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MONITORING OF SEED COUNTER IN 1000 SEED WEIGHT TESTING

PROVERA BROJAČA SEMENA U ISPITIVANJU MASE 1000 SEMENA

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ABSTRACT

Accuracy and random selection of seeds when testing the 1000 seeds weight in the laboratory is of great importance in order to ensure the representativeness of the sample and precise information for further packaging process. The aim of this research was to check whether the laboratory seed counter selects seeds by shape and size and whether there is a trend during operation at maximum and reduced speed. Ten species of different seed sizes were used. Ten replicates of 100 seeds were counted by counter, the number of seeds was manually checked and the weight measured. The analysis of the obtained results showed that the counter is precise, but weight results showed selection of smaller seeds (Capsicum annuum and Glycine max) at maximum counting speed. Trend of larger seed selection was observed in Medicago sativa and pelleted Beta vulgaris. Slower counting (50% of the maximum speed), is ensured precise counting without trends.

***Keywords**: trend, 1000 seed weight, seed counter.*

REZIME

Praćenje i kontrola rada laboratorijske opreme je jedan od zahteva akreditacionih standarda za laboratorije za ispitivanje semena. U dosadašnjoj praksi nije se obraćala pažnja da li prilikom rada brojača dolazi do selektivnog izbora semena koje se broji. Preciznost i slučajan izbor semena kod ispitivanja mase 1000 semena u laboratoriji je od velike važnosti kako bi se obezbedila reprezentativnost uzorka. Cilj ovog istraživanja je provera da li laboratorijski brojač semena u toku svog rada, pri maksimalnoj i smanjenoj brzini selektuje seme po obliku i veličini i da li postoji trend. U radu je ispitivano 10 vrsta različite krupnoće semena (Capsicum annuum, peletirano seme Beta vulgaris, Brassica napus, Medicago sativa, Raphanus sativus, Sinapis alba, Triticum aestivum, Helianthus annuus, Glycine max i Zea mays). Analizom dobijenih rezultata utvrđeno je da brojač precizno broji. Na osnovu rezultata izmerene mase uočeno je da se na maksimalnoj brzini brojanja pojavljuje trend selektovanja prvo sitnijeg, a zatim krupnijeg semena kod vrsta Capsicum annuum i Glycine max. Nasuprot tome, kod semena Medicago sativa i peletiranog semena Beta vulgaris, uočen je trend selektovanja semena od krupnijeg ka sitnijem. Prilikom sporijeg brojanja (50% od maksimalne brzine), postiže se slučajan odabir semena tj. ne pojavljuje se trend prilikom rada brojača, kod gore navedenih vrsta semena. Za ostale vrste nije uočen trend postepenog smanjenja niti povećanja vrednosti mase u okviru ispitivanih 10 ponavljanja. Rezultati ovih analiza ukazuju na važnost provere opreme kako u smislu tačnosti brojanja tako i selektovanja semena u cilju dobijanja tačnih rezultata ispitivanja mase 1000 semena.

***Ključne reči:** trend, masa 1000 semena, brojač semena.*

INTRODUCTION

Monitoring and control of laboratory equipment is one of the requirements of accreditation standards for seed testing laboratories (SRPS ISO/IEC 17025, 2017; ISTA 2018). The period and method of control depends on the frequency of use of the equipment, its age, etc. In Seed Testing Laboratory of the Maize Research Institute Zemun Polje, seed counter is used to speed up the testing of 1000 seeds weight (TSW), and its counting accuracy is regularly checked once a year. However, in the practice so far, no attention has been paid whether the seed selection occurs during the operation of the counter. Accuracy and random selection of seeds when testing the 1000 seeds weight in the laboratory is of great importance in order to ensure the representativeness of the sample and precise information for further packaging process. The first research on yield, processing and packaging of corn by number of seeds was started by the Maize Research Institute "Zemun Polje" in 1991 and 1992 (*Selakovic et al., 1999*). The sowing unit has recently become the predominant type of packaging of maize seed in our country for domestic and foreign markets (*Miric et al., 2001*). Furthermore, TSW is used for calculation of sowing rate - the amount of seed of an individual species that's needed to achieve an adequate stand. Thousand seed weight is very important seed quality parameter and is often included in seed research projects (*Tabakovic et al., 2021; Wu et al., 2018*). According to the ISTA Rules (2022) 1000 seed weight can be determined by two methods: by counting the whole fraction of pure seed and by counting replications of 100 seeds. In both cases, the counting can be performed manually or by counter. Different apparatus can be used for obtaining working sample for 1000 seed weight. When 100 seed replicates are counted they are afterwards used for germination testing. So imprecise counting, and selection of lighter/heavier seed will be reflected in germination test also. The aim of this research was to check whether the laboratory seed counter tendentiously selects seeds by shape and size and whether there is a trend during operation at maximum and reduced speed.

