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The relation between GxE interaction and the number of locations in series of oilseed rape trials

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SUMMARY

The problem of the selection of locations (experimental stations) for experiments on oilseed rape is considered. The results of 138 experiments conducted by the Research Centre for Cultivar Testing (COBORU) in the period 2006–2010 at 41 experimental stations form the basis for all considerations. The method applied earlier by Pilarczyk and Fraś (2007, 2010) for analysis of similar results concerning winter wheat was utilized here. However, because of the high degree of non-orthogonality of the data (slightly overlapping sets of varieties among years) only analyses of single-year series were possible. The locations with a high contribution to the genotype-environment interaction were identified.

Key words: genotype-environment interaction, oilseed rape, participation of location in interaction, series of trials

1. Introduction

In the analysis of multi-environment field trials under different types of mixed models (Cochran and Cox, 1938, Caliński et al., 2009), the differences among varieties are tested against mean square for GxE interaction. Hence the possession of a reliable estimate of that interaction is crucial. There have been some attempts aimed at reducing the size of the GxE interaction. For example in a paper by Pilarczyk (1983) cluster analysis was applied in the analysis of series of potato trials. Clusters were formed in such a way that the GxE interaction within clusters was maximally reduced, while interaction of varieties with clusters (sometimes called regions) was maximized.

The problem of the necessary number of locations in series of variety trials was considered for example in Lin and Butler (1988) and Pilarczyk and Fraś (2010, 2011), where additionally a method of identification of locations with a large and negligible contribution to the GxE interaction was proposed. All these investigations provided a means to find out the necessary number of trials to guarantee the obtaining of stable estimates of mean squares for GxE interaction. Following analysis of series of 219 winter wheat trials from the period 1991–1994 (Pilarczyk and Fraś, 2011) it was concluded that a one-year series should consist of at least 15 trials conducted at properly chosen locations (experimental stations). Analysis of series of 119 spring barley trials from the period 1993–1995 (Pilarczyk and Fraś, 2011) led to a similar conclusion. In this paper similar investigations are performed using oilseed rape trial data from the years 2006 to 2010. All of the trials were conducted by the Research Centre for Cultivar Testing, Słupia Wielka, at 41 variety-testing experimental stations spread over the whole country. The main aim of this research was to identify locations which made respectively significant and negligible contributions to the GxE interaction.

2. Data

The series of oilseed rape trials performed by the Research Centre for Cultivar Testing at Słupia Wielka form the basis of all our considerations. In total the results of 138 trials conducted in the years 2006–2010 are included. There were 27 trials from 2006, 27 from 2007, 28 from 2008, 29 from 2009 and 27 from 2010. All trials were arranged as 1-resolvable incomplete blocks with four replicates (in the last three years) and with two replicates (in 2006 and 2007). The block sizes ranged from 8 to 11 plots.

The plot size was 12 m^2 in all trials. The number of tested varieties was always larger than 30, but differed to a large extent between locations and years. For yearly analyses only such trials were chosen in which the set of common varieties consisted of at least 14 genotypes. The number of common varieties

between years was smaller than 10 (see Table 1). For that reason only yearly analyses were performed for the considered set of data, as for a small number of varieties the results could be "variety dependent".

Table 1. The numbers of varieties tested in particular years and numbers of varieties common among years

Year	2006	2007	2008	2009	2010
2006	14	8	4	3	2
2007		17	8	4	2
2008			16	8	4
2009				21	9
2010					14

The analyzed characteristic was seed yield recalculated to a common moisture content of 9% and expressed in dt per hectare. In Table 2 the 41 locations included in the analysis are listed, with information on the years in which trials were conducted at particular locations. It can be seen that only at 17 locations were trials were performed in all the years under consideration. There are also 6 locations at which trials were performed only once. At the remaining locations trials were conducted in two, three or four years.

