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THE COMPARISON OF HAND-MADE AND COMPUTERIZED MEASUREMENTS IN DUS TRIALS ON OIL-SEED RAPE

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Summary

In a paper two methods of making measurements of some characteristics in distinctness, uniformity and stability (DUS) trials are compared. The results of parallel measurements concerning cotyledon length and width and petal length and width for 30 oil-seed rape varieties are used. Measurements were performed both by traditional method (using electronic caliper) and by special program (using scans of measured objects). Variety mean values (used in testing distinctness) and variety standard deviations (used in testing uniformity) were often significantly dependent on the method of making measurements.

Keywords and phrases: DUS trials, methods of making measurements, oil-seed rape

Classification AMS 2010: 62K99, 62P10

1. Introduction

In distinctness, uniformity and stability (DUS) testing of varieties of cultivated plants new (candidate) variety must be distinct from each other variety of so-called common knowledge. To fulfill this requirement each candidate variety is tested in DUS trials with large number of other potentially indistinct varieties. The number of observed characteristics is often large (in extreme cases the number of characteristics is as large as 80). DUS trials are usually performed in randomized complete block design in two (majority of species) or in six replicates (all grasses). From each plot the same number of plants (parts of plants) are randomly chosen and measured. The number of measured plants for each variety depends on species (and characteristic) and varies from 30 to 60. For example in all grasses 10 plants from each replicate are measured giving finally 60 measurements for variety. On the other hand in oil-seed rape DUS trials 30 (or 20) plants are measured from each of two plots giving again 60 (or 40) measurements per variety. Measurements of some characteristics are easily obtained e.g. plant length, other are much more difficult to make (petal length and width). In order to save time and costs in many countries some attempts were undertaken to facilitate making measurements of some characteristics. For example in Holland (TWC/29/29) measurements of some parameters of onion bulbs and roots of carrot are performed automatically using photographs or scans of these objects. In UK similar technique is used for measurements of some parameters of roots of turnip and swede (see TWC/29/19). Also in Poland the effort of replacing handmade measurements (classical) by computerized ones was undertaken (Sysak and Kamiński, 2012). In this paper the results of measurements obtained classically with use of electronic caliper and made by specially prepared software are compared.

2. Materials and methods

In oil-seed rape DUS trials, among many observational data, there are also 14 measured characteristics. Two of them concern cotyledon (length and width) another two concern flower petals (also length and width). Measured objects are relatively small and performing measurements "by hand" is a tedious task. In practice 40 cotyledons and 60 petals of each tested variety (candidate and reference) are stick to the sheet of paper and next measured with use of electronic caliper. How these four characteristics are measured is illustrated in Fig.1 and 2.

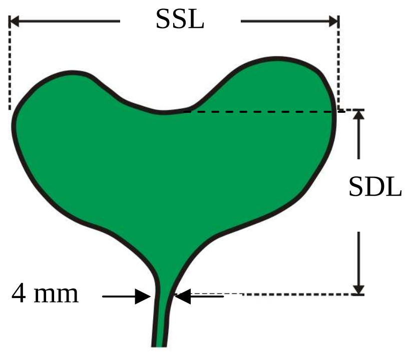

Fig. 1. How the length (SDL) and width (SSL) of cotyledon are defined

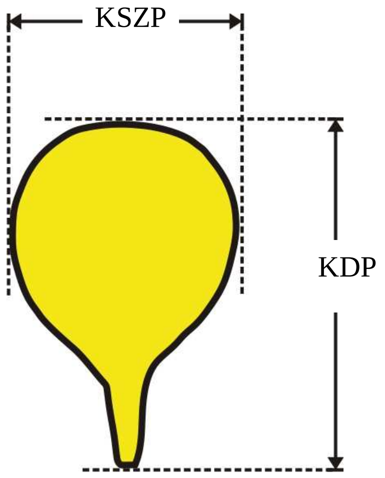

Fig. 2. How the length (KDP) and width (KSZP) of petal are defined

The codes of characteristics are abbreviations of their official Polish names used in The Research Centre for Cultivar Testing, the institution responsible for all DUS matters in Poland.

In year 2010 a special software was prepared and measurements of these four characteristics were automated. Namely all sheets with stuck petals and cotyledons were scanned and measurements “performed” by program. Details of used software can be found in a paper by Sysak and Kamiński (2011). In order to check the influence of method of making measurements (by hand and by computer) in year 2010, for 30 varieties these measurements were performed by both methods. It gave an opportunity to compare both variety mean values (used in testing distinctness) and their standard deviations (used as a measure of uniformity). An example data obtained by these two methods for two varieties are given in Table 1. Measurements made by hand are denoted by x^t whereas those made by computer by x^a.

