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|  |  | GTC/52/23ORIGINAL: englischDATUM: 27. Januar 2016 |
| INTERNATIONALER VERBAND ZUM SCHUTZ VON PFLANZENZÜCHTUNGEN  |
| Genf |

TECHNISCHER AUSSCHUSS

Zweiundfünfzigste Tagung
Genf, 14. bis 16. März 2016

Statistische Verfahren für visuell erfasste Merkmale

vom Verbandsbüro erstelltes Dokument

Haftungsausschluß: dieses Dokument gibt nicht die Grundsätze oder eine Anleitung der UPOV wieder

# ZUSAMMENFASSUNG

 Zweck dieses Dokuments ist es, über die Entwicklungen betreffend „Statistische Verfahren für visuell erfasste Merkmale“ zu berichten.

 Der TC wird ersucht:

a) zur Kenntnis zu nehmen, daß die TWF vereinbarte, daß statistische Verfahren nicht routinemäßig für Obstarten verwendet werden, und die TWO vereinbarte, daß diese nicht für die Analyse visuell erfaßter Merkmale bei der DUS-Prüfung von Zierpflanzen verwendet werden;

b) zur Kenntnis zu nehmen, daß China eingeladen wurde, ein Referat auf der vierunddreißigsten Tagung der TWC zu halten, um die in dem DUSTC-Softwarepaket für die Analyse von Unterscheidbarkeit und Homogenität verwendeten statistischen Verfahren zu beschreiben;

c) zur Kenntnis zu nehmen, daß Finnland vorhat, das neue statistische Verfahren für die Analyse sieben visuell erfasster ordinaler Merkmale bei Lieschgras, Wiesenschwingel und Rohrschwingel, Weißklee und Rotklee zu verwenden;

d) zu prüfen, ob die Benennung der verschiedenen Verfahren klargestellt werden sollte, um eine Verwechslung mit anderen bei der UPOV verwendeten Verfahren, wie beispielsweise COYD, zu vermeiden; und

e) zur Kenntnis zu nehmen, daß die TWC das Angebot von einem Sachverständigen aus Frankreich begrüßte, die Entwicklung von Software zur Umsetzung des von Sachverständigen aus Dänemark und Polen entwickelten Verfahrens in Zusammenarbeit mit Sachverständigen aus Finnland und dem Vereinigten Königreich zu untersuchen.

 Folgende Abkürzungen werden in diesem Dokument verwendet:

TC: Technischer Ausschuß

TC-EDC: Erweiterter Redaktionsausschuß

TWA: Technische Arbeitsgruppe für landwirtschaftliche Arten

TWC: Technische Arbeitsgruppe für Automatisierung und Computerprogramme

TWF: Technische Arbeitsgruppe für Obstarten

TWO: Technische Arbeitsgruppe für Zierpflanzen und forstliche Baumarten

TWP: Technische Arbeitsgruppen

TWV: Technische Arbeitsgruppe für Gemüsearten

 Der Aufbau dieses Dokuments ist nachstehend zusammengefasst:

[ZUSAMMENFASSUNG 1](#_Toc442111374)

[HINTERGRUND 2](#_Toc442111375)

[ENTWICKLUNGEN IM JAHR 2015 2](#_Toc442111376)

[Technischer Ausschuß 2](#_Toc442111377)

[Technische Arbeitsgruppen 2](#_Toc442111378)

ANLAGE Neues statistisches Verfahren für visuell erfaßte Merkmale mit multinomial verteilten Daten (nur auf Englisch)

# HINTERGRUND

 Der Hintergrund dieser Angelegenheit ist in Dokument TC/51/22 „Überarbeitung von TGP/8: Teil II: Ausgewählte Verfahren für die DUS-Prüfung, neuer Abschnitt: Statistische Verfahren für visuell erfaßte Merkmale“ dargelegt.

# ENTWICKLUNGEN IM JAHR 2015

## Technischer Ausschuß

 Der TC prüfte auf seiner einundfünfzigsten Tagung vom 23. bis 25. März 2015 in Genf das Dokument „Überarbeitung von Dokument TGP/8: Teil II: Ausgewählte Verfahren für die DUS-Prüfung, neuer Abschnitt: Statistische Verfahren für visuell erfaßte Merkmale“ (vergleiche Dokument TC/51/39 „Bericht“, Absätze 153 bis 156).

 Der TC forderte die Verbandsmitglieder dazu auf, den TWP darzulegen, auf welche Weise sie beabsichtigen, das neue statistische Verfahren für visuell erfaßte Merkmale bei der DUS-Prüfung zu verwenden.

 Der TC vereinbarte, das Dokument „Statistische Verfahren für visuell erfaßte Merkmale“ vorerst aus dem Programm für die Überarbeitung von Dokument TGP/8 herauszunehmen und die Angelegenheit unter einem getrennten Tagesordnungspunkt zu prüfen.

