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COEFFICIENT OF COMPATIBILITY WITH THE STANDARD (CCS) AND ITS APPLICATION IN CULTIVAR RESEARCH

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ABSTRACT

The present paper concerns interactions between a set of objects, where the same components (fractions) can be isolated, and a standard object, which consists of arithmetical mean shares in these fractions. A method was proposed how to estimate the variability observed in the structure of a given object, as compared with the standard structure, as calculated with a coefficient of compatibility with the standard (CCS). According to the algorithm introduced, the coefficient value falls between (0, 1). When the structure of a given object is identical with the one of the standard, the coefficient amounts to 0.5. If a growth in cumulative interest for respective fractions is more intensive as compared with the one of the standard, the coefficient amounts to less than 0.5, otherwise the coefficient is higher than 0.5. Applying the method presented, it was observed that the sowing material in the majority of pea cultivars, researched by the Centre for Cultivar Testing (COBORU) in 1995, showed seed size structure similar to the cumulative standard structure, with its significant variability.

Key words: statistics, concentration analysis, cultivar testing, pea

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INTRODUCTION

In research, traits of objects researched are frequently compared with at the same common level. In the agricultural cultivar testing, it is mainly a cumulative standard, average (mean) value of the trait in cultivars analysed. If the comparison concerns a single trait (e.g cultivar yielding), researching differences between cultivars and the standard poses no difficulty. If the assessment concerns a comparison of complex structures (e.g. a seed fraction share in the sowing material of many cultivars within the same species), a description of similarities and differences between the cultivars and the standard can be very difficult.

An object (e.g. cultivar) set may consist of objects with their composition, being very similar to an average and then the standard defines them well. However, the standard structure very often varies from a composition of objects which provided a basis for its definition. It happens so when objects, which differ significantly in their shares of respective fractions, are compared simultaneously. The more significant the differences, the less significant the concentration (greater dispersion, greater unification of the fraction shares) is shown by the standard structure.

A comparison of complex structures of cultivar traits and the standard would be easier with a digital coefficient, which would compare the similarities and differences in a synthetical way. It would be possible with a modification of the well-known method, shown in the present paper, namely calculating a concentration coefficient. The aims of the analysis presented, are defined by the term proposed to calculate the structure similarity coefficient, a coefficient of compatibility with the standard.

HOW TO CALCULATE THE COEFFICIENT OF COMPATIBILITY WITH THE STANDARD

The starting point to calculate the coefficient is a method which defines an asymmetry of trait distribution, which is based on the construction of the so-called Lorenz concentration polygon. A procedure to follow to make a graphic representation of the concentration coefficient is defined in the literature [3, 5]. The representation of similarities and differences between the structures compared is a broken line (the so called concentration curve) which joins the points representing the values of cumulative interests of respective fractions of two traits in the co-ordinate system, which, at the same time, defines the sides of a 100 x 100 square area. The concentration coefficient is calculated with the ratio of the size of the area between the broken line and the square diagonal ('concentration polygon') to the triangle area under the diagonal. The more significant the similarity of the two structures being compared, the smaller the area of the polygon is, and the concentration coefficient approaches zero. When totally different, the polygon area equals the triangle area under the diagonal, and the concentration coefficient equals one. The concentration polygon, therefore, can represent a difference of both structures.