3. Method

In this research a method similar to that applied by Pilarczyk and Fraś (2010) is used, with the difference that only yearly analyses are performed here, because of the small number of common varieties between years (see Table 1). The smallest of the analyzed series consisted of 27 trials, and the largest 29 trials. The applied method consists of the following steps:

a) Analysis of one-year series of trials and testing whether the GxE interaction is significant;

Table 2. Oilseed rape. List of locations and their contributions to GE interaction

No.	Location	Trials performed in years					Numbers of years	Group of 15 locations
1	Bąków	2006	**2007**			**2010**	3	**2**
2	Bezek	**2006**	**2007**	**2008**	2009	**2010**	5	**4**
3	Białogard		2007	**2008**	2009		3	**1**
4	Borowo	**2006**	2007	**2008**	**2009**	**2010**	5	**4**
5	Chrząstowo	2006	**2007**	2008	2009	2010	5	**1**
6	Cicibór	**2006**	2007	**2008**	2009	2010	5	**2**
7	Głubczyce	**2006**	**2007**	**2008**	2009	2010	5	**3**
8	Karżniczka	**2006**	2007	2008	**2009**	**2010**	5	**3**
9	Kościelec	2006	**2007**	**2008**	**2009**	2010	5	**3**
10	Kościelna Wieś	2006	**2007**	2008	**2009**	2010	5	**2**
11	Krościna Mała	2006					1	**0**
12	Krzemlin		**2007**				1	**1**
13	Krzepice			**2008**	**2009**	2010	3	**2**
14	Krzyżewo		2007	2008			2	**0**
15	Lisewo		2007	**2008**			2	**1**
16	Lubinicko	**2006**	2007				2	**1**
17	Lućmierz		**2007**	2008	**2009**	**2010**	4	**3**
18	Łosiów	**2006**	**2007**			2010	3	**2**
19	Małyszyn			2008	**2009**	2010	3	**1**
20	Masłowice		2007		2009		2	**0**
21	Nowa Wieś Ujska			**2008**	**2009**	**2010**	3	**3**
22	Naroczyce	2006					1	**0**
23	Palikije			**2008**	2009		2	**1**
24	Pawłowice	2006	2007	**2008**	2009	**2010**	5	**2**
25	Pawłowice	2006					1	**0**
26	Pągów	**2006**				**2010**	2	**2**
27	Prusim			2008	2009		2	**0**
28	Przecław			2008	**2009**		2	**1**
29	Radostowo	**2006**	2007		**2009**	**2010**	4	**3**
30	Rarwino	**2006**	**2007**	**2008**	**2009**	**2010**	5	**5**
31	Ruska Wieś	2006	**2007**	2008	**2009**	2010	5	**2**
32	Słupia	2006	2007	**2008**	2009	**2010**	5	**2**
33	Słupia Wielka	2006	2007	2008	2009	2010	5	**0**
34	Spytkówki	**2006**	**2007**	2008	2009	**2010**	5	**3**
35	Strzelce				**2009**		1	**1**
36	Śrem	2006	**2007**	**2008**	2009	2010	5	**2**
37	Świebodzin			2008	**2009**	**2010**	3	**2**
38	Tarnów Śląski	**2006**					1	**1**
39	Tomaszów Bol.	**2006**	**2007**	2008	**2009**	**2010**	5	**4**
40	Ulhówek	**2006**				2010	2	**1**
41	Zybiszów	**2006**	**2007**	**2008**	2009	**2010**	5	**4**

b) If the interaction is significant, its mean square MS(1,2,…n), where n denotes the number of locations, is split into two components. The first component MS(1,2,…,n-1) denotes the mean square for interaction of all considered varieties with the set of n-1 locations after removing one location (here location n). The second component SR(n) is closely related to the sum of interactions of all pairs of locations that include that removed location. This makes it possible to identify the location with the smallest contribution to the GxE interaction;

c) After removing the location with the smallest contribution, the whole process is repeated for the set of n-1 locations;

d) Finally the two locations with the largest interaction are identified.

As the size of the GxE interaction depends on the year of the trial, to have a common basis for the relationship between the size of series (number of locations), the mean squares for interaction MS(1,2,…,n), MS(1,2,…n-1),…., MS(1,2) in all annual series of trials were expressed as percentages of the mean square for interaction for the two locations with the largest interaction. Finally the results were presented graphically.

4. Results

The results of the preliminary calculations, namely the mean squares for interactions for the whole series and for the two locations with the largest interactions, are given in Table 3, for all years under consideration.

It is readily noticed that the largest interaction appeared in the year 2007 and the smallest in 2010.

