to continue this work with new aspects. These and other suggestions must be further discussed within the group and with the forum here.