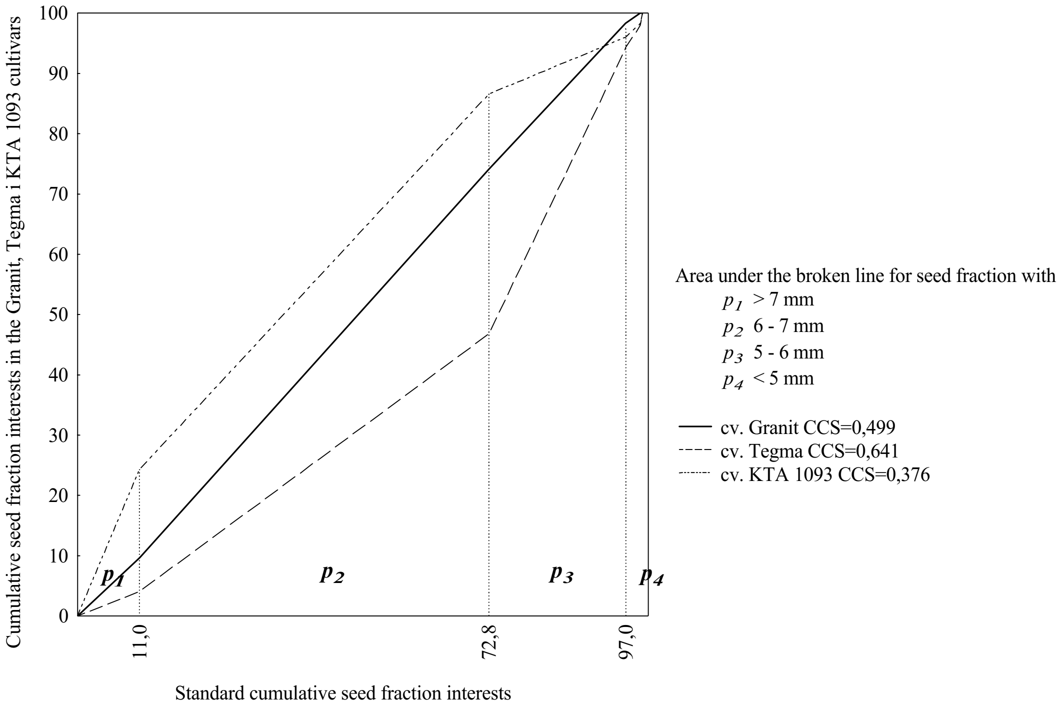
Applying concentration analysis to a comparison of structures for set of objects with their mean structure, one shall pay attention to the central location of the fraction values presented by the standard. While constructing a concentration polygon, cumulative interests of the standard shall score on the horizontal (X) of the concentration graph, and similarly, interests of the objects compared on the vertical (Y) of the graph. It is easy to notice that the broken line, which defines the concentration polygon at the bottom, depending on the structure of the Y variable, may run either through the triangle area under the diagonal, or the triangle over the diagonal; it may also be on the diagonal of the co-ordinate system. Therefore, the coefficient of compatibility with the standard shall be calculated as the ratio of concentration polygon area and the area of the square 100 x 100 which equals 10000 (Figure 1).

The area, beyond the concentration polygon ($p = \sum_{1}^{k} p_i$) equals a sum of triangle area p_1 and the p_2, p_3, p_4....p_k trapezoids under the broken lines (Figure 1).

$$\text{coefficient of compatibility with the standard} = \frac{10000 - p}{10000}$$

If a fraction share in a variable marked as dependent is identical with that of the standard, the broken line shall run on the diagonal of the co-ordinate system, dividing it into two equal areas of 5000. A coefficient of compatibility with the standard shall then amount to 0.5 and will mean a total compatibility of both structures. If an interest share of the dependent variable structure shows more rapid cumulating, as compared with the one of the standard structure, the coefficient shall score between 0.5 to 0, and the broken line shall be drawn within the upper triangle (over the diagonal). The area of the figure under the broken line shall be greater than 5000. However, if a growth in interest value of the standard is more rapid, as compared with the object compared, the area under the broken line shall be smaller than the lower triangle area and hence smaller than 5000. The coefficient of compatibility with the standard shall be somewhere between 1 to 0.5.

Figure 1. Concentration curves against the cumulative standard for pea cultivars different in seed size fraction composition in the sowing material



Consequently, concentration polygon, as a graphic representation of variability of the structures being compared on the graph, is defined with a broken line joining resultant points of the respective cumulative interests as well as the left and upper sides of the square (Figure 1). The following are potential applications of coefficients of compatibility with the standard for synthetical comparison of seed size in different pea cultivar sowing materials.

The source material (Table 1, columns 1-6) consists of the fraction division results for pea seed size, published by the COBORU in Slupia Wielka [6]. There the seed fraction share in some cultivars does not give the sum of 100%, which can be due to a failure to include the data on the share of the residue at the bottom of the sorter [4]. The following analysis, deviations obtained are included, creating a fraction of 'the others' (Table 1, column 7).

