UPOV

Unión Internacional para la Protección de las Obtenciones Vegetales

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Comité Técnico	**TC/53/24**
Quincuagésima tercera sesión **Ginebra, 3 a 5 de abril de 2017**	**Original:** Inglés **Fecha:** 21 de febrero de 2017

MÉTODOS ESTADÍSTICOS APLICADOS A CARACTERES OBSERVADOS VISUALMENTE

Documento preparado por la Oficina de la Unión

Descargo de responsabilidad: el presente documento no constituye un documento de política u orientación de la UPOV

RESUMEN

1.   El propósito del presente documento es informar acerca de las novedades relativas a los "Métodos estadísticos aplicados a caracteres observados visualmente".

2.   Se invita al TC a tomar nota de que:

a)   el TWC y el TWA tomaron nota de que el experto de Francia presentará una ponencia al TWC, en su trigésima quinta sesión que se celebrará en 2017, sobre el estudio de desarrollo de programas informáticos para la aplicación del método elaborado por expertos de Dinamarca y Polonia;

b)   el TWC estuvo de acuerdo y el TWA tomó nota sobre la necesidad de considerar una nomenclatura y un proyecto de orientación adecuados para el método elaborado por expertos de Dinamarca y Polonia, una vez que se hubiese adquirido experiencia y el programa informático estuviese disponible para facilitar su aplicación en el examen DHE; y

c)   el TWA había observado que China había presentado una ponencia en la trigésima cuarta sesión del TWC para describir los métodos estadísticos utilizados en el conjunto de programas informáticos DUSTC para el análisis de la distinción y la homogeneidad.

3.   En el presente documento se utilizan las abreviaturas siguientes:

TC:	Comité Técnico
TC-EDC:	Comité de Redacción Ampliado
TWA:	Grupo de Trabajo Técnico sobre Plantas Agrícolas
TWC:	Grupo de Trabajo Técnico sobre Automatización y Programas Informáticos
TWF:	Grupo de Trabajo Técnico sobre Plantas Frutales
TWO:	Grupo de Trabajo Técnico sobre Plantas Ornamentales y Árboles Forestales
TWP:	Grupos de Trabajo Técnico
TWV:	Grupo de Trabajo Técnico sobre Hortalizas

4.   La estructura del presente documento es la siguiente:

ANTECEDENTES

5.   En su quincuagésima primera sesión, celebrada en Ginebra del 23 al 25 de marzo de 2015, el TC examinó el documento TC/51/22 "Revisión del documento TGP/8:   Parte II: Técnicas utilizadas en el examen DHE, nueva sección: Métodos estadísticos aplicados a caracteres observados visualmente" (véanse los párrafos 153 a 156 del documento TC/51/39 "Informe").

6.   El TC instó a los miembros de la Unión a presentar a los TWP la manera en que tienen previsto emplear el nuevo método estadístico para los caracteres observados visualmente en el examen DHE que se reproduce en el Anexo del presente documento (véase el Anexo del documento TC/52/23 "Métodos estadísticos aplicados a caracteres observados visualmente"

7.   El TC convino en eliminar el documento "Métodos estadísticos aplicados a caracteres observados visualmente" del programa de revisión del documento TGP/8 y examinar la cuestión en un punto diferente del orden del día.

8.   Los antecedentes recientes de esta cuestión se facilitan en el documento TC/52/23 "Métodos estadísticos aplicados a caracteres observados visualmente".

NOVEDADES ACAECIDAS EN 2016

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9.   En su quincuagésima segunda sesión, celebrada en Ginebra del 14 al 16 de marzo de 2016, el TC examinó el documento TC/52/23 "Métodos estadísticos aplicados a caracteres observados visualmente" (véanse los párrafos 148 a 153 del documento TC/52/29 Rev. "Informe revisado").

10.   El TC tomó nota de que el TWF había convenido en que no se utilizan habitualmente métodos estadísticos en el ámbito de las plantas frutales, y de que el TWO había convenido en que no se utilizan para el análisis de caracteres observados visualmente en el examen DHE de plantas ornamentales.

11.   El TC tomó nota de que se había invitado a China a presentar una ponencia en la trigésima cuarta sesión del TWC para describir los métodos estadísticos utilizados en el conjunto de programas informáticos DUSTC para el análisis de la distinción y la homogeneidad.

12.   El TC tomó nota de que Finlandia tenía previsto emplear el nuevo método estadístico descrito en el Anexo del documento TC/52/23 para el análisis de siete caracteres ordinales observados visualmente en fleo, festuca pratense y festuca alta, trébol blanco y trébol rojo.

13.   El TC convino en que procede aclarar la nomenclatura de los diferentes métodos para evitar su confusión con otros métodos utilizados en la UPOV, como el COYD.

14.   El TC tomó nota de que el TWC había acogido con agrado el ofrecimiento de un experto de Francia de estudiar el desarrollo de programas informáticos para la aplicación del método elaborado por expertos de Dinamarca y Polonia, en colaboración con expertos de Finlandia y el Reino Unido.

Grupos de Trabajo Técnico

15.   En sus sesiones de 2016, el TWC el TWA examinaron, respectivamente los documentos TWC/34/18 y TWA/45/23 "*Statistical Methods for Visually Observed Characteristics*" (Métodos estadísticos aplicados a caracteres observados visualmente).