Using such data for 30 varieties the basic statistical parameters have been calculated and compared. For each variety the hypotheses of equality of mean values calculated from data obtained traditionally and with use of computer program were tested. Also global comparison of standard deviations has been performed. Because the samples were not independent, the use of traditional tests for comparing individual varietal variances such Fisher F-test, Bartlett’s test or Hartley test was impossible so only global comparison of two sets of variances has been performed with use of the sign test (Conover 1980, Greń 1984, Domański and Pruska 2000).

3. The results

All the calculations have been performed for 30 varieties and four mentioned earlier characteristics. In order to compare varietal mean values, the differences between hand-made measurements and computerized ones (concerning the same measured objects) have been calculated. Then, for each variety and characteristic, the hypothesis

$$H_0 : \mu = 0 \text{ against } H_a : \mu \neq 0$$

was verified at 0.05 significance level, where μ denotes the expected value of the random variable defined as the difference between hand-made and computerized measurements of the same object. If the H_0 was rejected, the number of cases that $\mu<0$ (“computerized” variety means significantly larger than hand-made means) and the number of occasions that $\mu>0$ (“hand-made” variety mean significantly larger than computerized ones) have been counted. Summarized results are presented in Table 2.

Table 1. Hand-made (x^t) and computerized (x^a) measurements of four characteristics for two oil-seed rape varieties

Variety RG 2506				Variety RNX 1206			
Cotyledon length		Cotyledon width		Petal length		Petal width	
x^t	x^a	x^t	x^a	x^t	x^a	x^t	x^a
9.59	9.60	17.96	17.50	1.75	1.71	0.91	0.94
10.88	10.10	17.85	17.40	1.67	1.69	0.91	0.94
10.11	10.10	16.85	16.50	1.67	1.68	0.95	0.96
10.57	10.60	19.89	20.00	1.70	1.71	0.93	0.93
10.60	10.40	19.58	19.70	1.66	1.70	0.96	0.95
12.25	11.90	20.00	19.90	1.68	1.71	0.94	0.93
10.43	10.10	19.84	19.60	1.64	1.63	0.92	0.92
10.78	10.20	18.36	18.10	1.69	1.68	0.97	0.96
12.17	11.90	19.64	19.20	1.74	1.74	0.91	0.91
10.29	9.90	18.78	18.10	1.69	1.69	0.89	0.93
9.86	9.70	18.14	18.10	1.66	1.67	0.91	0.88
9.40	10.40	18.77	18.60	1.60	1.63	0.95	0.93
9.37	9.60	18.17	17.90	1.64	1.65	0.90	0.88
11.69	11.90	20.63	20.30	1.63	1.65	0.92	0.91
11.63	11.10	19.03	19.20	1.66	1.68	0.93	0.93
10.85	11.10	18.98	19.20	1.69	1.70	0.91	0.94
11.47	10.60	19.39	19.30	1.71	1.68	0.92	0.91
10.77	10.90	19.50	19.10	1.64	1.66	0.91	0.88
10.49	9.90	18.45	18.40	1.77	1.79	0.89	0.91
11.41	11.10	19.13	18.90	1.76	1.78	0.91	0.91
11.32	10.40	18.76	18.70	1.65	1.63	0.97	0.96
10.72	10.40	17.17	17.40	1.70	1.68	1.00	1.01
13.46	11.90	19.39	19.60	1.78	1.73	0.95	0.94
12.48	11.60	18.72	19.80	1.64	1.67	0.89	0.99
12.59	11.40	19.31	18.90	1.69	1.72	0.95	0.97
12.57	12.60	20.00	19.70	1.77	1.74	0.96	0.99
12.77	11.90	19.93	19.90	1.63	1.62	0.92	0.88
12.39	11.90	21.28	21.40	1.67	1.68	0.88	0.88
11.63	10.90	18.37	18.40	1.69	1.73	0.95	0.99
11.23	10.10	20.71	20.60	1.67	1.71	0.96	1.02