Table 3. Oilseed rape – interaction of varieties and locations

Year	Number of locations n	MS(n)	MS(2)
2006	27	13.724	44.044
2007	27	18.805	57.301
2008	28	17.846	53.922
2009	29	12.651	52.893
2010	27	9.281	30.472

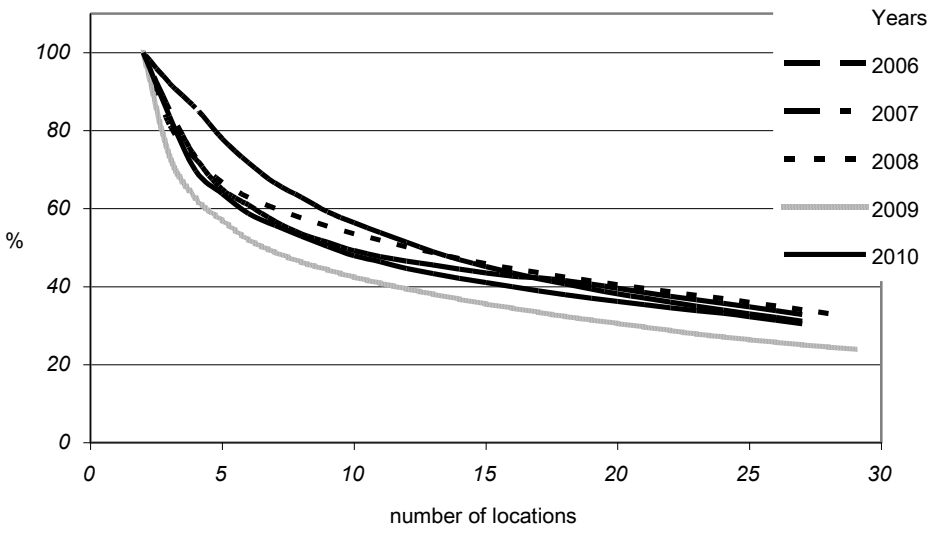

Figure 1. Oilseed rape. Relative values of mean squares for interaction (for different numbers of locations) expressed in percentages of mean square of interaction of two locations with the highest interaction

Figure 1 shows the dependence of the size of interaction (expressed by the mean square for GxE interaction) and the number of locations (experimental stations). Similarly to the results obtained by Pilarczyk and Fraś (2010) for winter wheat trial series, here also stable values of mean squares for GxE interaction were obtained for series consisting of approximately 15 trials. Hence the minimum size of series should be about 15 locations. In Figure 1 this is illustrated by the fact that from that number of trials onwards all the curves are relatively flat.

In order to assess which locations are significant (contribute meaningfully to the interaction), in each yearly series it was checked whether or not any particular location belongs to the minimal subset of 15 locations. The results are presented in Table 2. In that table, bold print indicates the years in which each location belonged to the minimal subset. It is seen, for example, that at the location Bąków experiments were performed in the years 2006, 2007 and 2010, but this location belonged to the minimal subset only in 2006 and 2010. At the location Krościna Mała the experiment was performed only in the year 2006,

and this location did not belong to the minimal subset in that year. It is also observed that at 17 locations experiments were established every year, but only the location Rarwino belonged every year to the minimal subset of locations with the largest interaction. There are also four locations (Bezek, Borowo, Tomaszów Bol. and Zybiszów) which appeared in the minimal subset four times. All of these locations are the most suitable for winter rape trials. Such preferable locations also include Lućmierz (trials performed four times, in the minimal subset three times) and Nowa Wieś Ujska (three trials, always in the minimal subset).

On the other hand, at the location Słupia Wielka trials were performed each year but this location did not appear at all in the minimal subset. Hence this location is less useful from that point of view. Also Chrząstowo (five trials, only one year in the minimal subset) can be classed among the less useful locations.

5. Conclusions

Analysis of five years' results of trials on oilseed rape carried out at numerous locations indicates that:

- to guarantee stable estimates of mean squares for genotype-by-location interaction, the series of trials (number of locations) should consist every year of at least 15 locations;
- when choosing locations for performing trials, the results of previous trials should be taken into account; in particular the contribution of locations to the GxE interaction should be considered.

The present results coincide with the results concerning series of spring barley trials reported by Pilarczyk and Fraś (2011) and also with the results concerning winter wheat trials reported by Pilarczyk and Fraś (2010). Additional aspects of the discussed problem arise when other characterizations of locations – related for example to "representativeness" – are considered.

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