MATERIAL AND METHOD

Ten species of different seed sizes (Capsicum annuum, pelleted seed Beta vulgaris, Brassica napus, Medicago sativa, Raphanus sativus, Sinapis alba, Triticum aestivum, Helianthus annuus, Glycine max and Zea mays) were used. Ten replications of 100 seeds were counted. After counting each replicate by the counter, the number of seeds was manually checked and the weight measured.

The Contador optical counter with integrated vibration channel was used. The counter was set to two counting speeds (maximum speed set automatically and 50% of maximum speed). The feed container was changed depending on the size of seed to be counted.

Obtained results were plotted in Excel graphs and linear trend lines added. Trend line formulas and R^2 values were analyzed for presence of seed selection. Value of 0.3 for R^2 was taken as a limit.

Thousand seed weight was calculated as average of 10 replicates containing 100 seed multiplied by 10. Difference between 1000 seed weight obtained by counter at maximum and reduced speed was tested by ANOVA (single factor).

Fig. 1. Photo of the seed counter used in this study

RESULTS AND DISCUSSION

Trend analysis quantifies and explains trends and patterns in a "noisy" data over time. A "trend" is an upwards or downwards shift in a data set over time (*Glen, 2022*).

Trend analysis in this paper involved observation of values distribution (100 seed weight replication), i.e. dispersal of points on the graph. A random distribution of points confirms that there is no trend. If values had gradually decreased, it would have indicated selection of seed from larger to smaller (presence of trend).

Obtained results are presented on the Graph 1 separately for each tested species. At maximum speed, a trend appears during the operation of the counter, for certain types of seeds. In the species *Capsicum annuum* and *Glycine max*, a trend from smaller to larger seeds was observed (trend line is climbing upwards). In the case of *Medicago sativa* seeds and pelleted *Beta vulgaris* seeds, a trend from larger to smaller was observed (trend line is oriented downwards). Initial hypothesis that seed counter during vibration would select smaller seed was just partially approved. Those data indicate that both seed size and seed shape affect the counting process.

For soybean seed, R^2 value was the highest (0.75) when counting was done at maximum speed. Fast vibrations resulted in separation of smaller seed in the sample at the bottom of feed container. As a result, first replications had lower seed weight, followed by higher values till the end of counting process. When the seed counter was operating at 50% speed, trend line changed the orientation. The first 100 seed replicate had the highest weight, followed by alternating values above and below the average. The R^2 value was much lower in this case (0.26), which lead to the conclusion that trend is not present.

Seed counter gave very good results for majority of tested species even at the 100% speed. This is an indication that seed was randomly selected during counting process. For example, trend lines for *Sinapis alba* were almost identical, and for *Helianthus annuus* very similar.

Overall analysis of the experimental data revealed that at reduced speed (50% of the maximum), there was no trend during the operation of the counter, for all observed types of seeds. Thus, slower counting leads to a more representative sample, indicating that a compromise must be made between speed and accurate result. Similarly, *Wu et al.* (2018) got positive moderate linear relationship between running time and the number of kernels. They developed a system for the automated evaluation of thousand kernel weight "gain TKW" which was tested for acceptable ration between accuracy and efficiency.

In future, during regular laboratory practice care will be taken in order to achieve representativeness. For the species where a trend at maximum speed was observed, the speed on the counter will be reduced to 50%, or counting will be performed manually.

Final conclusion of trend analyses is presented in Table 1.

Table 1. Trend analysis conclusions, trend line formula and R^2 values obtained by counter operated at maximum (100%) and reduced (50%) speed

Species	Trend analysis conclusions Trend line formula and R^2	
	100% speed	50% speed
Capsicum annuum	Trend from smaller to larger Y= 0,0021x+0,6859 R^2=0.38	No trend Y= -0,0007x+0,7025 R^2=0.02
Beta vulgaris pelleted seed	Trend from larger to smaller Y= -0,0119x+2,1488 R^2=0.50	No trend Y= 0,0039x+2,0796 R^2=0.06
Brassica napus	No trend Y= -0,0003x+0,3957 R^2=0.02	No trend Y= 0,0006x+0,4 R^2=0.07
Medicago sativa	Trend from larger to smaller Y= 0,0011x+0,1976 R^2=0.55	No trend Y= 0,0004x+0,1876 R^2=0.08
Raphanus sativus	No trend Y= -0,0036x+0,7657 R^2=0.16	No trend Y= 0,0023x+0,7254 R^2=0.06
Sinapis alba	No trend Y= 0,0006x+0,5704 R^2=0.03	No trend Y= 0,0008x+0,5689 R^2=0.04
Triticum aestivum	No trend Y= 0,0181x+4,2373 R^2=0.23	No trend Y= -0,0213+4,5473 R^2=0.22
Helianthus annuus	No trend Y= -0,0033x+6,6333 R^2=0.04	No trend Y= 0,0059x+6,5653 R^2=0.04
Glycine max	Trend from smaller to larger Y= 0,0886x+13,635 R^2=0.75	No trend Y= -0,066x+14,782 R^2=0.26
Zea mays	No trend Y= -0,0538x+33,901 R^2=0.03	No trend Y= -0,0985x+33,59 R^2=0.05

Average 1000 seed weight results obtained by counter and statistical significance are presented in Table 2. Existence of a trend at maximum speed, in the case of seeds of certain species, was not reflected on 1000 seed weight. Average values were almost identical for *Capsicum annuum*. Maize TSW results differed 6 g in case of maximum and 50% reduced counting speed, which was not statistically significant.

