

Technical Working Party on Automation and Computer Programs TWC/36/6**Thirty-Sixth Session
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**IMPACT OF THE NUMBER OF GROWING CYCLES ON VARIETY DESCRIPTIONS
AND DISCRIMINATION POWER***Document prepared by an expert from Germany**Disclaimer: this document does not represent UPOV policies or guidance***INTRODUCTION**

1. The TC, at its fifty-third session, held from April 3 to 5, 2017, considered the presentations made by experts at the TWP sessions in 2016, simulating the impact of using different numbers of growing cycles on DUS decisions using actual data, as set out in the Annexes to document TC/53/21 (see document TC/53/31, paragraph 184).
2. The TC noted the offers by members of the Union to make presentations to the TWPs, at their sessions in 2017, on the impact of using different numbers of growing cycles on DUS decisions using actual data and agreed to invite the TWPs to report to the TC, at its session in 2018 (see document TC/53/31, paragraph 185).
3. The TC noted the expression of interest by Authorities to reduce the costs associated with DUS examination and agreed that the number of growing cycles for DUS examination should be the minimum necessary for a robust DUS decision and the establishment of a reliable variety description (see document TC/53/31, paragraph 186).
4. The TC agreed that it was not appropriate to generalize that ornamental varieties should be examined in a single growing trial while other types of crops should be examined in two growing cycles and agreed that the typical number of growing cycles should be established on a crop-by-crop basis (see document TC/53/31, paragraph 187).
5. The TWA, at its forty-sixth session held in Hanover, Germany, from June 19 to 23, 2017, agreed that discussions on the number of growing cycles in DUS examination for agricultural crops should continue and welcomed the offers by Australia, Denmark, France, Germany, the United Kingdom and ISF to make presentations at its forty-seventh session (see document TWA/46/10, paragraph 41).
6. This document provides examples for wheat, barley and potato based on actual data from DUS examinations in Germany as considered by the TWA at its sessions in 2017 and 2018. The related documents TWA/46/8 Annex I and TWA/47/5 are provided as Annexes I and II to this document, respectively.

DEVELOPMENTS AT THE TECHNICAL WORKING PARTY FOR AGRICULTURAL CROPS

7. The developments at the TWA at its forty-sixth session, held in Hanover, Germany, in 2017, were summarized in document TWA/46/10, paragraph 36 to 41, as follows:

“36. The TWA considered documents [TWP/1/21](#), [TWA/46/8](#) and [TWA/46/8 Add.](#)

“37. The TWA noted the presentations made to the TWPs at their sessions in 2016, simulating the impact of using different numbers of growing cycles on DUS decisions using actual data, as set out in the Annexes to document TWP/1/21.

“38. The TWA noted that the TC had agreed that the number of growing cycles for DUS examination should be the minimum necessary for a robust DUS decision and the establishment of a reliable variety description.

“39. The TWA noted that the TC had agreed that it was not appropriate to generalize that ornamental varieties should be examined in a single growing trial while other types of crops should be examined in two growing cycles. It noted further that the TC had agreed that the typical number of growing cycles should be established on a crop-by-crop basis.

“40. The TWA received the following presentations, as reproduced in documents TWA/46/8 and TWA/46/8 Add.:

(a)	“Impact of number of growing cycles on variety descriptions and discrimination power in wheat and barley”, prepared by an expert from Germany
(b)	“Number of Growing Cycles in Potato”, prepared by an expert from the Netherlands
(c)	“Number of growing cycles in potato varieties - DUS examination of lightsprouts”, prepared by an expert from Poland
(d)	“Number of growing cycles: the impact on cereal variety descriptions”, prepared by an expert from the United Kingdom

“41. The TWA agreed that discussions on the number of growing cycles in DUS examination for agricultural crops should continue and welcomed the offers by Australia, Denmark, France, Germany, the United Kingdom and ISF to make presentations at its forty-seventh session.”

8. The TWA at its forty-seventh session held in Naivasha, Kenya, in 2018 (document TWA/47/7, paragraphs 35 to 38) concluded as follows:

“35. The TWA considered document TWA/47/5 “Impact of the number of growing cycles on descriptions and discrimination power in potato” and received a presentation by an expert from Germany, a copy of which would be provided as document TWA/47/5 Add.

“36. The TWA agreed that variety descriptions generated over two growing cycles were more robust than those generated over a single growing cycle. The TWA agreed that two growing cycles allowed a more robust assessment of individual characteristics.

“37. The TWA agreed that a robust decision on distinctness could be reached after a single growing cycle on the basis of sufficiently large differences in characteristics.

