UPOV

F

Union internationale pour la protection des obtentions végétales

Comité technique	**TC/53/24**
Cinquante-troisième session **Genève, 3-5 avril 2017**	**Original :** anglais **Date :** 21 février 2017

METHODES STATISTIQUES APPLICABLES AUX CARACTERES OBSERVES VISUELLEMENT

Document établi par le Bureau de l'Union

Avertissement : le présent document ne représente pas les principes ou les orientations de l'UPOV

RESUME

1.   L'objet du présent document est de faire rapport sur les faits nouveaux concernant les "Méthodes statistiques applicables aux caractères observés visuellement".

2.   Le TC est invité à noter que :

a)   le TWC et le TWA ont pris note que l'expert de la France rendrait compte, à la trente-cinquième session du TWC, qui se tiendra en 2017, des avancées concernant l'étude visant à mettre au point un logiciel capable d'appliquer la méthode élaborée par les experts du Danemark et de la Pologne;

b)   le TWC est convenu et le TWA a pris note qu'il conviendrait de se pencher sur la désignation appropriée et les orientations en matière de rédaction de la méthode élaborée par des experts du Danemark et de la Pologne une fois que l'on aurait acquis une plus grande expérience et disposerait d'un logiciel capable de faciliter l'utilisation de cette méthode dans le cadre de l'examen DHS; et

c)   le TWA a indiqué que la Chine avait présenté un exposé à la trente-quatrième session du TWC, afin de décrire les méthodes statistiques utilisées dans le progiciel DUST China (DUSTC) pour l'analyse de la distinction et de l'homogénéité.

3.   Les abréviations ci-après sont utilisées dans le présent document :

TC :	Comité technique
TC-EDC :	Comité de rédaction élargi
TWA :	Groupe de travail technique sur les plantes agricoles
TWC :	Groupe de travail technique sur les systèmes d'automatisation et les programmes d'ordinateur
TWF :	Groupe de travail technique sur les plantes fruitières
TWO :	Groupe de travail technique sur les plantes ornementales et les arbres forestiers
TWP :	Groupes de travail techniques
TWV :	Groupe de travail technique sur les plantes potagères

4.   Le présent document est structuré comme suit :

CONTEXTE

5.   À sa cinquante et unième session tenue à Genève du 23 au 25 mars 2015, le TC a examiné le document TC/51/22 "Révision du document TGP/8 : deuxième partie : Techniques utilisées dans l'examen DHS, nouvelle section : Méthodes statistiques applicables aux caractères observés visuellement" (voir les paragraphes 153 à 156 du document TC/51/39, intitulé, "Compte rendu").

6.   Le TC a encouragé les membres de l'Union à expliquer aux TWP comment ils envisagent d'utiliser la nouvelle méthode statistique applicable aux caractères observés visuellement aux fins de l'examen DHS, dont une copie figure à l'annexe du présent document (voir l'annexe du document TC/52/23 intitulé "Méthodes statistiques applicables aux caractères observés visuellement").

7.   Le TC est convenu de retirer le document "Méthodes statistiques applicables aux caractères observés visuellement" du programme de révision du document TGP/8 pour le moment et de l'examiner au titre d'un point de l'ordre du jour distinct.

8.   L'historique récent de cette question figure dans le document TC/52/23, intitulé, "Méthodes statistiques applicables aux caractères observés visuellement".

FAITS NOUVEAUX INTERVENUS EN 2016

Comité technique

9.   Le TC, à sa cinquante-deuxième session tenue à Genève du 14 au 16 mars 2016, a examiné le document TC/52/23, intitulé "Méthodes statistiques applicables aux caractères observés visuellement" (voir les paragraphes 148 à 153 du document TC/52/29 Rev., intitulé, "Compte rendu révisé").

10.   Le TC a noté que le TWF était convenu que ces méthodes statistiques n'étaient pas couramment utilisées pour les plantes fruitières et que le TWO était convenu que ces méthodes n'étaient pas utilisées pour l'analyse des caractères observés visuellement dans l'examen DHS des plantes ornementales.

11.   Le TC a noté que la Chine avait été invitée à présenter un exposé à la trente-quatrième session du TWC, afin de décrire les méthodes statistiques utilisées dans le progiciel DUST China (DUSTC) pour l'analyse de la distinction et de l'homogénéité.

12.   Le TC a noté que la Finlande envisageait d'utiliser la nouvelle méthode statistique décrite dans l'annexe au document TC/52/23 pour l'analyse de sept caractères ordinaux observés visuellement chez la fléole, la fétuque des prés et la fétuque élevée, le trèfle blanc et le trèfle violet.

13.   Le TC est convenu que le nom des différentes méthodes devrait être clarifié afin d'éviter toute confusion avec d'autres méthodes utilisées à l'UPOV, telles que la méthode COYD.