Table 1. Seed fractions in the pea sowing material and the coefficient of compatibility of cultivar seed size structure with the cumulative standard structure

Seed diameter [mm]	Seed share [%] in the yield				Cumulative interests				p_i		
	Standard	cultivar			Standard	cultivar			cultivar		
		Granit	Tegma	KTA 1093		Granit	Tegma	KTA 1093	Granit	Tegma	KTA 1093
> 7	11,0	9,7	4,1	24,3	11,0	9,7	4,1	24,3	53,4	22,5	133,7
7 – 6	61,8	64,4	42,7	62,3	72,8	74,1	46,8	86,6	2589,4	1572,8	3426,8
6 – 5	24,2	23,3	47,5	9,4	97,0	97,4	94,3	96,0	2075,1	1707,3	2209,5
< 5	2,6	2,6	3,7	2,3	99,6	100,0	98,0	98,3	256,6	250,0	252,6
The others*	0,4	0,0	2,0	1,7	100,0	100,0	100,0	100,0	40,0	39,6	39,7
$p = \sum p_i$									5014,5	3592,3	6062,3
$WZW = \frac{10000 - p}{10000}$									0,499	0,641	0,394

*Impurities and residue at the bottom of the sorter

THE PROCEDURE OF CALCULATING THE COEFFICIENT OF COMPATIBILITY WITH THE STANDARD, EXEMPLIFIED BY RESULT ANALYSIS FOR FRACTIONATION OF PEA SEEDS, THE GRANIT, TEGMA AND KTA 1093 CULTIVARS AGAINST THE CUMULATIVE STANDARD

A calculation method is presented for three pea cultivars different in seed fraction fractures [2]. A graphic representation of the differences is presented in Figure 1, while the calculation results for the area under the broken line (p) and respective coefficients of compatibility with the standard are shown in Table 2.

Table 2. Comparison of seed size structure of the pea sowing material in the Granit, Tegma and KTA 1093 cultivars with the trait standard structure. Calculating the coefficient of compatibility with the standard.

Cultivar		Share (%) in the yield of seeds (seed diameter)					CCS
		> 7 mm	6 - 7 mm	5 - 6 mm	< 5 mm	The others*	
No.	**Standard**	**11,0**	**61,8**	**24,2**	**2,6**	**0,4**	
1.	Agra	5,5	45,8	43,6	2,9	2,2	0,616
2.	Ametyst	9,2	64,5	24,1	2,1	2,1	0,502
3.	Rubin	6,0	55,5	34,8	3,6	0,1	0,568
4.	Agat	11,0	64,7	22,1	2,1	0,1	0,486
5.	Ergo	13,2	66,3	18,0	2,4	0,1	0,462
6.	Piast	11,6	67,5	18,3	1,9	0,7	0,470
7.	Sol	13,4	66,0	17,2	3,4	0,0	0,463
8.	Granit	9,7	64,4	23,3	2,6	0,0	0,499
9.	Kwestor	9,0	72,4	16,6	1,9	0,1	0,469
10.	Gniewko	8,8	61,4	26,0	2,9	0,9	0,520
11.	Cyrkon	7,2	62,3	27,7	2,7	0,1	0,528
12.	Rodan	5,6	55,5	36,2	2,7	0,0	0,570
13.	Karat	6,9	61,9	27,8	3,2	0,2	0,533
14.	Tegma	4,1	42,7	47,5	3,7	2,0	0,641
15.	Szafir	26,8	57,4	13,1	2,7	0,0	0,393
16.	Hermes	18,8	65,1	13,9	2,1	0,1	0,423
17.	Miko	12,5	68,2	16,8	2,2	0,3	0,460
18.	Diament	22,9	62,0	12,6	2,4	0,1	0,404
19.	SOD 1892	11,8	63,4	22,4	2,2	0,2	0,486
20.	WTD 1992	13,6	69,5	14,7	2,1	0,1	0,445
21.	WIA 992	7,8	59,5	30,2	2,5	0,0	0,535
22.	SOD 1792	11,9	64,3	21,5	2,2	0,1	0,481
23.	WTD 2092	16,1	65,0	16,0	2,9	0,0	0,446
24.	Profi	6,9	62,8	26,7	3,1	0,5	0,529
25.	Carrera	5,7	51,0	37,3	3,7	2,3	0,593
26.	SZC 1293	7,4	58,9	29,4	3,0	1,3	0,543
27.	SOD 1993	6,6	58,3	31,6	3,0	0,5	0,551
28.	SOD 2093	9,4	68,7	19,6	2,2	0,1	0,482
29.	KTA 1093	24,3	62,3	9,4	2,3	1,7	0,376
30.	WTD 2193	15,3	62,7	19,5	2,1	0,4	0,461
31.	PRH 993	14,7	66,6	16,7	1,8	0,2	0,449
32.	SOD 2194	7,5	60,2	29,9	2,3	0,1	0,534
33.	SOD 2294	9,1	61,9	26,7	2,3	0,0	0,513
34.	KTA 1194	14,2	61,4	20,3	2,1	2,0	0,478
35.	Eiffel	9,9	65,0	22,1	2,2	0,8	0,495
36.	POA 1894	9,8	61,4	24,9	2,9	1,0	0,513
37.	WTD 2694	12,5	68,5	17,0	2,0	0,0	0,458
38.	Delta	5,1	50,1	40,9	2,4	1,5	0,599
39.	PRH 1094	11,5	66,9	18,2	3,0	0,4	0,475
40.	RAH 594	6,5	56,1	32,6	3,8	1,0	0,563