“38. The TWA noted that DNA-marker information could provide supporting information in the DUS examination, as set out in document TGP/15 “Guidance on the Use of Biochemical and Molecular Markers in the Examination for Distinctness, Uniformity and Stability (DUS)”. The TWA noted the experience reported by the Netherlands that DNA-marker information was also used for enforcing plant breeders’ rights in combination with side-by-side verification of conformity of plant material to a protected variety.”

[Annexes follow]

IMPACT OF NUMBER OF GROWING CYCLES ON VARIETY DESCRIPTIONS AND DISCRIMINATION POWER IN WHEAT AND BARLEY

The impact of the number of growing cycles was analyzed for quantitative characteristics in wheat and barley on the basis of data from DUS trials.

Material and methods

Discrimination power of individual characteristics was calculated in three steps:

- (a) '1 cycle': Comparison of all varieties in the growing trial (year 0)
- (b) '2 cycles': For all varieties which were also grown in the year before, distinctness was assessed in both years (year 0 / -1). Two varieties are considered to be distinct if a clear difference in the same direction was observed in both years.
- (c) '2 out of 3 cycles': For all varieties which were also grown the two previous years, distinctness was assessed in all 3 years (year 0 / -1 / -2). Two varieties are considered to be distinct if a clear difference in the same direction was observed in at least 2 out of 3 years.

The German DUS growing trials comprise about 600 varieties in winter wheat and 300 varieties in winter barley. Three year data are available for about 50% of the varieties and two year data for about 70% of the varieties. Every year, the distinctness test includes about 40,000 pairwise 1-cycle-comparisons in wheat and 30,000 in barley (under consideration of some grouping characteristics). About 25,000 2-cycle-comparisons and 15,000 2 out of 3 comparisons were considered in wheat, 15,000 and 6,000 in barley, respectively.

The same analysis was performed for 2014, 2015 and 2016. The discrimination power was calculated in percent pairwise comparisons in which a clear difference was observed. The mean discrimination power over the three years was calculated

A different data set was used to calculate the impact of the number of growing cycles on variety descriptions. DUS observations for 77 winter wheat varieties and 47 winter barley varieties in 6 successive growing cycles were used to establish annual descriptions (year 0). In addition, descriptions over 2 cycles (year 0 / -1) and 3 cycles (year 0 / -1 / -2) were established. The variation of descriptions over one, two and three cycles was calculated.

Results

Discrimination power

The mean discrimination power over the three years is presented in figure 1 and 2. The decision on distinctness was significantly influenced by the number of growing cycles. A clear difference observed in the first cycle was not always confirmed in the second cycle. Consequently, the discrimination power was lower after 2 cycles in most of the characteristics. A clear difference observed in only one of the years may be confirmed in a third year, resulting in a higher discrimination power in 2 out of 3 cycles.

A few characteristics in wheat did not follow this principle, see figure 2: grain coloration with phenol, lower glume beak shape, awns or scurs length and straw pith in cross section. A low 1-cycle-discrimination power was observed for these characteristics. This result may be attributed to the fact that the expression of these characteristics is not evenly distributed in the collection. The low mean discrimination power in 1-cycle comparisons could be caused by a different distribution in the varieties in the first year (about 30% of all varieties). Environmental effects can also have an impact on the discrimination power in some years.

Variety descriptions

The variation of descriptions over one, two and three cycles is illustrated in figures 3 and 4. Annual variety descriptions show a higher variation than descriptions over two and three years for all characteristics in both species. The stability of descriptions is much higher after two cycles and can be further improved by a third cycle.

Conclusion

The study has shown that the number of growing cycles has a significant impact on distinctness decisions and variety descriptions. It confirms the current recommendation in the Test Guidelines for barley and wheat which reads as follows: "The minimum duration of test should normally be two independent growing cycles".

The recommended minimum duration of test should be followed to establish the official variety description. Reliability and stability of the description is a precondition for enforcement.

Descriptions also play an important role for the management of references collections, in particular when databases with descriptions for varieties of common knowledge are used for the selection of similar varieties for the growing trial. The possible error of descriptions has to be taken into account for any comparison. The exclusion of varieties from the growing trial is a crucial step in the distinctness test. Normally, the error for descriptions of candidate varieties is quite high at the beginning of test. The most important is to limit the error of descriptions of reference varieties by feeding the database with sufficiently stable descriptions. All descriptions in a database should be based at least on the recommended minimum number of growing cycles. Any additional cycle can improve the quality of the description.