 Der TC nahm zur Kenntnis, daß ein Sachverständiger aus China dazu eingeladen worden war, auf der nächsten Tagung der TWC ein Referat über die Analyse visuell erfaßter Merkmale anhand des DUST China (DUSTC) Softwarepakets unter Verwendung des von Finnland bereitgestellten Datensatzes von Wiesenschwingel zu halten.

## Technische Arbeitsgruppen

 Auf ihren Tagungen im Jahr 2015 prüften die TWV, TWC und TWA entsprechend Dokumente TWV/49/20, TWC/33/26, und TWA/44/20 „*Statistical Methods for Visually Observed Characteristics*” (Statistische Verfahren für visuell erfasste Merkmale).

 Die TWV, TWC, TWA, TWF und TWO nahmen zur Kenntnis, daß der TC auf seiner einundfünfzigsten Tagung vereinbart hatte, das Dokument „Statistische Verfahren für visuell erfaßte Merkmale“ aus dem Programm für die Überarbeitung von Dokument TGP/8 herauszunehmen und die Angelegenheit unter einem getrennten Tagesordnungspunkt zu prüfen (vergleiche Dokumente TWV/49/32 Rev. „*Report*“, Absatz 77, TWC/33/30 „*Report*“, Absatz 70, TWA/44/23 „*Report*“, Absatz 60, TWF/46/29 Rev. „*Revised Report*“, Absatz 62 und TWO/48/26 „*Report*“, Absatz 71).

 Die TWV, TWC, TWA, TWF und TWO nahmen zur Kenntnis, daß die TWC einen Sachverständigen aus China eingeladen hatte, auf ihrer dreiunddreißigsten Tagung ein Referat über die Analyse visuell erfaßter Merkmale anhand des DUST China (DUSTC) Softwarepakets unter Verwendung des von Finnland bereitgestellten Datensatzes von Wiesenschwingel zu halten (vergleiche Dokumente TWV/49/32 Rev., Absatz 78, TWA/44/23, Absatz 61, TWF/46/29 Rev., Absatz 62 und TWO/48/26, Absatz 73).

 Die TWF vereinbarte, daß statistische Verfahren nicht routinemäßig für Obstarten verwendet werden (vergleiche Dokument TWF/46/29 Rev. „*Revised Report*“, Absatz 61). Die TWO vereinbarte, daß statistische Verfahren nicht für die Analyse visuell erfaßter Merkmale bei der DUS-Prüfung von Zierpflanzen verwendet werden (vergleiche Dokument TWO/48/26 „*Report*“, Absatz 70).

 Die TWC nahm die Referate von Verbandsmitgliedern darüber, wie sie beabsichtigen, das neue statistische Verfahren für visuell erfaßte Merkmale bei der DUS-Prüfung zu verwenden, zur Kenntnis, wiedergegeben in der Anlage dieses Dokuments (nur auf Englisch) (vergleiche Dokument TWC/33/30, Absätze 69 bis 76).

 Die TWC hörte ein Referat von einem Sachverständigen aus China über die „Analyse visuell erfaßter Merkmale anhand des DUST China (DUSTC) Softwarepakets“ unter Verwendung des von Finnland bereitgestellten Datensatzes für die Wuchsform bei Wiesenschwingel. Eine Abschrift des Referats steht in Dokument TWC/33/26 Add.1 Rev.zur Verfügung.

 Die TWC vereinbarte, China einzuladen, ein Referat auf der vierunddreißigsten Tagung der TWC zu halten, um die in dem DUSTC Softwarepaket für die Analyse von Unterscheidbarkeit und Homogenität verwendeten statistischen Verfahren zu beschreiben.

 Die TWC hörte ein Referat über „die Weise, auf die Verbandsmitglieder beabsichtigen, das neue statistische Verfahren für visuell erfaßte Merkmale bei der DUS-Prüfung zu verwenden“ von einem Sachverständigen aus Finnland. Eine Abschrift des Referats steht in Dokument TWC/33/26 Add.2 zur Verfügung.

 Die TWC nahm zur Kenntnis, daß Finnland vorhat, das neue statistische Verfahren für die Analyse sieben visuell erfasster ordinaler Merkmale bei Lieschgras, Wiesenschwingel und Rohrschwingel, Weißklee und Rotklee zu verwenden.

 Die TWC vereinbarte, daß die Benennung der verschiedenen Verfahren klargestellt werden sollte, um eine Verwechslung mit anderen bei der UPOV verwendeten Verfahren, wie beispielsweise COYD, zu vermeiden.

 Die TWC begrüßte das Angebot von einem Sachverständigen aus Frankreich, die Entwicklung von Software zur Umsetzung des von Sachverständigen aus Dänemark und Polen entwickelten Verfahrens (vergleiche Dokument TWC/30/19 „*Consequences of Decisions for DUS Examination when using Statistical Methods for Visually Observed Characteristics*“ (Auswirkungen der Entscheidungen für die Prüfung von Unterscheidbarkeit, Homogenität und Beständigkeit) in Zusammenarbeit mit Sachverständigen aus Finnland und dem Vereinigten Königreich zu untersuchen.