* Residue and impurities at the bottom of the sorter

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For example, for the Tegma cultivar, the calculations are as follows:

Triangle area

$$p_1 = \frac{11{,}0 \cdot 4{,}1}{2} = 22{,}55$$

Trapezium area

$$p_2 = \frac{4{,}1 + 46{,}8}{2} \cdot 61{,}8 = 1572{,}8$$

$$p_3 = \frac{46{,}8 + 94{,}3}{2} \cdot 24{,}2 = 1707{,}3$$

$$p_4 = \frac{94{,}3 + 98{,}0}{2} \cdot 2{,}6 = 250{,}0$$

$$p_5 = \frac{98{,}0 + 100}{2} \cdot 0{,}4 = 39{,}6$$

Hence

$$p = \sum_{1}^{5} p_i = 3569{,}7$$

$$CCS = \frac{10000 - p}{10000} = \frac{10000 - 3569{,}7}{10000} = 0{,}643$$

Concentration curves, drawn in Figure 1 show a different structure for each of the three selected cultivars. The broken line, which represents cumulative interests for the Granit cultivar, almost coincides with the diagonal of the co-ordinate system. The KTA 1093 broken line rises most steeply, its line has a significant share in sowing material of big seeds. However, the curve representing differences in the standard structure and the Tegma cultivar structure, as concerns respective fraction intervals for the biggest seeds, shows a less considerable dynamics as compared with those of the two other cultivars.

COEFFICIENTS OF COMPATIBILITY OF THE STANDARD AS CONCERNS A SYNTHETICAL SEED SIZE EVALUATION IN PEA CULTIVAR SOWING MATERIAL

With the above digital procedure and for all the pea cultivars and breeding lines covered in 1995 by the research of the COBORU, coefficients of similarities between seed fraction structures and the cumulative standard structure were calculated. The results are presented in Table 1, column 8.

A starting point for the analysis of the results obtained is a standard fraction composition. It shows that the dominant fraction consists of 6-7 mm thick seeds. The share of the seeds remaining on the sieves with a sieve mesh diameter of 6 mm amounts to 71.8 % here, which means that smaller-size seeds amount to almost 30%, which, in turn, shows a considerably high variability within the standard structure. The coefficient of compatibility with the standard for pea cultivars, representing a higher seed percentage for up to 6mm diameter seeds score lower, from 0.5. However, the cultivars with a smaller number of seeds in that interval, as compared with the standard, show a higher coefficient value than 0.5.

For practical reasons, the sowing material with unified seed size, at an overwhelming majority of big-sized seeds or a considerable advantage of smaller-sized seeds [1] are most desirable. As far as the homogeneity of the sowing material analysed is concerned, the most favourable structure can be found in the pea cultivars which differ from the standard most considerably. Amongst those with large-sized seeds, one shall enumerate the Szafir, Hermes, Diament cultivars as well as the KTA 1092 line (the coefficient of compatibility with the standard – from 0.376 to 0.423), while in the small-seeded cultivars with leafless cultivars: the Agra, Tegma, Carrera and Delta (the coefficient from 0.593 to 0.616). The above cultivars make only 20 % of the total cultivar and line numbers researched in 1995.

CONCLUSIONS

1. Coefficient of compatibility with the standard is a digital index which allows to make a synthetical comparison of fraction share in the structure of many objects with a mean share of the fractions in the cumulative standard, calculated as mean for objects.
2. The value of the coefficient of compatibility with the standard scores in the interval from zero to one. If, for a given object, cumulative interest for respective fractions increases more rapidly than for the standard, the coefficient scores under 0.5, otherwise – higher than 0.5. If cumulative interest for respective fractions is identical with that of the standard, then the coefficient amounts to 0.5.
3. The application of the structure analysis method proposed showed that a majority of pea cultivars, researched by the COBORU in 1995, revealed a significant similarity between seed fraction composition and the one of the cumulative standard. A typical trait of those cultivars is producing seeds with significant size variability.

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