Figure 1: Winter barley - Impact of the number of growing cycles on discrimination power

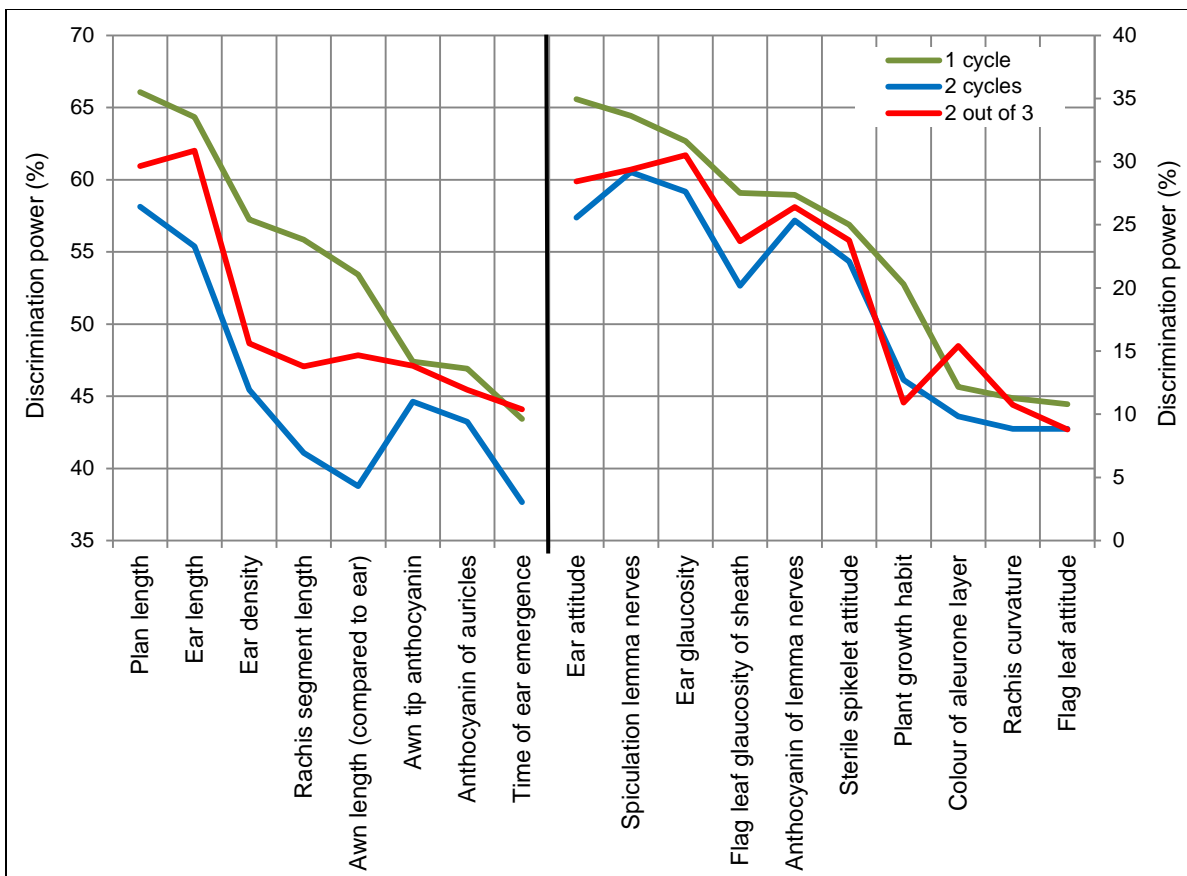


Figure 2: Winter wheat - Impact of the number of growing cycles on discrimination power