 Der TC wird ersucht:

 a) zur Kenntnis zu nehmen, daß die TWF vereinbarte, daß statistische Verfahren nicht routinemäßig für Obstarten verwendet werden, und die TWO vereinbarte, daß diese nicht für die Analyse von visuell erfaßten Merkmalen bei der DUS-Prüfung von Zierpflanzen verwendet werden;

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[Anlage folgt]

(NUR AUF ENGLISCH)

NEW STATISTICAL METHOD FOR VISUALLY OBSERVED CHARACTERISTICS
WITH MULTINOMIAL DISTRIBUTED DATA

I. ORDINAL CHARACTERISTICS

Summary of requirements for application of the method

* + The method is appropriate to use for assessing distinctness of varieties where:
	+ The characteristic is ordinal and recorded for individual plants (usually recorded visually)
	+ There are some differences between plants
	+ The observations are made over at least two years or growing cycles on a single location
	+ There should be at least 20 degrees of freedom for estimating the random variety-by-year interaction term.
	+ The distribution of the characteristic should be unimodal, i.e. notes with large number of plants should occur next to each other, zeros at one or both ends of the scale should not cause problems as long as most varieties have plants that fall in different notes
	+ The total number of plants for each variety should not be too low, at least 5 times the number of notes the variety covers

Summary

The method can be considered as an alternative to the χ2-test for independence in a contingency table. The χ2-test only takes the variation caused by random sampling into account and may thus be too liberal if additional sources of variation are present. Also the χ2-test does not take the ordering of the notes into account. The combined over-years method for ordinal characteristics takes other sources of variation into account by including a random variety-by-year interaction term (as for the COYD method described in TGP/8/1 Part II: 3).It takes the ordering of notes into account by using a cumulative function over the ordered notes. The inclusion of the random effect is expected to decrease the number of distinct pairs of varieties compared to the χ2-test for independence, but to better ensure that the decisions are consistent over coming years. Taking the ordering of notes into account is expected to increase the power of the test and thus to increase the number of distinct pairs.

The method is based on a generalisation of the traditional analyses of variance and regression methods for normally distributed data, which are called “generalized linear mixed models”. A general description of the method may be found in Agresti (2002) and a more specific description – using other examples of data may be found in Kristensen (2011).

The combined over-years method for ordinal characteristics involves

* Calculating the number of plants for each note for each variety in each of the two or three years of trials, which results in a 3-way table (see the example)
* Analyse the data using appropriate software
* Compare each candidate to the reference varieties and the other candidates at the appropriate level of significance to see which varieties the candidate is distinct from
* Check if the variety-by-year interaction term for distinct pairs is considerably larger than the average for all variety pairs

Example

For demonstration a subset of varieties from a DUS experiment with Meadow fescue (*Festuca pratensis*) in Finland was chosen. The notes for Plant: growth habit at inflorescence emergence (Characteristic 9 of TG/39/8) in 2010, 2011 and 2012 were analysed (Table 4). In most cases 40-60 plants were recorded in each year. This characteristic is rather sensitive to the growing conditions. This is apparent from table 4 where it is seen that the note 1 was recorded only in 2012 while note 7 was recorded only in 2010. Also it is seen that the most common note (over all varieties) in the three years was note, 5, 3 and 3, respectively in 2010, 2011 and 2012. The applied analysis method takes this into account by calculating an additive effect of each year (as for the COYD method for normal distributed data).

The estimated percent of plants in each note for each variety are shown in Table 2.

Table 1. Number of individual plants with each note for each variety and year for the characteristic Plant: growth habit at inflorescence emergence in Meadow fescue *(Festuca pratensis)*