14.   Le TC a noté que le TWC avait accueilli avec satisfaction l'offre de l'expert de la France d'examiner la possibilité de mettre au point un logiciel capable d'appliquer la méthode élaborée par les experts du Danemark et de la Pologne, en collaboration avec des experts de la Finlande et du Royaume-Uni.

Groupes de travail techniques

15.   À leurs sessions de 2016, le TWC et le TWA ont respectivement examiné les documents TWC/34/18, et TWA/45/23 "*Statistical Methods for Visually Observed Characteristics*".

16.   Le TWC et le TWA ont noté que l'expert de la France rendrait compte, à la cinquante-cinquième session du TWC, qui se tiendra en 2017, des avancées concernant l'étude visant à mettre au point un logiciel capable d'appliquer la méthode élaborée par les experts du Danemark et de la Pologne (voir le paragraphe 87 du document TWC/34/32, intitulé, "Report" et le paragraphe 74 du document TWA/45/25, intitulé, "Report").

17.   Le TWC est convenu et le TWA a noté qu'il conviendrait de se pencher sur la désignation appropriée et les orientations pour la rédaction de la méthode mise au point par les experts du Danemark et de la Pologne une fois qu'une plus grande expérience aurait été acquise et que l'on disposerait d'un logiciel apte à

faciliter l'utilisation de cette méthode dans le cadre de l'examen DHS (voir le paragraphe 88 du document TWC/34/32, intitulé, "Report", et le paragraphe 73 du document TWA/45/25, intitulé, "Report").

18. Le TWA a pris note que la Chine avait présenté un exposé à la trente-quatrième session du TWC, afin de décrire les méthodes statistiques utilisées dans le progiciel DUST China (DUSTC) pour l'analyse de la distinction et de l'homogénéité (voir le paragraphe 72 du document TWA/45/25, intitulé, "Report").

19. Le TC est invité à noter que :

a) le TWC et le TWA ont pris note que l'expert de la France rendrait compte, à la trente-cinquième session du TWC, qui se tiendra en 2017, des avancées concernant l'étude visant à mettre au point un logiciel capable d'appliquer la méthode élaborée par les experts du Danemark et de la Pologne;

b) le TWC est convenu et le TWA a pris note qu'il conviendrait de se pencher sur la désignation appropriée et les orientations de rédaction de la méthode mise au point par les experts du Danemark et de la Pologne, une fois qu'une plus grande expérience aurait été acquise et que l'on disposerait d'un logiciel apte à faciliter l'utilisation de cette méthode dans le cadre de l'examen DHS; et

c) le TWA a pris note que la Chine avait présenté un exposé à la trente-quatrième session du TWC, afin de décrire les méthodes statistiques utilisées dans le progiciel DUST China (DUSTC) pour l'analyse de la distinction et de l'homogénéité.

[L'annexe suit]

ANNEXE
(EN ANGLAIS SEULEMENT)

NOUVELLE METHODE STATISTIQUE APPLICABLE AUX CARACTERES OBSERVES VISUELLEMENT
AVEC DES DONNEES A DISTRIBUTION MULTINOMIALE

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.
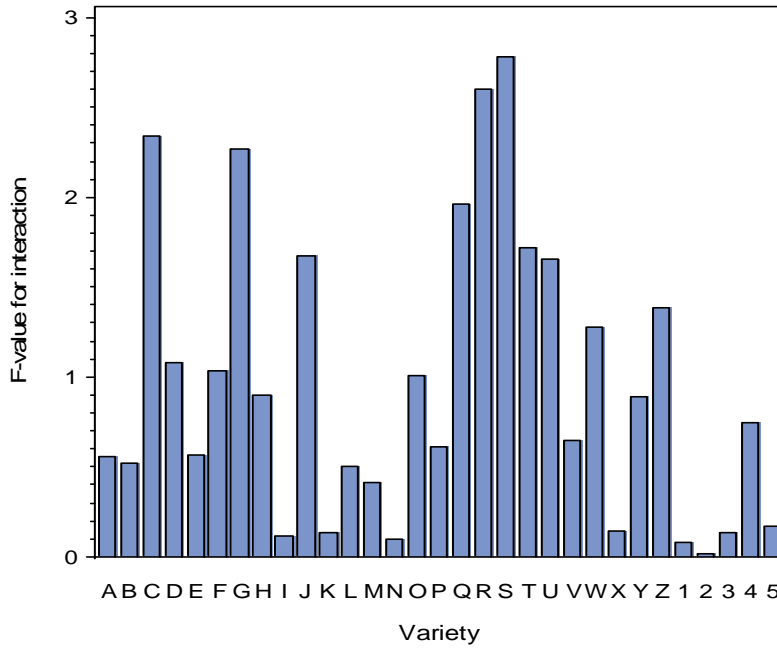
Figure 1. F_4-values for each variety's contribution to the interaction for ordinal characteristic growth habit

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)

[Fin de l'annexe et du document]