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Seed spacing evaluation for seed drills

ISO-Standard 7256/2 is in need of revision

The method prescribed in the ISO standard 7256/2 for evaluating seed drills is characterized by its lacking precision and discrepancies in several evaluation procedures. Therefore, the standard is used only in fundamental modifications in DLG seed drill testing. An optical sensor developed in Hohenheim, which continuously monitors the seed spacing of seed drills, provides a data base which is sufficient for examining the ISO 7256/2 method from a statistical perspective and for working on suggestions for improvement.

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Keywords

Seed drills, seed spacing, testing of equipment, measurement methods

According to the ISO-Standard, the evaluation of seed spacing can take place while in motion or stationary, whereby the seed drill is driven over an adhesive band on a solid and plain surface or an adhesive band with a suitable velocity is pulled through under the stationary machine. A test run of a total length of 30 m is defined, which depending on the length of the test bed employed can be carried out in stages. The results of the tests are obtained by counting up the number of seeds for 100 mm sections, which are marked as lines on the adhesive band. A visual or audible detection of the seeds can be used as an option. In this case the evaluation of seed counting per time interval is carried out with a sowing length corresponding to 100 mm. As an absolute measure for the seed dispersion the variation coefficient VK_{ISO} for the seed quantity k in z sections was calculated whereby s_k represents the standard deviation from the mean $\bar{k}$ of seed quantity .

$$VK_{ISO} = \frac{s_k}{\bar{k}} \cdot 100 = \frac{\sqrt{\frac{1}{z-1}\sum_{i=1}^{z}\left(k_i - \bar{k}\right)^2}}{\bar{k}} \cdot 100 \qquad (1)$$

Although the variation coefficient is reliable and is meaningful for various diverse mean variation applications, an application in this case is not permissible, which can be shown as follows.

According to the proofs of [1] and later [2] the seed distribution on the sections for normal seed drills can be closely represented using a Poisson distribution, whereby the parameter λ represents both, the mean μ and the variance σ^2:

$$VK_{ISO} = \frac{\sqrt{\sigma^2}}{\mu} \cdot 100 = \frac{\sqrt{\lambda}}{\lambda} \cdot 100 = \frac{100}{\sqrt{\lambda}} \qquad (2)$$

Because a nominal sectional length of 100 mm is stated in the ISO-Standard, for estimation of the parameter λ a defined mean seed quantity $\bar{k}$ per section with $\bar{k} = 100/\bar{x}$ is resulting from the sowing quantity under investigation or the corresponding mean spacing $\bar{x}$, respectively. With this it is possible to calculate the theoretical VK_{ISO} as a function of the mean seed spacing $\bar{x}$. The function is marked as a line in *Figure 1* and it can be clearly seen that VK_{ISO} changes systematically with the seed quantity sown. Empirically determined VK_{ISO} values from seed sequences with different sowing quantities support the theoretically derived results. As seed drills for different sowing quantities are being investigated, VK_{ISO} is unsuitable as an absolute measure to define the quality of seed spacing, therefore making it necessary to revise the ISO Standard.

Modification of the ISO-Standard 7256/2 within the DLG test criteria

In contrast to the ISO-Standard, the variation factor VF was implemented as a mean variation within the DLG test criteria [3, 4]:

$$VF = \frac{\sigma^2}{\mu} = \frac{\lambda}{\lambda} = 1 \qquad (3)$$

As shown in *Figure 1*, VF does not change with respect to the sowing quantity. As VF is based on the variance instead of the standard deviation, a larger mean variation of the

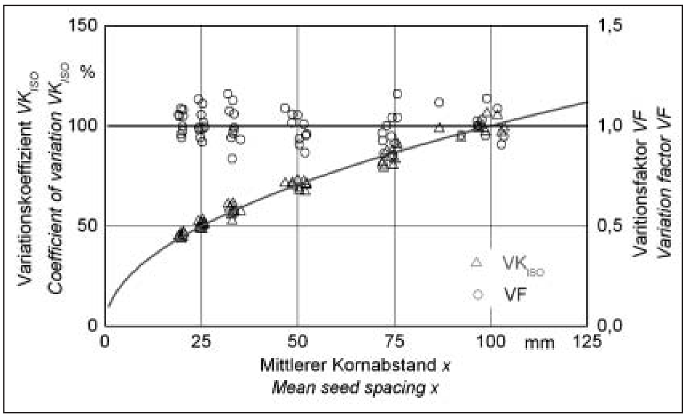

Fig. 1: Variation coefficient VK_{ISO} according ISO 7256/2 and variation factor VF according DLG versus seed spacing