|  |  |
| --- | --- |
| Variety | Note |
| 1 | 2  | 3 | 4  | 5 | 6 | 7 |
| 2010 | 2011 | 2012 | 2010 | 2011 | 2012 | 2010 | 2011 | 2012 | 2010 | 2011 | 2012 | 2010 | 2011 | 2012 | 2010 | 2011 | 2012 | 2010 | 2011 | 2012 |
| A | 0 | 0 | 2 | 0 | 2 | 20 | 4 | 27 | 23 | 1 | 23 | 5 | 32 | 2 | 8 | 4 | 0 | 1 | 0 | 0 | 0 |
| B | 0 | 0 | 0 | 0 | 1 | 20 | 1 | 12 | 21 | 9 | 5 | 11 | 29 | 0 | 5 | 8 | 0 | 0 | 0 | 0 | 0 |
| C | 0 | 0 | 0 | 0 | 4 | 24 | 3 | 21 | 21 | 1 | 21 | 7 | 30 | 7 | 6 | 8 | 1 | 1 | 0 | 0 | 0 |
| D | 0 | 0 | 2 | 0 | 6 | 17 | 7 | 35 | 23 | 6 | 11 | 14 | 31 | 1 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| E | 0 | 0 | 1 | 1 | 9 | 22 | 9 | 30 | 28 | 13 | 12 | 6 | 31 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| F | 0 | 0 | 0 | 0 | 1 | 11 | 0 | 13 | 14 | 6 | 22 | 15 | 27 | 14 | 18 | 10 | 4 | 1 | 0 | 0 | 0 |
| G | 0 | 0 | 0 | 0 | 3 | 29 | 8 | 34 | 25 | 10 | 18 | 4 | 25 | 3 | 1 | 4 | 0 | 0 | 0 | 0 | 0 |
| H | 0 | 0 | 5 | 0 | 6 | 28 | 7 | 48 | 21 | 19 | 6 | 4 | 19 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| I | 0 | 0 | 1 | 0 | 2 | 20 | 5 | 29 | 21 | 6 | 23 | 8 | 29 | 5 | 9 | 6 | 0 | 0 | 0 | 0 | 0 |
| J | 0 | 0 | 0 | 0 | 0 | 15 | 1 | 35 | 27 | 0 | 16 | 12 | 35 | 5 | 6 | 4 | 0 | 0 | 2 | 0 | 0 |
| K | 0 | 0 | 0 | 0 | 0 | 16 | 2 | 24 | 14 | 4 | 17 | 13 | 29 | 17 | 13 | 9 | 0 | 2 | 2 | 0 | 0 |
| L | 0 | 0 | 3 | 0 | 3 | 20 | 4 | 34 | 26 | 7 | 17 | 8 | 28 | 5 | 3 | 2 | 0 | 0 | 0 | 0 | 0 |
| M | 0 | 0 | 0 | 0 | 1 | 18 | 5 | 24 | 22 | 7 | 27 | 13 | 30 | 7 | 6 | 5 | 0 | 0 | 2 | 0 | 0 |
| N | 0 | 0 | 0 | 0 | 2 | 10 | 3 | 18 | 24 | 2 | 15 | 9 | 25 | 16 | 14 | 11 | 1 | 1 | 1 | 0 | 0 |
| O | 0 | 0 | 0 | 0 | 5 | 19 | 9 | 39 | 29 | 9 | 8 | 10 | 23 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0 |
| P | 0 | 0 | 2 | 0 | 9 | 23 | 13 | 30 | 32 | 7 | 4 | 3 | 19 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Q | 0 | 0 | 1 | 0 | 4 | 24 | 9 | 27 | 24 | 10 | 19 | 8 | 28 | 5 | 2 | 3 | 0 | 0 | 0 | 0 | 0 |
| R | 0 | 0 | 0 | 0 | 3 | 24 | 2 | 30 | 26 | 6 | 21 | 6 | 35 | 6 | 1 | 5 | 0 | 0 | 0 | 0 | 0 |
| S | 0 | 0 | 1 | 0 | 5 | 16 | 6 | 25 | 27 | 14 | 19 | 11 | 26 | 8 | 4 | 2 | 0 | 0 | 0 | 0 | 0 |
| T | 0 | 0 | 0 | 0 | 6 | 19 | 3 | 36 | 24 | 4 | 5 | 7 | 18 | 3 | 7 | 5 | 0 | 0 | 0 | 0 | 0 |
| U | 0 | 0 | 2 | 0 | 7 | 17 | 11 | 41 | 31 | 15 | 11 | 8 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| V | 0 | 0 | 3 | 0 | 15 | 32 | 11 | 33 | 18 | 13 | 6 | 5 | 30 | 3 | 0 | 4 | 0 | 1 | 0 | 0 | 0 |
| W | 0 | 0 | 0 | 0 | 7 | 22 | 4 | 28 | 30 | 6 | 16 | 6 | 37 | 5 | 2 | 6 | 0 | 0 | 1 | 0 | 0 |
| X | 0 | 0 | 1 | 0 | 5 | 19 | 2 | 24 | 17 | 4 | 17 | 15 | 40 | 6 | 7 | 2 | 0 | 0 | 0 | 0 | 0 |
| Y | 0 | 0 | 1 | 0 | 3 | 12 | 2 | 8 | 24 | 4 | 6 | 5 | 24 | 0 | 13 | 6 | 0 | 0 | 0 | 0 | 0 |
| Z | 0 | 0 | 0 | 0 | 1 | 14 | 1 | 25 | 17 | 2 | 16 | 15 | 26 | 10 | 13 | 10 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 2 | 0 | 6 | 24 | 5 | 38 | 24 | 8 | 9 | 8 | 34 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 1 | 4 | 20 | 5 | 29 | 26 | 5 | 16 | 11 | 37 | 5 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 2 | 0 | 10 | 24 | 7 | 28 | 27 | 8 | 12 | 4 | 30 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 1 | 0 | 9 | 17 | 7 | 31 | 28 | 6 | 10 | 9 | 30 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 3 | 14 | 1 | 24 | 26 | 9 | 22 | 16 | 36 | 8 | 4 | 5 | 0 | 0 | 0 | 0 | 0 |