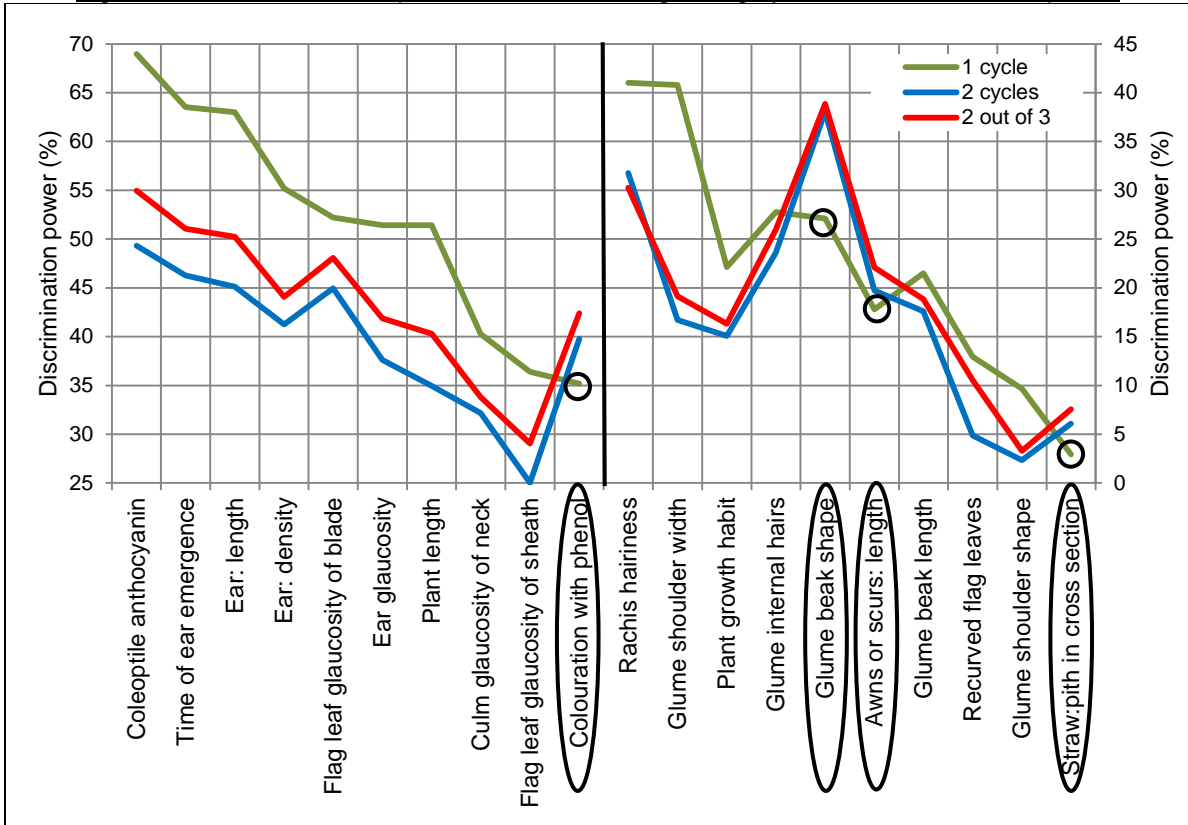


Figure 3: Winter barley – variance of variety descriptions over testing periods

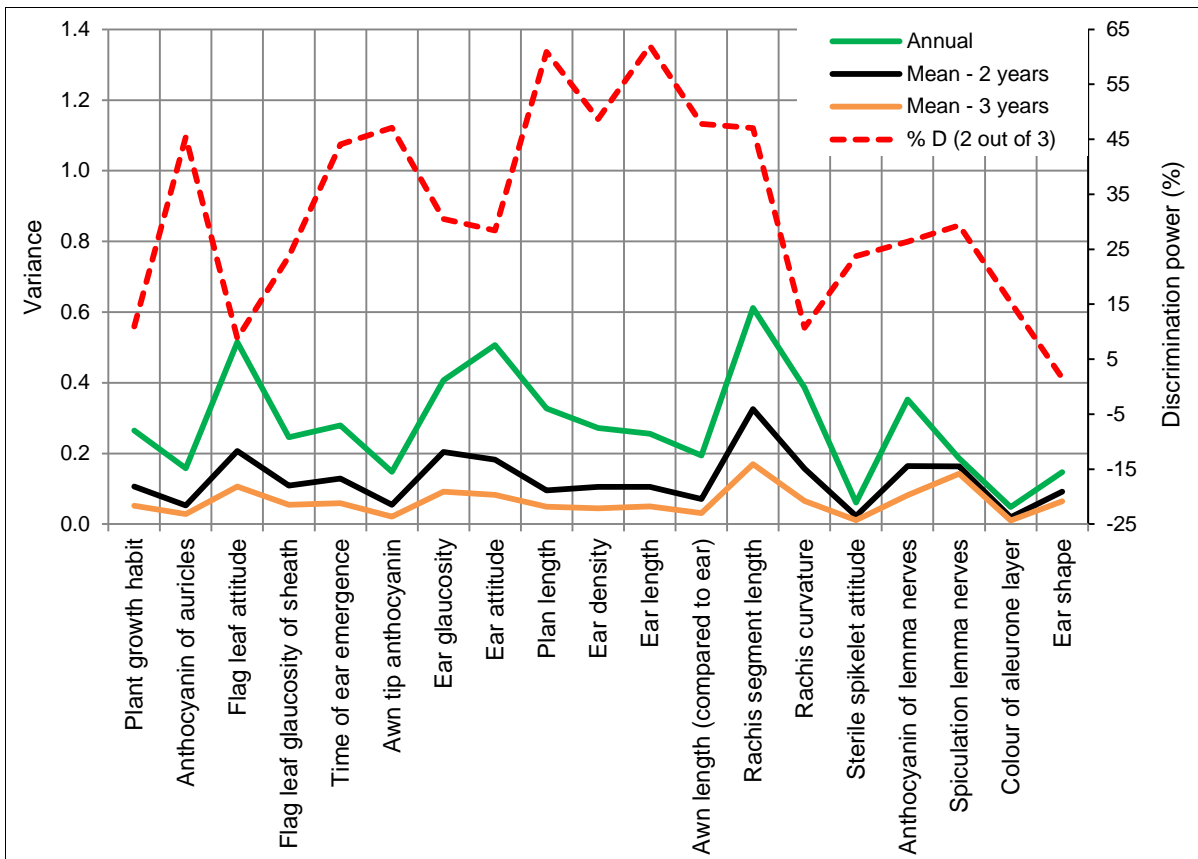
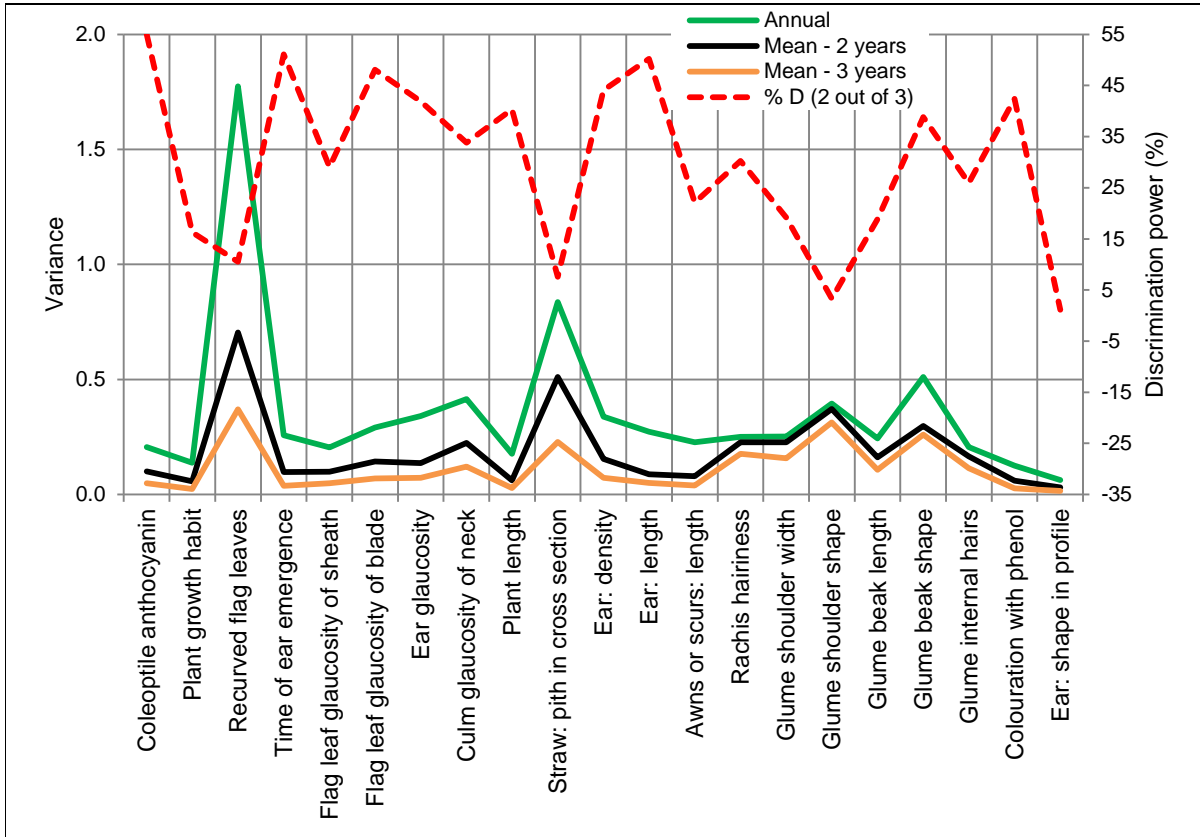


Figure 4: Winter wheat – variance of variety descriptions over testing periods



[Annex II follows]

IMPACT OF THE NUMBER OF GROWING CYCLES ON VARIETY DESCRIPTIONS AND DISCRIMINATION POWER IN POTATO

1. The TWA, at its forty-sixth session, held in Hanover, Germany, from June 19 to 23, 2017, considered several examples on the impact of using different numbers of growing cycles on DUS decisions and the establishment of variety descriptions (see document TWA/46/8, TWA/46/8 Add.). Members of the Union were invited to provide further examples to be considered in 2018. The present document provides a potato example.

2. In the Test Guidelines for Potato (document TG/23/6), it is recommended that the minimum duration of tests should normally be two independent growing cycles. This study was performed to validate whether two growing cycles are necessary or the duration of test could be reduced. The impact of the number of growing cycles was analyzed for quantitative characteristics in potato on the basis of data from actual DUS trials.

