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COMPARISON OF UNIFORMITY DECISIONS BASED ON COYU AND BENNET'S METHODS USING REAL AND SIMULATED DATA

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COMPARISON OF UNIFORMITY DECISIONS BASED ON COYU AND BENNETT'S METHODS USING REAL AND SIMULATED DATA

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Summary

1. In Poland, the uniformity of candidate varieties for quantitative characteristics is usually checked using the COYU method after collecting results from two or 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 document TWC/27/10 these problems were addressed again with the use of DUS data for oilseed rape varieties. There were some differences between decisions concerning uniformity for these two methods, but they were statistically indistinct (when tested at 0.01 significance level). Because there were only six candidate varieties, it was suggested to use a larger set of candidates, using simulated data. In this document the results of actual DUS trials of oilseed rape are used for reference set varieties, whereas data for candidate varieties are simulated.

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.
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> […]
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> 6.4.2.2 Measured Characteristics
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> 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.
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> 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 candidate 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 significantly exceed the average values of reference varieties for all characteristics under consideration, the candidate variety is accepted and in the next cycles it can be included in the set of reference[1] 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. A possible alternative to the COYU method 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 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.

Data

7. The data from DUS trials on oilseed rape performed at experimental station Słupia Wielka in the period 2006-2008 formed the basis of investigations. Only data for varieties already registered were used.

8. Because the aim of this research was comparison of decisions concerning uniformity supported by COYU and by Bennett's test, there was no necessity to use all of the observed characteristics. So one characteristic – the plant height – was chosen. For all analyzed

[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.

periods, namely 2006-2007, 2007-2008 and 2006-2008, the data for candidate varieties were generated using method as follows:

a) the minimum and maximum value of the real variety mean and standard deviation were calculated x_{min}, x_{max}, s_{min}, s_{max};

b) starting from (rounded) x_{min}, the values for "candidate" varieties were formed using the formula

$x_i = x_{min} + (i\text{-}1)d, \quad i=1,2,3,....$

where values x_i were generated as far as x_{max} was reached.

c) every value x_i was associated with all values of standard deviations generated as follows

$s_j = s_{min} + (j\text{-}1)s, \quad j = 1,2,3,....$

where the s_j were generated so far as s_{max} was reached.

The values of d and s were chosen in a way that guaranteed a reasonable number of "candidate" varieties.

9. For the period 2006-2007, there were 66 established varieties (forming so-called reference set) and 187 candidate (simulated) varieties. Similarly for the period 2007-2008, there were 57 established and 272 simulated varieties and for the period 2006-2008, 72 and 238 such varieties. Uniformity of every "candidate" variety was tested using the methods described below.

Method

10. Each candidate variety was tested using the COYU method and Bennett's test. A method similar to that described by Zawieja, Pilarczyk and Kowalczyk (2009) was used to compare decisions concerning uniformity. The COYU method uses average values of within-plot standard deviations as a measure of uniformity. These values are next ln (natural logarithm) transformed, and "adjusted" using a moving average approach. Adjusted values are compared with similar values received for the reference set varieties. Details of the COYU approach can be found in a paper by Talbot (2000).

11. In the Bennett's approach, the coefficients of variations are used as a measure of uniformity. Equality of coefficient of variation of the candidate variety and a subset of coefficients of variation of reference set varieties is a criterion of acceptance of candidate variety as uniform. It can be applied when none of the coefficients of variation exceed 0.3 (Forkman, 2006 Iglewicz and Meyers, 1970). In our case this condition was always fulfilled. The subset of reference set varieties was formed in similar way as in the COYU approach, namely varieties with closest mean values were taken. More details on Bennett's test are given in a paper by Zawieja and Pilarczyk (2006).

12. The decisions concerning uniformity of candidate varieties supported by the two methods are compared in such a way, that a two-by-two contingency table (Table 1) is formed as follows:

Table 1: Two-by-two contingency table for decisions on uniformity of candidate varieties

Method		Bennett's test	
COYU approach	decision	uniform	not uniform
	uniform	n_{11}	n_{12}
	not uniform	n_{21}	n_{22}

13. The COYU and Bennett's methods were applied at the same significance level. The $n_{11}+n_{22}$ denotes the number of concordant decisions; $n_{12}+n_{21}$ denotes the number of contradictory decisions. There are several methods for testing concordance of decisions with the use of such data. In a paper by Zawieja and Pilarczyk (2006), the Fisher exact test was used to investigate if there is an association between decisions, whilst in a paper by Zawieja and Pilarczyk (2007), the McNemar test was used to verify the hypothesis that probabilities of contradictory decisions $p_{12} = p_{21}$ can be accepted or not. Here the "odds ratio" *OR* (Rudas, 1998, Uebersax 2006) is applied as a measure of association between decisions. Odds ratio is calculated as

$$OR = \frac{n_{11} \bullet n_{22}}{n_{12} \bullet n_{21}}$$

14. A large value of *OR* indicates association between methods. The statistical significance of lack of association can be tested using statistics Z_0 of the form

$$Z_0 = \frac{\ln(OR)}{\sigma_{\ln(OR)}}$$

where $\sigma_{\ln(OR)} = \sqrt{\frac{1}{n_{11}} + \frac{1}{n_{12}} + \frac{1}{n_{21}} + \frac{1}{n_{22}}}$. The Z_0 statistics has asymptotic normal distribution.