Table 2. Estimated percent of plants for each note of each variety

|  |  |
| --- | --- |
| Variety | Note |
| 1 erect | 2 erect – semi erect | 3 semi erect | 4 semi erect – intermediate | 5 intermediate | 6 intermediate – semi prostrate | 7 semi prostate |
| A | 0.2 | 5.7 | 34.8 | 33.7 | 24.5 | 1.1 | 0.1 |
| B | 0.2 | 5.9 | 35.4 | 33.5 | 23.9 | 1.0 | 0.0 |
| C | 0.1 | 4.8 | 31.2 | 34.4 | 28.1 | 1.3 | 0.1 |
| D | 0.2 | 8.2 | 41.8 | 30.8 | 18.2 | 0.7 | 0.0 |
| E | 0.4 | 12.4 | 48.7 | 25.7 | 12.4 | 0.5 | 0.0 |
| F | 0.0 | 1.7 | 14.6 | 28.9 | 51.0 | 3.6 | 0.2 |
| G | 0.3 | 10.3 | 45.8 | 28.2 | 14.9 | 0.6 | 0.0 |
| H | 0.6 | 17.0 | 52.3 | 20.9 | 8.9 | 0.3 | 0.0 |
| I | 0.2 | 5.6 | 34.1 | 33.9 | 25.1 | 1.1 | 0.1 |
| J | 0.1 | 4.3 | 29.2 | 34.6 | 30.3 | 1.4 | 0.1 |
| K | 0.1 | 2.5 | 19.6 | 32.5 | 42.8 | 2.5 | 0.1 |
| L | 0.2 | 7.8 | 40.8 | 31.4 | 19.1 | 0.8 | 0.0 |
| M | 0.1 | 4.6 | 30.2 | 34.5 | 29.1 | 1.3 | 0.1 |
| N | 0.1 | 2.2 | 18.1 | 31.6 | 45.1 | 2.8 | 0.1 |
| O | 0.3 | 10.1 | 45.5 | 28.4 | 15.1 | 0.6 | 0.0 |
| P | 0.5 | 16.0 | 51.8 | 21.8 | 9.5 | 0.3 | 0.0 |
| Q | 0.3 | 8.8 | 43.1 | 30.0 | 17.1 | 0.7 | 0.0 |
| R | 0.2 | 6.7 | 37.8 | 32.7 | 21.7 | 0.9 | 0.0 |
| S | 0.2 | 7.0 | 38.8 | 32.3 | 20.8 | 0.8 | 0.0 |
| T | 0.2 | 7.9 | 41.0 | 31.2 | 18.8 | 0.7 | 0.0 |
| U | 0.4 | 12.1 | 48.4 | 25.9 | 12.7 | 0.5 | 0.0 |
| V | 0.5 | 16.5 | 52.1 | 21.4 | 9.2 | 0.3 | 0.0 |
| W | 0.2 | 7.1 | 38.9 | 32.2 | 20.7 | 0.8 | 0.0 |
| X | 0.1 | 5.2 | 32.6 | 34.2 | 26.6 | 1.2 | 0.1 |
| Y | 0.1 | 4.4 | 29.7 | 34.6 | 29.7 | 1.4 | 0.1 |
| Z | 0.1 | 2.7 | 21.3 | 33.3 | 40.3 | 2.2 | 0.1 |
| 1 | 0.3 | 10.6 | 46.2 | 27.8 | 14.5 | 0.5 | 0.0 |
| 2 | 0.2 | 6.7 | 37.8 | 32.7 | 21.7 | 0.9 | 0.0 |
| 3 | 0.4 | 12.6 | 49.0 | 25.4 | 12.2 | 0.4 | 0.0 |
| 4 | 0.3 | 9.3 | 44.1 | 29.4 | 16.3 | 0.6 | 0.0 |
| 5 | 0.1 | 4.4 | 29.7 | 34.6 | 29.7 | 1.4 | 0.1 |

The candidates were variety *A* and *B* and the remaining varieties *C, D,…, 5* were reference varieties, a measure of the differences and the P-values for testing the hypothesis of no difference between candidate and reference varieties were calculated. The differences and the *P*-values are shown in Table 6. An *F3*-value is calculated in a similar way as for COY-D for normally distributed characteristics and is used in order to ensure that the pair did not became distinct because of a very large difference in only of the years without being different in other years (TGP/8/1 Draft 13 Section 3.6.3). Therefore, a significant difference between two varieties with a high *F3*-value should be examined carefully before the final decision is taken. The *F3*‑values and their significances are also shown in Table 6.