Material and methods

3. The German DUS growing trials comprise about 360 potato varieties every year. 50 to 70 varieties are candidate varieties, half in the first and half in the second year. Discrimination power of individual characteristics was calculated based on candidate varieties after the second growing cycle. Each 2nd-year-candidate variety was compared to all other varieties in the same growing trial. Two distinctness tests were performed:

- (d) '1-cycle': second year only. Two varieties are considered to be distinct if a clear difference was observed.
- (e) '2-cycles': second year and first year. Two varieties are considered to be distinct if a clear difference in the same direction was observed in both years.

4. Discrimination power of each characteristic was calculated as percentage of clear differences in relation to all pairwise comparisons.

The same analysis was performed for 2013 to 2017. In total, about 130 candidate varieties were compared to 350 reference varieties resulting in about 45,000 pairwise comparisons for '1-cycle' and '2-cycles' each.

5. A different data set was used to calculate the impact of the number of growing cycles on variety descriptions. Orthogonal DUS observations for 211 varieties in 6 successive growing cycles (2012-2017) were used to establish annual variety descriptions and descriptions over 2 cycles. Six annual descriptions and six descriptions over two cycles were produced for each variety and variation between these descriptions was calculated.

6. DUS tests were conducted according to document TG/23/6. The numbering of characteristics follows these Test Guidelines.

Results and discussion

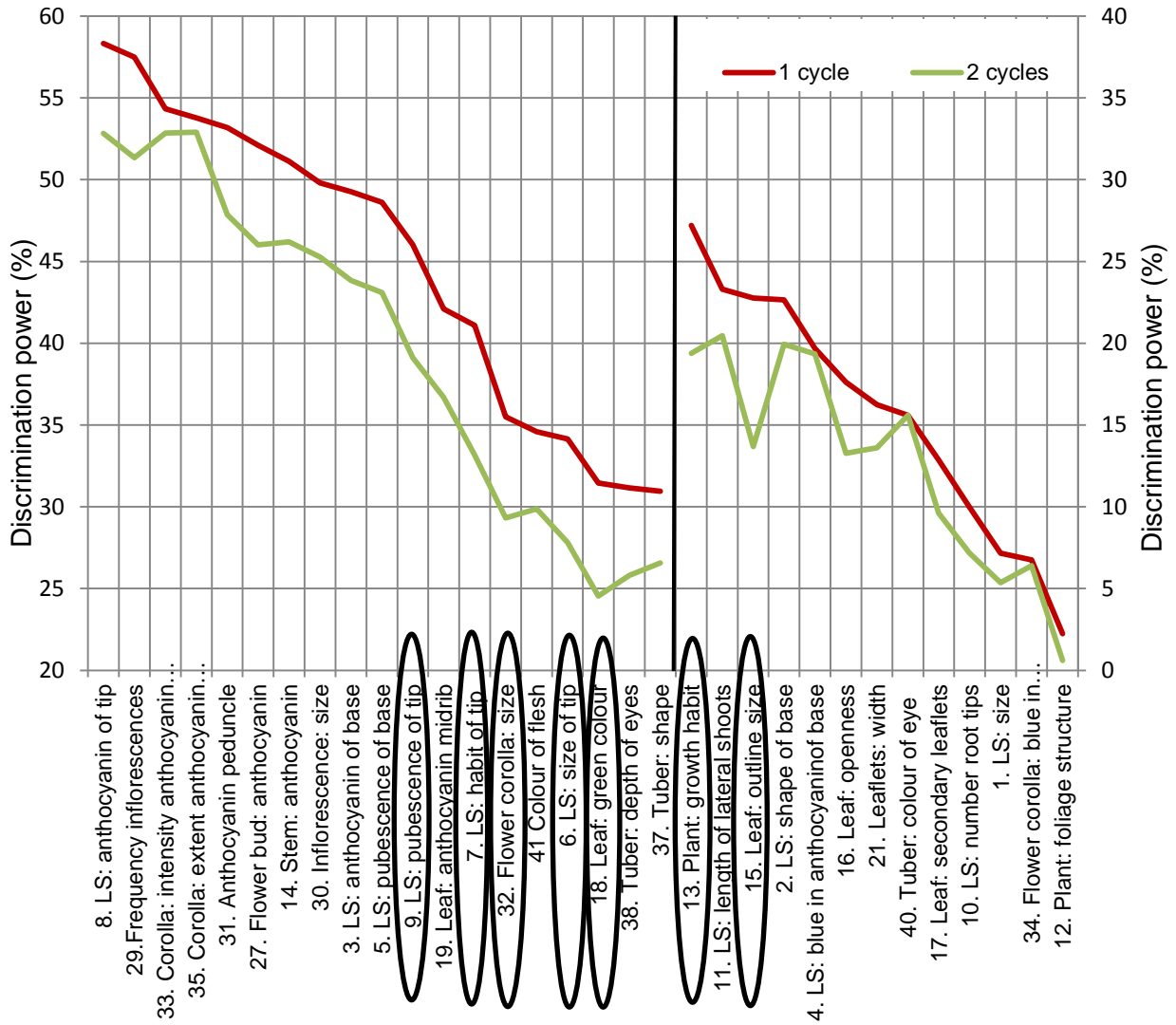
Discrimination power:

7. The mean discrimination power based on a single cycle and over two cycles is presented in figure 1. Characteristics were sorted according to the discrimination power in a single cycle with a range between 58 % and 2 % discrimination power. The decision on distinctness was significantly influenced by the number of growing cycles. A clear difference observed in one cycle was not always confirmed in the second cycle. Consequently, the discrimination power was lower after 2 cycles. If varieties were compared in a single year, for some characteristics distinctness was up to 10 % higher than after 2 cycles. Characteristics with the highest 'overestimation' in discrimination power were marked in figure 1.

8. A clear difference observed in only one of the cycles might be confirmed in a third cycle. But in general, a third cycle is not necessary to establish distinctness in potato due to clear differences in at least one of the other characteristics. Therefore, the '2 out of 3 cycles' option was not analyzed in this study.

9. If distinctness shall be based on a single cycle, larger minimum differences have to be applied for several characteristics in order to allow reliable decisions. This would lead to lower discrimination power.

Figure 1: Impact of the number of growing cycles on discrimination power



Variety descriptions:

10. The maximum difference between six 1-cycle variety descriptions and between six 2-cycle variety descriptions is presented in figures 2 and 3. Characteristics have the same order in both figures, sorted according to the frequency of identical 1-cycle descriptions (0 note difference). Some characteristics were very stable with conformity between the six 1-cycle descriptions for more than 90 % of the varieties, see characteristics 40. Tuber: color of base of eye, 34. Flower corolla: proportion of blue in anthocyanin coloration on inner side and 4. Lightsprout: proportion of blue in anthocyanin coloration of base. On the other side, the percentage of zero notes difference was less than 20 % for characteristics 9. Lightsprout: pubescence of tip, 13. Plant: growth habit and 15. Leaf: outline size.

11. The stability of descriptions was clearly improved with a second cycles (figure 3).

12. The frequency of zero notes difference is significantly higher between 2-cycle descriptions compared to 1-cycle descriptions. The following frequencies of differences were observed across all characteristics:

Differences	1-cycle	2-cycles
0 notes	47 %	62 %
1 note	47 %	36 %
>1 note	6 %	2 %

13. Variation in variety descriptions of 1 note from year to year can be considered as quite stable. Nevertheless, a clear difference between two varieties e. g. of two notes in a testing period might decrease to 1 or 0 notes in another testing period. Two growing cycles produce more robust variety descriptions.

14. Databases with descriptions for varieties of common knowledge can play an important role in the process of assessing distinctness. Descriptions are often used for the identification of similar varieties to be grown together with new candidate varieties. The efficiency of excluding varieties from the growing trial is strongly influenced by the consistency of variety descriptions over years. The potential environmental influence has to be taken into account for defining thresholds and to decide whether a difference between two varieties can be considered as clear and consistent. Less consistency of descriptions leads to more similar varieties in the growing trial.

Figure 2: Difference between 1-cycle variety descriptions
(Maximum difference between 6 descriptions per variety, 211 varieties)

