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OILSEED RAPE - COMPARISON OF UNIFORMITY DECISIONS BASED ON COYU AND BENNETT'S METHODS

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OILSEED RAPE –COMPARISON OF UNIFORMITY DECISIONS BASED ON COYU AND BENNETT'S METHODS

[1]BOGNA ZAWIEJA, [1,2]WIESŁAW PILARCZYK, [2]BOGNA KOWALCZYK

[1]Department of Mathematical and Statistical Methods, Poznań University of Life Sciences, Wojska Polskiego 28, 60-637 Poznań, Poland
[2]The Research Centre for Cultivar Testing, 63-022 Słupia Wielka, Poland
e-mail: bogna13@up.poznan.pl; wpilar@up.poznan.pl; b.kowalczyk@coboru.pl

Summary

1. In Poland, uniformity of new varieties for quantitative characteristics is usually checked using the COYU method after collecting results from three years of trials. There are some other possibilities of testing uniformity as indicated, for example, in papers by Zawieja and Pilarczyk (2005, 2006).

2. In documents TWC/23/9 "A Comparison of COYU and a Method Based on Bennett's Test for Coefficients of Variation", TWC/24/7 "Further Comparison of Decisions on Uniformity of Rye Varieties Based on COYU Approach and on Bennett's Test", and TWC/25/8 "Comparison of COYU and a Method Based on Bennett's Test for Coefficients of Variation", the conclusions concerning uniformity of rye varieties based on the UNIF (COYU) approach and on the Bennett's test were compared. The conclusions were generally similar, but in some cases differences appeared.

3. During the discussions at the twenty-fourth session of the TWC, held in Nairobi, Kenya, from June 19 to 22, 2006, it was proposed to make additional comparisons of these two methods in order to investigate if there was a relationship between the degree of correlation between level of expression of characteristic and log transformed values of standard deviations and decisions concerning uniformity supported by the two mentioned methods. It was also suggested to apply McNemar's (McNemar, 1947) test instead of a test of independence. This problem was initially discussed at the twenty-fifth session of the TWC (see document TWC/25/8) and - in conclusion - it was also suggested to compare these two methods of testing uniformity using results of another species. In this document these problems are addressed again with the use of DUS data for oilseed rape varieties.

Introduction

4. In the case of uniformity of cross-pollinated varieties, the General Introduction explains that

> "6.4.2 Cross-Pollinated Varieties
>
> Cross-pollinated varieties, including mainly cross-pollinated and synthetic varieties, generally exhibit wider variations within the variety than vegetatively propagated or self-pollinated varieties and inbred lines of hybrid varieties, and it is more difficult to determine off-types. Therefore, relative tolerance limits, for the range of variation, are set by comparison with comparable varieties, or types, already known. This

means that the candidate variety should not be significantly less uniform than the comparable varieties.

[…]

6.4.2.2 Measured Characteristics

6.4.2.2.1 For measured characteristics, the acceptable level of variation for the variety should not significantly exceed the level of variation found in comparable varieties already known. UPOV has proposed several statistical methods for dealing with uniformity in measured quantitative characteristics. One method, which takes into account variations between years, is the Combined Over Years Uniformity (COYU) method.

6.4.2.2.2 For more details on the handling of uniformity in measured quantitative characteristics, see document TGP/10, "Examining Uniformity."

5. In the COYU method, the log transformed and adjusted by moving average method, values of standard deviations of new varieties are compared with similar (averaged) values calculated for varieties treated as standards. Such comparisons are made for all relevant measured characteristics in DUS trials. If new values for the variety do not exceed significantly the average values of reference[1] varieties for all characteristics under consideration, the new variety is accepted and in the next cycles it can be included in the set of reference varieties.

6. Because standard deviations sometimes depend on the levels of expression of the characteristic under consideration some additional procedures have been elaborated to remove these influences. The COYU method is a slightly sophisticated method; a possible alternative is the application of a measure of uniformity based on coefficient of variation. Such an approach was described in documents TWC/23/9, TWC/24/7 and TWC25/8. Equality of coefficients of variation of the new (candidate) variety and of the varieties belonging to the reference set can also be tested using the Bennett test, which is much simpler than COYU. This method was applied to a set of three-year results of oilseed rape. Because conclusions concerning uniformity were slightly different, it was suggested to check if these discrepancies are related to existing relationships between levels of expression of observed characteristics and values of (log transformed) standard deviations. This document deals with that consideration.

Data

7. The data from DUS trials for oilseed rape varieties during the period 2006-2008 at experimental station Słupia Wielka are used. Data concern 221, 230 and 314 cross-pollinated varieties tested in year 2006, 2007 and 2008 respectively. However, only a subset of 83 established (old) varieties and six candidate varieties are included in the considerations in this document.

8. There were 12 measured, quantitative characteristics, (characteristic codes taken from UPOV Test Guidelines) and two additional characteristics, coded here as X1 and X2:

[1] The term reference varieties here refers to established varieties which have been included in the growing trial and which have comparable expression of the characteristics under investigation.

02 - Cotyledon: length, 03 – Cotyledon: width, 16 – Plant: height (at full flowering), 17 – Plant: total length including side branches, 08 – Leaf: length (blade and petiole), 09 – Leaf: width (widest point), 06 – Leaf: number of lobes (fully developed leaf), X1 – Leaf: length of petiole, 13 – Flower: length of petals, 14 – Flower: width of petals, 18 – Siliqua: length (between peduncle and beak), 19 – Siliqua: length of beak, 20 – Siliqua: length of peduncle, X2 – Siliqua: width. All the calculations were performed using mean values and standard deviations calculated over 30 single plant measurements.