For the data shown here candidate *A* could be separated from 11 of the reference varieties when using a 1% level of significance while candidate B could be separated form 10 of the reference varieties. The two candidates could not be separated from each other. The largest *F3-value,* 5.43, was found for variety pair *B-S* (the approximate threshold for the *F4* values to be significant is 4.98). This means that the interaction for this pair should have been considered if this pair had been distinct on this characteristic.

Table 3. Differences and F3 values together with P-values for relevant pairs of varieties

|  |  |  |
| --- | --- | --- |
| Variety | Candidate A | Candidate B |
|  | Difference | PDifference | F3 | PF3 | Difference | PDifference | F3 | PF3 |
| A | - | - | - | - | 0.03 | 0.9011 | 0.22 | 0.4051 |
| B | -0.03 | 0.9011 | 0.21 | 0.6566 | - | - | - | - |
| C | 0.19 | 0.4507 | 0.02 | 0.8782 | 0.22 | 0.4051 | 0.09 | 0.7694 |
| D | -0.39 | 0.1243 | 0.04 | 0.8522 | -0.35 | 0.1856 | 0.07 | 0.7947 |
| E | -0.84 | 0.0011 | 0.73 | 0.4154 | -0.81 | 0.0030 | 1.73 | 0.2215 |
| F | 1.26 | <.0001 | 0.56 | 0.4743 | 1.29 | <.0001 | 1.46 | 0.2584 |
| G | -0.63 | 0.0125 | 1.66 | 0.2298 | -0.60 | 0.0255 | 3.06 | 0.1144 |
| H | -1.22 | <.0001 | 1.17 | 0.3080 | -1.19 | <.0001 | 2.37 | 0.1579 |
| I | 0.03 | 0.8922 | 0.29 | 0.6041 | 0.07 | 0.8004 | 0.99 | 0.3448 |
| J | 0.30 | 0.2267 | 1.13 | 0.3146 | 0.34 | 0.2081 | 0.37 | 0.5600 |
| K | 0.88 | 0.0007 | 0.00 | 0.9669 | 0.91 | 0.0010 | 0.25 | 0.6274 |
| L | -0.33 | 0.1879 | 0.52 | 0.4895 | -0.30 | 0.2651 | 1.39 | 0.2681 |
| M | 0.24 | 0.3255 | 0.82 | 0.3878 | 0.28 | 0.2949 | 1.87 | 0.2047 |
| N | 0.99 | 0.0002 | 0.00 | 0.9734 | 1.02 | 0.0003 | 0.18 | 0.6805 |
| O | -0.61 | 0.0162 | 0.27 | 0.6151 | -0.58 | 0.0317 | 0.96 | 0.3525 |
| P | -1.15 | <.0001 | 0.24 | 0.6350 | -1.11 | 0.0001 | 0.90 | 0.3664 |
| Q | -0.47 | 0.0630 | 2.59 | 0.1421 | -0.43 | 0.1039 | 4.28 | 0.0685 |
| R | -0.17 | 0.5056 | 0.06 | 0.8115 | -0.13 | 0.6174 | 0.50 | 0.4984 |
| S | -0.22 | 0.3813 | 3.50 | 0.0943 | -0.18 | 0.4858 | 5.43 | 0.0448 |
| T | -0.34 | 0.1848 | 0.82 | 0.3879 | -0.31 | 0.2578 | 0.20 | 0.6650 |
| U | -0.82 | 0.0013 | 1.04 | 0.3352 | -0.79 | 0.0035 | 2.18 | 0.1735 |
| V | -1.18 | <.0001 | 0.03 | 0.8674 | -1.15 | <.0001 | 0.08 | 0.7799 |
| W | -0.23 | 0.3621 | 0.17 | 0.6870 | -0.19 | 0.4653 | 0.00 | 0.9662 |
| X | 0.12 | 0.6441 | 0.00 | 0.9863 | 0.15 | 0.5764 | 0.23 | 0.6444 |
| Y | 0.27 | 0.3246 | 0.19 | 0.6753 | 0.30 | 0.2936 | 0.00 | 0.9791 |
| Z | 0.77 | 0.0032 | 0.64 | 0.4435 | 0.80 | 0.0038 | 0.12 | 0.7404 |
| 1 | -0.66 | 0.0093 | 0.00 | 0.9861 | -0.63 | 0.0196 | 0.23 | 0.6443 |
| 2 | -0.17 | 0.5049 | 0.15 | 0.7116 | -0.13 | 0.6165 | 0.71 | 0.4219 |
| 3 | -0.87 | 0.0009 | 0.07 | 0.8017 | -0.83 | 0.0026 | 0.52 | 0.4907 |
| 4 | -0.53 | 0.0393 | 0.03 | 0.8714 | -0.49 | 0.0684 | 0.09 | 0.7760 |
| 5 | 0.27 | 0.2712 | 0.31 | 0.5938 | 0.31 | 0.2471 | 1.03 | 0.3376 |