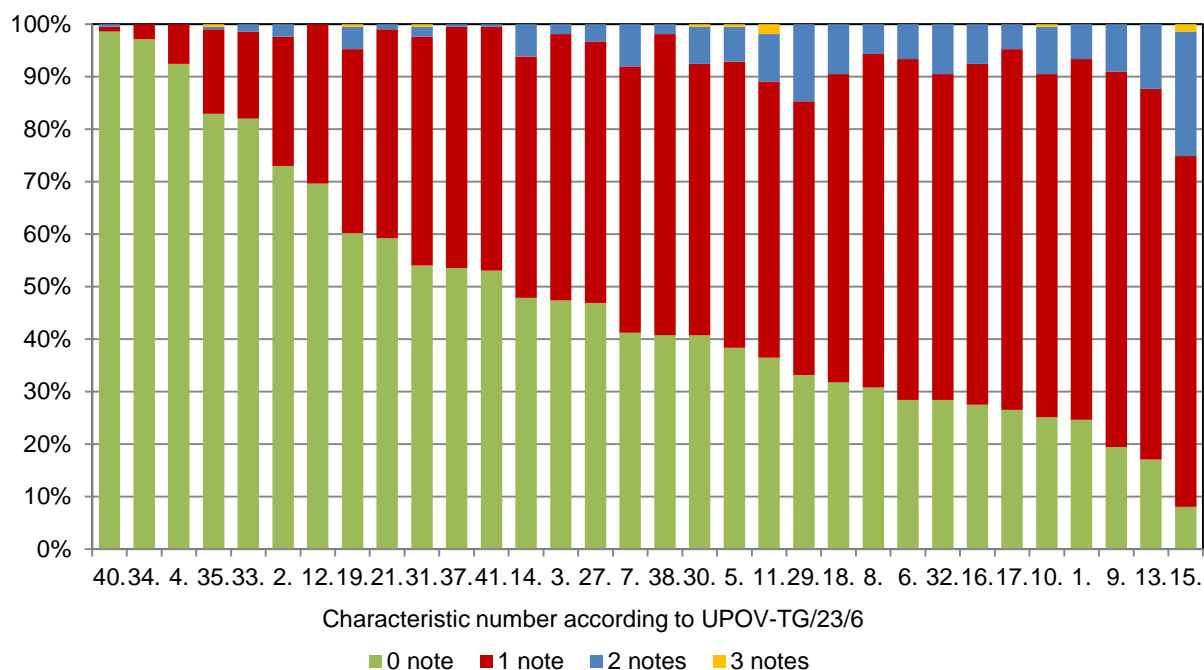
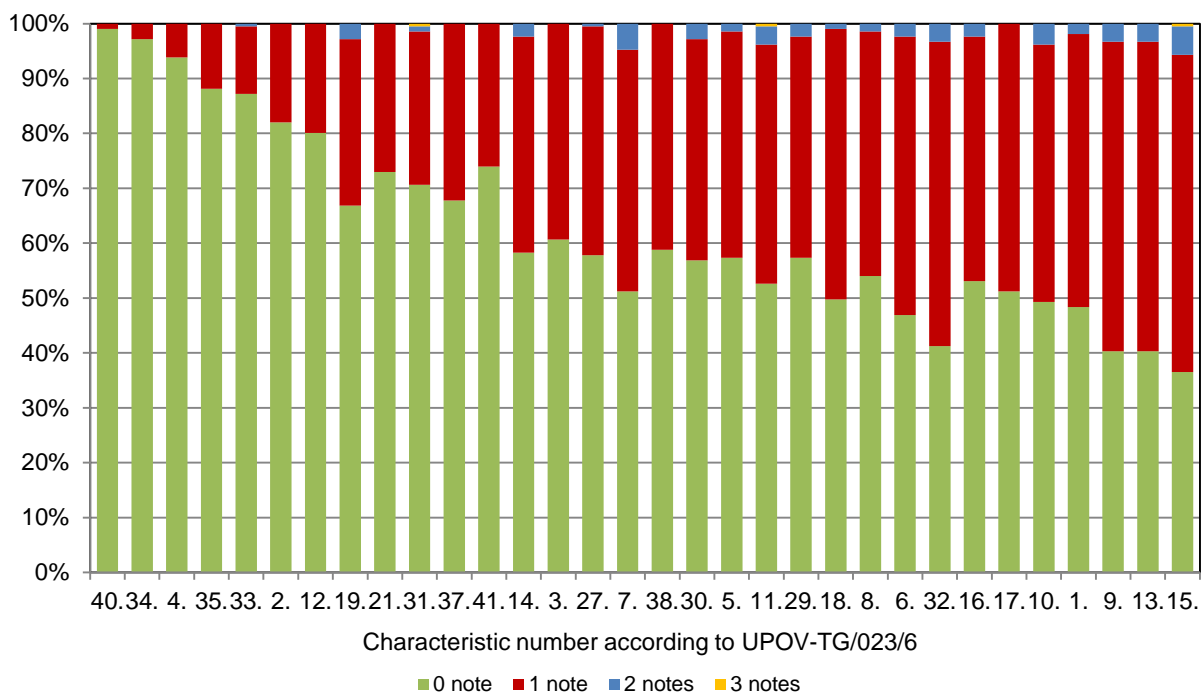


Figure 3: Difference between 2 cycle- variety descriptions
(Maximum difference between 6 descriptions per variety, 211 varieties)



Conclusion

- The number of growing cycles has a significant impact on distinctness decisions and variety descriptions. An impact was observed on distinctness decisions for varieties compared in the same growing trials as well as on the management of the reference collection on the basis of descriptions stored in a database.
- Two growing cycles produce more robust variety descriptions and DUS decisions.
- The recommended minimum number of two growing cycles should be followed.
- Variety descriptions based on two cycles provide a better basis for enforcement.

[End of annex II and of document]