9. To have an orthogonal (complete) set of data from three years of trialling, only a subset of six new (candidate) varieties and a subset of 83 old varieties (forming the reference set), were taken into consideration. Other characteristics were also observed, but because the observations were qualitative, they were excluded from statistical analysis.

Method

10. In order to check if there were relationships between mean values and standard deviations, the analysis of regression was applied. Before applying the analysis of regression of standard deviations on mean values, the standard deviations s_d were transformed using $\log(s_d +1)$ transformation. That is the same transformation as used in COYU (see Talbot 2000) approach. The statistical significance of regression was checked and coefficients of determination were calculated for all characteristics. In order to find an explanation for the discrepancies between conclusions on uniformity provided by the two methods, the following approach was applied.

11. The data were analyzed twice: firstly using COYU; and secondly using Bennett's method. The same level of significance for these two methods was used. For every considered characteristic, the number of universally positive conclusions (acceptance of variety as uniform) and negative conclusions (rejecting of variety as non-uniform) across all characteristics was counted. So the two-by-two contingency tables were formed, with two rows reflecting decisions taken by COYU method and with two columns reflecting conclusions supported by Bennett test. For these tables the McNemar's test was applied, McNemar(1947).

12. If n_{11} and n_{22} are the number of cases that two methods under comparison resulted in the same conclusions concerning uniformity and lack of uniformity, and respectively n_{12} and n_{21} the number of cases with contradictory conclusions, the hypothesis tested was of the form $H_0 : n_{12}=n_{21}$ against alternative $H_1: n_{12} \neq n_{21}$.

The McNemar statistic takes a form

$$Q_M = (n_{12}-n_{21})^2/(n_{12}+n_{21})$$

and is distributed as χ^2 with one degree of freedom.

Results

13. The method described above was applied to oilseed rape data. As mentioned earlier, the data were analyzed twice. The procedure COYU of DUST package (see Weatherup 1992), was applied first, followed by analysis of the same data using Bennett's test for coefficients of

variation and, finally, the conclusions on uniformity were compared on a characteristic-by-characteristic basis.

14. An additional difficulty in the analysis of the data appeared. Namely, for the majority of varieties belonging to the reference set, a lack of uniformity for at least one characteristic was detected. So when applying the Bennett's test, such varieties were excluded from the reference set. This means that the uniformity of each candidate variety was checked against a sometimes different (for different characteristics) set of ten varieties with the closest mean values, but after excluding non-uniform cases.

15. When uniformity tests were performed at the level 0.01 the conclusions were exactly the same for the two methods under comparison, i.e. all six candidate varieties were considered to be uniform for all considered characteristics. Some differences appeared when testing was performed at the level 0.05. The results are collected in Table 1.

16. The decisions do not differ significantly (see empirical α-levels). For eight characteristics, both methods declared all candidate varieties uniform. For the remaining six characteristics, the COYU declared all candidates uniform but after application of the Bennett's test, five candidates were declared uniform (not necessarily the same for all characteristics), one being declared non-uniform. Such a situation occurred for two characteristics (X1 and 20), for which a significant regression of standard deviations on mean values was detected. Even though the decisions supported by the COYU and Bennett's test were statistically the same, the COYU method seems to be slightly more tolerant than the Bennett's test.

17. In a previous comparison with the use of rye data (documents TWC/23/9, TWC/24/7 and TWC/25/8), the situation was slightly different. The conclusions were also statistically the same, but the Bennett's approach was more tolerant.

Table 1
The comparison of decisions concerning uniformity (tested by McNemar test) given by COYU and by Bennett's test, both applied at 0.05 level

Characteristic	Significance of regression - empirical α-level	Coefficient of determination in percentage	Number of varieties accepted by COYU	Number of varieties accepted by Bennett's test	Significance of differences between decisions on uniformity – empirical α-level
02	0.3976	0. 82	6	6	
03	0.4245	0. 73	6	6	
16	0.0620	3.95	6	5	0.3173
17	0.2365	1.61	6	6	
08	0.9437	0. 01	6	6	
09	0.0215	5.93	6	5	0.3173
06	0.9100	0. 01	6	5	0.3173
X1	0.0048**	8.78	6	5	0.3173
13	0.0385	4.83	6	6	
14	0.8311	0.05	6	6	
18	0.1945	1.93	6	5	0.3173
19	0.8001	0.07	6	6	
20	0.0000**	33.65	6	5	0.3173
X2	0.6941	0.18	6	6	

18. When an overall hypothesis (including all 14 characteristics) was tested, the COYU method declared all six candidate varieties to be uniform, while the application of the Bennett's test resulted in a declaration that two of those were uniform. These decisions were statistically not distinct when compared (by McNemar test) at 0.01 level, but distinct when 0.05 level was applied.

Comments and Conclusions

19. The analysis of oilseed rape data from official DUS trials in Poland showed that there was a statistically significant relationship between means and (between-plants) standard deviations for only two characteristics (X1 – length of petiole of leaf, 20 – length of peduncle of siliqua). However, the coefficients of determination were low (respectively 9% and 34%) for these two characteristics.

20. COYU and Bennett's test declared (on a characteristic-by-characteristic basis) the same varieties uniform when applied at 0.01 level. At 0.05 level the decisions were slightly (but not significantly) different.

21. When overall conclusions (across all characteristics) were compared, they were statistically indistinct when tested at α=0.01 level but distinct when α=0.05 level was used. In the latter case, less varieties were declared uniform by the Bennett's test than by COYU method.

22. For rye data (see documents TWC 23/9, TWC 24/7 and TWC 25/80), the Bennett's test was slightly more tolerant than COYU. The reverse situation appeared to be the case for oilseed rape data.

23. Further comparisons using other data are needed to conclude more generally about behaviour of these two approaches to the testing of varietal uniformity.

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