In order to examine whether one or more varieties have a different variety by year interaction than the main part of the varieties, the actual contribution to the interaction was calculated for each variety and compared to the average contribution from all varieties. This was done using an *F*- value, *F4.*

The *F4* values for each variety in the analysis are shown in Figure 2. The largest *F4-*value*,* 2.78, was found for variety *S* (the approximate threshold for the *F4-*values to be significant is 4.98)*.* This value was not significantly larger than 1. The *F4*-value is calculated as the quotients between the each varieties contribution to the overall interaction and the average interaction over all varieties. As the contribution for the actual variety enters in both the numerator and denominator of the *F4*-valuethis test is approximate.

 It is also seen that some varieties, e.g. *I, K, N, X, 1, 2, 3* and *5* have a very low interaction with year indicating that their response to year is very close to the mean reaction for all varieties.

|  |
| --- |
|  |
| **Figure 1. *F4*-values for each variety’s contribution to the interaction for ordinal characteristic growth habit**  |

II. NOMINAL CHARACTERISTICS

Summary of requirements for application of the method

The method is appropriate to use for assessing distinctness of varieties where:

* The characteristic is nominal and recorded for individual plants (usually recorded visually)
* There are some differences between plants
* The observations are made over at least two years or growing cycles on a single location
* There should be at least 20 degrees of freedom for estimating the random variety-by-year interaction term.
* The expected number of plants for each combination of variety and note should be at least one – and for most of the combinations the number should be at least 5.

Summary

The method can be considered as an alternative to the χ2-test for independence in a contingency table. The χ2-test only takes the variation caused by random sampling into account and may thus be too liberal if additional sources of variation are present. The combined over-years method for nominal characteristics takes other sources of variation into account by including a random variety-by-year interaction term (as for the COYD method described in TGP/8/1 Part II: 3). The inclusion of the random effect is expected to decrease the number of distinct pairs of varieties compared to the χ2-test for independence, but to better ensure that the decisions are consistent over coming years. The method is based on a generalisation of the traditional analyses of variance and regression methods for normally distributed data, which are called “generalized linear mixed models”. A detailed description of the method – using other examples of data may be found in Agresti (2002) or Kristensen (2011).

The combined over-years method for nominal characteristics involves

* Calculating the number of plants for each note for each variety in each of the two or three years of trials, which results in a 3-way table (see the example)
* Analyse the data using appropriate software
* Compare each candidate to the reference varieties and the other candidates at the appropriate level of significance to see which varieties the candidate is distinct from
* Check if the variety-by-year interaction term for distinct pairs is considerably larger than the average for all variety pairs

Example

No example shown at present.

III. BINOMIAL CHARACTERISTICS

Summary of requirements for application of the method

The method is appropriate to use for assessing distinctness of varieties where:

* The characteristic is recorded for individual plants (usually recorded visually) using a scale with only 2 levels (such as present/absent or similar)
* There are some differences between plants
* The observations are made over at least two years or growing cycles on a single location
* There should be at least 20 degrees of freedom for estimating the random variety-by-year interaction term.
* The expected number of plants for each combination of variety and note should be at least one – and for most of the combinations the number should be at least 5.

Summary

The method can be considered as an alternative to the χ2-test for independence in a contingency table. The χ2-test only takes the variation caused by random sampling into account and may thus be too liberal if additional sources of variation are present. The combined over-years method for binomial characteristics take other sources of variation into account by including a random variety-by-year interaction term (as for the COYD method described in TGP/8/1 Part II: 3). The inclusion of the random effect is expected to decrease the number of distinct pairs of varieties compared to the χ2-test for independence, but to better ensure that the decisions are consistent over coming years.

The method is based on generalisation of the traditional analyses of variance and regression methods for normally distributed data, which are called “generalized linear mixed models”.

The combined over-years method for binomial characteristics involves

* Calculating the number of plants for each note for each variety in each of the two or three years of trials, which results in a 3-way table
* Analyse the data using appropriate software
* Compare each candidate to the reference varieties and the other candidates at the appropriate level of significance to see which varieties the candidate is distinct from
* Check if the variety-by-year interaction term for distinct pairs is considerably larger than the average for all variety pairs

Example

The proportion of plants with cyanid glucoside (Characteristic 4 in TG/38/7) was measured for some white clover varieties in Northern Ireland in each of 3 years. The variable was recorded as absent or present. In this example only 20 varieties are used and variety 1 and 2 are considered as candidates, while the remaining varieties are considered as references. The data are shown in Table 7.