15. The coefficient *OR* can be easily transformed to the Yule coefficient of association *Q* (Yule and Kendall, 1966), using formula

$$Q = \frac{OR - 1}{OR + 1}$$

This coefficient is interpreted similarly to the coefficient of correlation. $Q = 0$ means lack of association between methods; a value close to 1 means high agreement.

16. To have an additional assessment of association, the probability *p* of agreement was also calculated according to the formula

$$p = \frac{n_{11} + n_{22}}{n}$$

where *n* denotes the total number of candidate varieties.

Results

17. The COYU method and the corrected Bennett's test (Shafer and Sulivan, 1986) were applied for three sets of data generated in the above method (data for candidate varieties). The data for reference varieties were taken from actual experiments performed at the experimental station Słupia Wielka. The COYU analysis was performed by the DUST package of Weatherup (1992). For Bennett's test, an EXCEL spreadsheet was utilized.

18. The results for two years' data, concerning the period 2006-2007, are given in Table 2 (testing at significance level $\alpha = 0.002$) and in Table 3 (significance level 0.02). When testing was performed at the level $\alpha = 0.002$, the two methods accepted all varieties as uniform (full agreement between methods, $p = 100\%$). However, when testing at 0.02 level (Table 3), 20 of the candidate varieties were rejected as not uniform by Bennett's test but were accepted as uniform by COYU. The probability of agreement between methods was equal to 89.3%. For data in Tables 2 and 3, the odds ratio *OR* could not be calculated, because either n_{12} or n_{21} (or both) were zero.

Table 2: Decisions on uniformity of candidate varieties for data from the period 2006-2007, $\alpha = 0.002$

Method		Bennett's test	
COYU approach	decision	uniform	not uniform
	uniform	187	0
	not uniform	0	0

Table 3: Decisions on uniformity of candidate varieties for data from the period 2006-2007, $\alpha = 0.02$

Method		Bennett's test	
COYU approach	decision	uniform	not uniform
	uniform	167	0
	not uniform	20	0

19. The results for the 2007-2008 are presented in Table 4 ($\alpha = 0.002$) and in Table 5 ($\alpha = 0.02$). The probability of agreement is equal to 90.8% (when testing at 0.002 level) and 76.1% (when testing at 0.02 level). Other measures of agreement (*OR* and *Q*) could not be calculated for results in Table 4. For results given in Table 5, these measures of agreement are respectively $OR = 15.48$, $Q = 0.879$ (the value of $Z_0 = 4.221$ is higher than critical value $Z_{0.01} = 2.576$).

Table 4: Decisions on uniformity of candidate varieties for data from the period 2007-2008, $\alpha = 0.002$

Method		Bennett's test	
COYU approach	decision	uniform	not uniform
	uniform	247	0
	not uniform	25	0

20. The results for three years' data (2006-2008) are presented in Table 6 (for $\alpha = 0.002$) and in Table 7 ($\alpha = 0.02$). When testing was performed at α=0.002 level, there were 144 (=141+3) concordant decisions concerning uniformity and respectively 94 (=13+81) contradictory decisions, corresponding to a probability of agreement of p = 60.5%.

Table 5: Decisions on uniformity of candidate varieties for data from the period 2007-2008, $\alpha = 0.02$

Method		Bennett's test	
COYU approach	decision	uniform	not uniform
	uniform	192	3
	not uniform	62	15

21. The other measures of agreement are respectively, OR = 0.402, Q = -0.427 and Z_0 = -0.949. For the results given in Table 7, the following values can be easily obtained p = 0.61, OR = 3.754, Q = 0.579, Z_0 = 4.315 (again Z_0 much higher than critical values at 0.05 and 0.01 levels).

Table 6: Decisions on uniformity of candidate varieties for data from the period 2006-2008, $\alpha = 0.002$

Method		Bennett's test	
COYU approach	decision	uniform	not uniform
	uniform	141	13
	not uniform	81	3

Table 7: Decisions on uniformity of candidate varieties for data from the period 2006-2008, $\alpha = 0.02$

Method		Bennett's test	
COYU approach	decision	uniform	not uniform
	uniform	107	15
	not uniform	79	40

Comments and Conclusions

22. In papers by Zawieja and Pilarczyk (2005, 2006) it has been shown that the COYU method and the Bennett's test applied to actual data concerning winter rye varieties did not differ statistically. It was observed that the Bennett's method was slightly more tolerant than the COYU method, but that, statistically (at $\alpha = 0.01$ level), these two methods gave the same decisions.

23. In the paper by Zawieja and others (2009), using actual oilseed rape data, it has been shown that, again, these two methods did not differ statistically, but for oilseed rape the COYU method was slightly more tolerant. In all previous investigations there were very limited numbers of candidate varieties.

24. The results obtained here, using a mixture of actual and simulated data, have shown that in some cases these two methods of testing uniformity do not differ (results for years 2006-2007). In some other cases, there were meaningful differences in decisions. The Bennett's test rejected more candidate varieties. Detailed inspection of analyzed data indicated that in all such cases the Bennett's test rejected varieties with small mean values and high standard deviations (with large coefficients of variation). COYU method was more tolerant for some of those varieties.

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