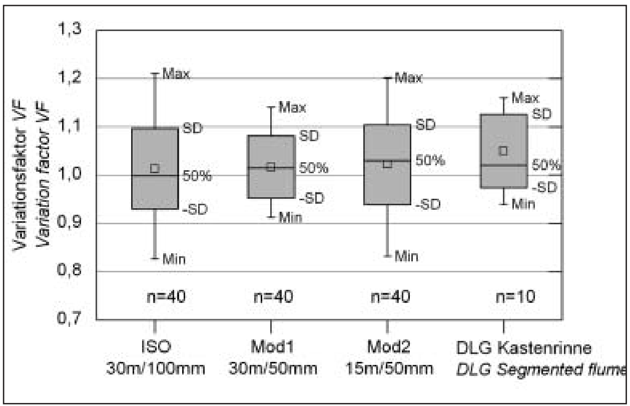

Fig. 2: Dispersion of variation factor VF at various total and segment length, calculated from 40 seed sequences and from ten empirical trials in the DLG segmented flume

results is produced for repeated trials. The large mean variation of the VF values is unsatisfactory regarding the evaluation of seed drills. For greater precision the sectional lengths within the DLG test criteria were shortened to 50mm. At the same time the test run was halved, so that 300 sections are evaluated per test run. The effects of this action can be seen in *Figure 2* represented by 40 seed sequences. The VF values can in fact be reduced by halving the sectional length as shown by the reduction in the standard deviation but this is only valid when the original length of the test run e.g. the distance of the observed seed sequence is retained. If at the same time a halving of the test run takes place as done in the DLG test criteria, a reduction in the random sample range will again cause a loss in precision.

DLG Segmented flume procedure and assessment scale

Based on ISO 7256/2 the sectionalized evaluation of seed sequencing is carried out in the DLG test procedure by sowing seeds in a 15 m segmented flume, which is subdivided into 50 mm sections, followed up by counting up the grains per section. To investigate the equivalence of both measurement processes, segmented flume experiments were conducted at the DLG test center at Groß-Umstadt employing ten trials. As shown in *Figure 2* there ensues comparable mean and standard deviation results for the VF values whereas the range of the values, that is the difference between the minimum and maximum values when calculating 40 trials is naturally larger, because the probability will increase to including extreme values.

Based on the standard deviation σ_{VF} of the Segmented flume experiments, the required number of trials n according to the required accuracy of results can be evaluated from:

$$n \geq \left(\frac{2 \cdot z_{1-\frac{\alpha}{2}} \cdot \sigma_{VF}}{\Delta VF} \right)^2 \qquad (4)$$

Here z is the $(1-\alpha/2)$-quantile of the normal distribution and ΔVF the allowable range of the confidence interval. If a probability of error of $\alpha = 0.05$ is chosen the equation then yields the number of required empirical trials to ensure that the Variation Factor VF lies within a range given by VF ± $\Delta VF/2$ with a probability of 95%. To define the minimum number of empirical trials, the allowable tolerance for VF must be established. Since the ISO standard does not include an assessment of the gained VK_{ISO}-values, the DLG evaluation is referred to, which is based on a gradation of $\Delta VF = 0.2$, where VF values between 0.9 and 1.1 will are considered as 'good'. To ensure a reliable classification of results for this scale of values, the allowable range of the confidence interval for VF must be considerably smaller than a scale increment. According to *Figure 3* three trials are required to just fall below a scale increment of $\Delta VF = 0.2$. A tolerance of half of this scale increment would require ten trials. As the results remain inaccurate, even with a greater number of trials due to the large increment, the time and effort involved would be disproportional.

A different approach

The present reports show, that the procedures established by the ISO-Standard cannot yield a satisfactory result for the evaluation of seed spacing of seed drills by means of counting the seeds in defined sections even when implementing corrections and improvements. The counting method should be replaced by measuring the actual seed spacing. As a characteristic measure the variation coefficient VK_x is given by:

$$VK_x = \frac{s_x}{\bar{x}} \cdot 100 = \frac{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}}{\bar{x}} \cdot 100 \qquad (5)$$

Due to the high precision of this method the VK_x-values show a considerably less dispersion. The standard deviation s_{VK} of the variation coefficient VK_x from 80 measurements for the usual DLG test run of 15 m amounts to 3.3 %. From this, the number of necessary number of trials can be evaluated. The result is shown in *Figure 3*.

By applying the optical sensor of the University of Hohenheim a test run of any desirable length can be chosen. Furthermore, a larger number of trials are possible due to less time and effort required. These procedure using three empirical trials with 1000 seed sequences allows an accuracy of ± 3.25% VK_x. For four empirical trials the accuracy is increased to 2.5% VK_x. If the DLG assessment scale would be based on the seed spacing, seed drills with VK values between 90 and 110 % would be graded as 'good'. The precision of this method is consequently sufficient enough to justify a scale increment of 20 % VK_x.

Literature

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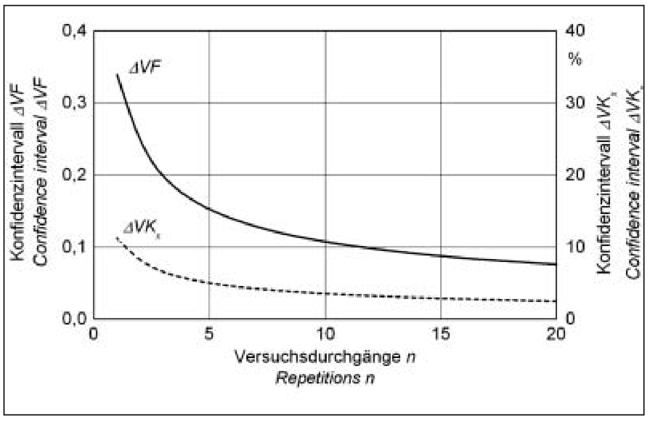

Fig. 3: Width of confidence interval variation factor VF and variation coefficient VK_x versus number of repetitions at a confidence level of 95 %