**Table 4. Number of plants without and with cyanid glucoside in 20 white clover varieties in each of 3 years**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Year 1 | Year 2 | Year 3 |
| Variety | Absent | Present | Absent | Present | Absent | Present |
| 1 | 31 | 29 | 22 | 38 | 17 | 43 |
| 2 | 40 | 20 | 42 | 18 | 41 | 19 |
| 3 | 50 | 10 | 52 | 8 | 55 | 5 |
| 4 | 42 | 18 | 40 | 20 | 34 | 26 |
| 5 | 37 | 23 | 42 | 18 | 37 | 23 |
| 6 | 51 | 9 | 49 | 11 | 52 | 8 |
| 7 | 30 | 30 | 25 | 35 | 26 | 34 |
| 8 | 37 | 23 | 31 | 29 | 30 | 30 |
| 9 | 27 | 33 | 27 | 33 | 25 | 35 |
| 10 | 48 | 12 | 47 | 13 | 43 | 17 |
| 11 | 40 | 20 | 40 | 20 | 32 | 28 |
| 12 | 18 | 42 | 13 | 47 | 12 | 48 |
| 13 | 10 | 50 | 12 | 48 | 5 | 55 |
| 14 | 41 | 19 | 46 | 14 | 45 | 15 |
| 15 | 58 | 2 | 55 | 5 | 58 | 2 |
| 16 | 7 | 53 | 10 | 50 | 11 | 49 |
| 17 | 25 | 35 | 22 | 38 | 20 | 40 |
| 18 | 48 | 12 | 54 | 6 | 52 | 8 |
| 19 | 20 | 40 | 20 | 40 | 23 | 37 |
| 20 | 57 | 3 | 54 | 6 | 55 | 5 |

The analysis showed that for these data there was no interaction between variety and year, which means that the variance component for year by variety was estimated to be zero and thus all variation in the data could be explained by sampling variation. The F-test for comparing the varieties was 36.67 with a P-value less than 0.01%, so there were clearly some differences among the varieties.

More specifically the analysis showed that candidate variety 1 was significantly different from 12 of the reference varieties at the 1% level (Table 8) whereas candidate variety 2 was significantly different from 11 of the reference varieties. Also the two candidate varieties were significantly different at the 1% level (Table 8).

As there was no interaction between variety and year, all *F3* and *F4* values are estimated to be zero for these data. Therefore, they are not shown here.**Table 5. Estimated percent of plants with cyanid glucoside for each variety and comparison of each variety with the candidate varieties 1 and 2 using F-tests**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Estimated percent | Candidate 1 | Candidate 2 |
| Variety | F | P | F | P |
| 1 | 61.1 |  |  | 30.45 | <.0001 |
| 2 | 31.6 | 30.45 | <.0001 |  |  |
| 3 | 12.7 | 77.01 | <.0001 | 17.58 | 0.0002 |
| 4 | 35.5 | 23.05 | <.0001 | 0.61 | 0.4395 |
| 5 | 35.5 | 23.05 | <.0001 | 0.61 | 0.4395 |
| 6 | 15.5 | 70.09 | <.0001 | 12.54 | 0.0011 |
| 7 | 55.0 | 1.38 | 0.2473 | 19.58 | <.0001 |
| 8 | 45.5 | 8.69 | 0.0054 | 7.27 | 0.0104 |
| 9 | 56.1 | 0.93 | 0.3414 | 21.39 | <.0001 |
| 10 | 23.3 | 49.59 | <.0001 | 3.12 | 0.0853 |
| 11 | 37.8 | 19.27 | <.0001 | 1.48 | 0.2309 |
| 12 | 76.1 | 9.28 | 0.0042 | 66.21 | <.0001 |
| 13 | 85.0 | 24.61 | <.0001 | 90.68 | <.0001 |
| 14 | 26.6 | 41.43 | <.0001 | 1.09 | 0.3034 |
| 15 | 5.0 | 82.34 | <.0001 | 33.21 | <.0001 |
| 16 | 84.5 | 23.44 | <.0001 | 89.25 | <.0001 |
| 17 | 62.8 | 0.11 | 0.7463 | 33.81 | <.0001 |
| 18 | 14.4 | 72.95 | <.0001 | 14.45 | 0.0005 |
| 19 | 65.0 | 0.58 | 0.4492 | 38.53 | <.0001 |
| 20 | 7.8 | 84.99 | <.0001 | 28.18 | <.0001 |

IV. COMMON TO ALL THREE METHODS

Software

The procedure *GLIMMIX* of *SAS* (SAS Institute Inc., 2010) can be used to estimate the parameters of the generalised linear mixed model, and the data-step facilities (and/or the procedure *IML*) of the same package can be used for the remaining calculations. However, similar facilities may be found in other statistical packages, thus the *glmer*() function of the package *lme4* of R can do the binomial analysis provided that there are more than one observation for each combination of variety and year.

Final note

In the case where there are only two notes, the methods for nominal and ordinal scaled characteristics both become identical as they reduce to the same binomial method: meaning that both methods can be applied to binomially distributed data.

References and literature

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[Ende der Anlage und des Dokuments]