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

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Summary

Uniformity of new varieties for quantitative characteristics is usually checked using the COYU (combined over years uniformity) 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, 2007). In these papers 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.

All our previous studies were limited to one species (winter rye). The potential user of this new approach, the international organization UPOV, is interested in checking usefulness of proposed test for wider set of species, see document TWC25/8. This document and a paper by Zawieja and Pilarczyk (2007) were aimed at explanation if there was a relationship between the degree of correlation between levels of expression of characteristics 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. In this document these problems are addressed again with the use of DUS data for oilseed rape varieties.

Key words and phrases: Bennett method, COYU method, DUS testing, oil seed rape, uniformity

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1. Introduction

Every new variety of any cultivated crop before being released and entered to market must prove its distinctness, uniformity and stability (DUS). Uniformity means that plant to plant variability for that variety must not exceed such variability observed for all already existing varieties (varieties of common knowledge).

Decisions concerning DUS are based on data of field (greenhouse as well) trials performed usually at one location for three years. One of officially accepted and promoted methods of checking uniformity for cross-pollinated varieties is so-called COYU (combined over years uniformity) method. In this approach, the log transformed (and adjusted by moving average method), values of standard deviations of new varieties are compared with similar (averaged) values calculated for established varieties treated as standards. Such comparisons are made for all characteristics observed (measured) in DUS trials. If values for the new (candidate) do not exceed significantly the average values of "old" varieties (forming so-called reference set) 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.

Because sample 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 used in majority member states of UPOV. It is a slightly sophisticated method. A possible alternative is the application of a little different measure of uniformity based on coefficient of variation, see Zawieja and Pilarczyk (2005, 2006, 2007). Equality of coefficients of variation of the new (candidate) variety and of the varieties belonging to the reference set can be tested using the Bennett test, which is much simpler than COYU. The aim of the present paper is to compare decisions concerning uniformity of varieties supported by the two mentioned method. The method was applied to a set of three-years data 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 also with this problem.

2. Data

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 paper.

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

02 - Cotyledon: height, 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 investigation were performed using mean values and standard deviations calculated over 30 single plant measurements.

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

3. The method

In order to check if there were relationships between mean values and standard deviations the analysis of regression was applied. Before application of 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 decisions concerning uniformity given by two methods under comparisons the following approach was applied.

The data were analyzed twice: firstly using COYU approach and secondly using the Bennett's method. The same levels of significance for these two methods were used. For every of considered characteristics 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. Next, 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).

If n_{11} and n_{22} are the numbers 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

$H_0 : n_{11} = n_{22}$ against alternative $H_1: n_{11} \neq n_{22}$. 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.

4. The results

The described above method was applied to oilseed rape data. As mentioned earlier, the data were analysed twice. The procedure COYU of DUST package (see Weatherup 1992), was applied first, followed by analysis of the same data using the Bennett's test for coefficients of variation and, finally, the conclusions on uniformity were compared on a characteristic by characteristic basis.

An additional difficulty in the analysis of these 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.

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.

The decisions do not differ significantly (see empirical α-levels). For eight characteristics both method declared all candidate varieties uniform. For the remaining six characteristics the COYU again 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 occured 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.

In a previous comparisons with the use of rye data (papers Zawieja and Pilarczyk (2005, 2006, 2007)) the situations was slightly different. The conclusions were also statistically indistinct but the Bennett's approach was slightly 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 of standard deviations on mean values - empirical α - level	Coefficient of determination in percentage	Number of accepted varieties by COYU	Number of accepted as uniform varieties by Bennett's test	Empirical level of the McNemar test
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	–

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.

5. Comments and conclusions

The performed 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) only. However the coefficients of determination were low (respectively 9% and 34%) for these two characteristics. it means that the method of adjusting of standard deviation used in the COYU method is ineffective for majority of considered characteristic.

The COYU and Bennett's methods declared (on a characteristic by characteristic basis) exactly the same varieties uniform when tests were performed at 0.01 level. At 0.05 level the decisions were slightly (but not significantly) different. Namely the COYU method declared all six varieties uniform while the Bennet's method indicated that only two of them are uniform. These decision do not differ statistically while tested by Mc Nemar test at $\alpha = 0.01$ level.

When overall conclusions (across all characteristics) were compared, they were statistically indistinct when tested at $\alpha=0.01$ level but distinct when $\alpha=0.05$ level was used

For winter rye data (see Zawieja and Pilarczyk (2005, 2006, 2007) the Bennett's test was slightly more tolerant than COYU. The reverse situation appeared to be the case for oilseed rape data.

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

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RZEPAK OZIMY – PORÓWNANIE DECYZJI DOTYCZĄCYCH WYRÓWNANIA ODMIAN PRZY UŻYCIU METODY COYU I METODY BENNETTA

Streszczenie

Sprawdzanie **w**yrównania nowych odmian (dla cech ilościowych) wykonuje się zwykle po trzech latach doświadczeń stosując metodę COYU. W pracach Zawieji i Pilarczyka (2005, 2006, 2007) zaproponowano inną metodę testowania wyrównania odmian.

W tych pracach porównano metodę COYU oraz metodę wykorzystującą test Bennetta. Metody te stosowano do danych empirycznych dotyczących odmian żyta ozimego. Podejmowane w obu metodach decyzje były podobne, jednakże - w niektórych przypadkach, pojawiały się drobne różnice.

Dotychczasowe badania porównawcze były wykonane przy użyciu danych dla jednego gatunku. Podczas obrad Grupy Roboczej organizacji UPOV zainteresowano się nową metodą

sprawdzania wyrównania oraz zasugerowano wykonanie porównania tych dwóch metod przy użyciu danych doświadczalnych innego gatunku. Dodatkowym celem tej pracy jest sprawdzenie czy istnieje zależność pomiędzy stopniem korelacji poziomu ekspresji cechy i transformowanym (za pomocą logarytmy naturalnego) odchyleniem standardowym, a decyzjami dotyczącymi wyrównania opartymi o dwie wspomniane metody. Wszystkie rozważania przeprowadzono wykorzystując wyniki badań doświadczalnych z odmianami rzepaku ozimego.

Słowa kluczowe: metoda COYU, metoda Bennett'a, OWT, rzepak ozimy, wyrównanie

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