16.   El TWC y el TWA tomaron nota de que el experto de Francia presentará una ponencia al TWC, en su trigésima quinta sesión que se celebrará en 2017, sobre el estudio de desarrollo de programas informáticos para la aplicación del método elaborado por expertos de Dinamarca y Polonia (véanse los documentos TWC/34/32 "*Report*" (Informe), párrafo 87, y TWA/45/25 "*Report*", párrafo 74).

17.   El TWC estuvo de acuerdo y TWA tomó nota sobre la necesidad de considerar una nomenclatura y un proyecto de orientación adecuados para el método elaborado por expertos de Dinamarca y Polonia, una vez que se hubiese adquirido experiencia y el programa informático estuviese disponible para facilitar su aplicación en el examen DHE (véanse los documentos TWC/34/32 "*Report*", párrafo 88, y TWA/45/25 "*Report*", párrafo 73).

18.   El TWA tomó nota de que China había presentado una ponencia en la trigésima cuarta sesión del TWC para describir los métodos estadísticos utilizados en el conjunto de programas informáticos DUSTC para el análisis de la distinción y la homogeneidad (véase el párrafo 72 del documento TWA/45/25 "*Report*").

19. Se invita al TC a tomar nota de que :

a)   el TWC y el TWA tomaron nota de que el experto de Francia presentará una ponencia al TWC, en su trigésima quinta sesión que se celebrará en 2017, sobre el estudio de desarrollo de programas informáticos para la aplicación del método elaborado por expertos de Dinamarca y Polonia;

b)   el TWC estuvo de acuerdo y el TWA tomó nota sobre la necesidad de considerar una nomenclatura y un proyecto de orientación adecuados para el método elaborado por expertos de Dinamarca y Polonia, una vez que se hubiese adquirido experiencia y el programa informático estuviese disponible para facilitar su aplicación en el examen DHE; y

c)   el TWA había observado que China había presentado una ponencia en la trigésima cuarta sesión del TWC para describir los métodos estadísticos utilizados en el conjunto de programas informáticos DUSTC para el análisis de la distinción y la homogeneidad.

[Sigue el Anexo]

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 χ^2-test for independence in a contingency table. The χ^2-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 χ^2-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 χ^2-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	2	3	4	5	6	7
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 F_3-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 F_3-value should be examined carefully before the final decision is taken. The F_3-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 F_3-*value,* 5.43, was found for variety pair *B-S* (the approximate threshold for the F_4 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 F_3 values together with P-values for relevant pairs of varieties

Variety	Candidate A				Candidate B			
	Difference	$P_{Difference}$	F_3	P_{F3}	Difference	$P_{Difference}$	F_3	P_{F3}
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, F_4.

The F_4 values for each variety in the analysis are shown in Figure 2. The largest F_4-value, 2.78, was found for variety S (the approximate threshold for the F_4-values to be significant is 4.98). This value was not significantly larger than 1. The F_4-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 F_4-value this 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.
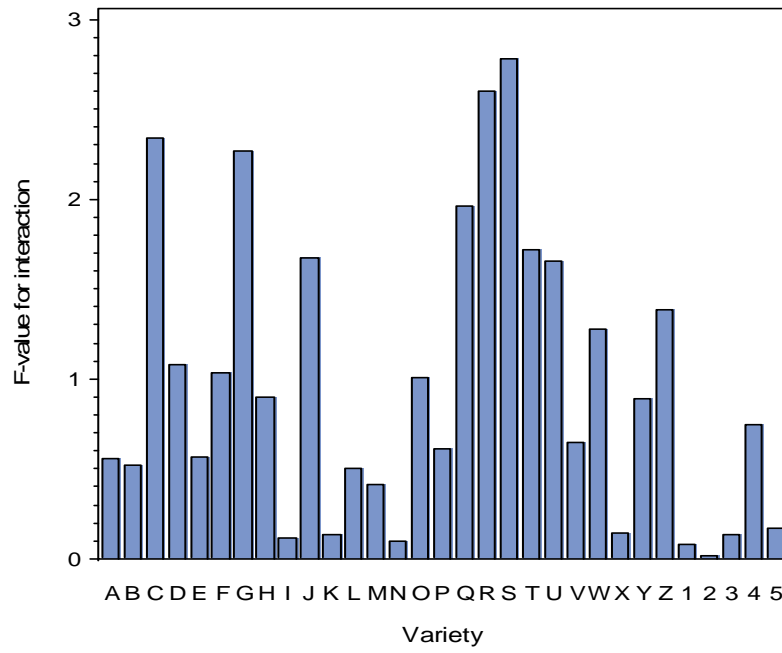
Figure 1. F_4-values for each variety's contribution to the interaction for ordinal characteristic growth habit

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 χ^2-test for independence in a contingency table. The χ^2-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 χ^2-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 χ^2-test for independence in a contingency table. The χ^2-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 χ^2-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

Variety	Year 1		Year 2		Year 3	
	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 F_3 and F_4 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

Variety	Estimated percent	Candidate 1		Candidate 2	
		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

Agresti, A., 2002, Categorical data analysis, 2nd edition. Wiley & Sons, Inc. 710 pp.

Kristensen, K. 2011 Analyses of visually accessed data from DUS trials using a combined over years analysis for testing distinctness. Biuletyn Oceny Odmian (Cultivar Testing Bulletin) 33, 49-62.

SAS Institute Inc. 2010, SAS/STAT® 9.22 User's Guide. Cary, NC: SAS Institute Inc.8460 pp. (online access: http://support.sas.com/documentation/cdl/en/statug/63347/PDF/default/statug.pdf, accessed 15th November 2010)

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