Table 1. continued

Variety RG 2506				Variety RNX 1206			
Cotyledon length		Cotyledon width		Petal length		Petal width	
x^t	x^a	x^t	x^a	x^t	x^a	x^t	x^a
11.05	10.70	18.79	18.50	1.64	1.62	0.84	0.86
10.96	11.10	19.16	19.50	1.68	1.66	0.84	0.88
12.92	11.90	21.69	21.50	1.61	1.62	0.89	0.90
12.46	11.90	22.65	22.50	1.65	1.70	0.93	0.92
12.12	11.40	20.28	20.30	1.67	1.69	0.96	0.96
11.03	10.60	17.87	18.00	1.71	1.69	0.97	0.96
11.02	10.90	18.61	18.40	1.58	1.61	0.93	0.92
12.00	12.00	21.39	21.80	1.58	1.58	0.90	0.91
10.93	10.60	17.54	17.90	1.70	1.72	0.93	0.91
11.72	11.40	19.06	19.00	1.67	1.71	0.90	0.94
				1.81	1.78	0.88	0.88
				1.73	1.74	0.95	0.94
				1.80	1.79	0.89	0.91
				1.76	1.78	0.89	0.91
				1.64	1.66	0.88	0.88
				1.64	1.63	0.96	0.94
				1.79	1.77	0.89	0.88
				1.72	1.70	0.86	0.89
				1.80	1.76	0.95	0.94
				1.79	1.79	0.88	0.97
				1.64	1.59	0.83	0.81
				1.67	1.65	0.82	0.86
				1.66	1.67	0.97	0.96
				1.71	1.75	0.95	0.94
				1.67	1.74	0.88	0.91
				1.68	1.72	0.90	0.94
				1.76	1.74	0.93	0.94
				1.56	1.54	0.86	0.86
				1.52	1.54	0.89	0.88
				1.62	1.68	0.90	0.94

Table 2. Number of cases with significant (at 0.05 level) differences between variety means

	$\mu<0$		$\mu>0$	
	length	width	length	width
Cotyledons	0	5	16	12
Petals	13	9	5	7

It is easy to notice that when length of cotyledon was measured, for 16 varieties the mean values were significantly smaller when measurements were made by computer. When the cotyledon width is concerned for five varieties significantly smaller mean values were obtained when values for this characteristics were measured by hand, on the other hand for 12 varieties significantly smaller were the “computerized” mean values. Similar distortion is observed for petal characteristics. So, from these results, one can conclude that too often the variety mean values are dependent on the method of making measurements. Introduction of “new”, computerized method of making measurements ought to be verified with use much extensive sets of data. Otherwise new results can be in contradiction with the older results and can lead, among other problems, to incoherent description of new varieties in relation to old ones.

Using measurements obtained by these two methods, two variances have been calculated for each characteristics and variety. Because measurements were performed using the same sample, the obtained estimates of variances were dependent. So simple comparison of two variances concerning the same variety and characteristic was impossible. But global comparison of sizes of variances across all varieties is possible with the use of the sign test (Conover, 1980). In this test the value of

$$r = \min(r_s, r_1)$$

is counted, where r_s and r_1 are the numbers of cases when obtained estimates of variance from hand-made measurements were smaller than estimates obtained from computerized ones or larger respectively. If this value is smaller than table value $r_{n,\alpha}$ (where n denotes the number of tested varieties) the hypothesis is rejected at α level, what denotes in fact, that variances are significantly different. The results are collected in Table 3.

Only for SDL there is no reason for rejection of hypothesis that variances are the same. For three other characteristics the sizes of variances are dependent on the method of making measurements. It means that also decisions concerning uniformity of varieties are dependent on the method of making measurements.

Table 3.Testing of equality of variances

Characteristic	n	R	$r_{n,0.01}$	Decision
SDL	30	12	10	No reason to reject
SSL	30	8^*	10	Hypothesis rejected
KDP	26	6^*	8	Hypothesis rejected
KSZP	29	7^*	9	Hypothesis rejected

4. Discussion and conclusions

There is permanent tendency observed toward simplification of DUS procedures across countries associated within UPOV (International Union for The Protection of New Varieties of Plants). The number of years (seasons) is reduced and decisions are often taken after two years of testing or even in some cases after one season. Also the number of measurements is reduced. The laborious hand-made measurements are replaced by computerized ones. But not always new techniques give equivalent results and in particular can influence the decisions concerning distinctness and uniformity of new varieties. Therefore before introducing new methods these ought to be carefully checked whether they give statistically equivalent final conclusions on new varieties. Performed in this paper analysis showed that replacement hand-made measurements by computerized ones can seriously (significantly) influence both the mean values and variances, so can influence the decisions concerning distinctness and uniformity of new varieties. Additional research is needed to show that new method not only simplifies making measurements but that also that “new” results are more reliable than results obtainable by traditional methods. If it is not the case, the program used as “computerized caliper” should be refined.

References

Conover W. J. (1980). *Practical Nonparametric Statistics*. 2nd ed. Wiley, New York.

Domański Cz., Pruska K. (2000). *Nieklasyczne metody statystyczne*. PWE Warszawa.

Greń J. (1984). *Statystyka matematyczna – modele i zadania.* PWN Warszawa.

Sysak A., Kamiński J. (2011). Data collecting using image processing for the chosen characteristics of oilseed rape. *Biuletyn Oceny Odmian* 33, 91–100.

TWC/29/19. (2011). *Image Analysis in the Netherlands*. UPOV Geneva,

TWC/29/29. (2011). *Image Analysis for DUS in the United Kingdom*. UPOV Geneva.