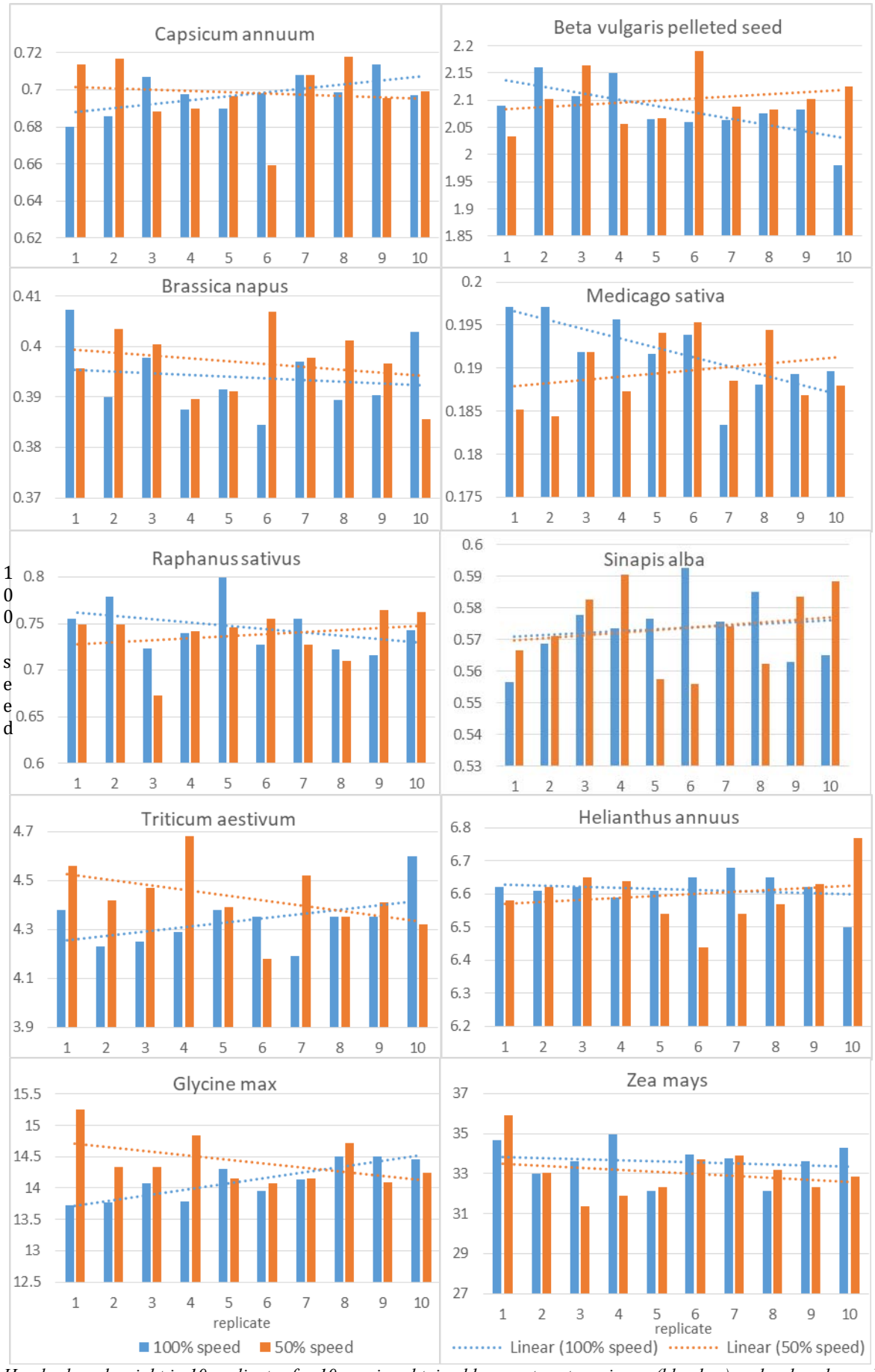

Fig.2. Hundred seed weight in 10 replicates for 10 species obtained by counter at maximum (blue bar) and reduced speed (orange bars) and related linear trend lines

However, if TSW results are multiplied by 25 for calculation of sowing unit weights, difference will increase to 150 g per bag of maize. Precision and representatives of sample for TSW will ensure good packaging weight and prevent disagreement regarding number of seeds in sowing units and potential customer complaints.

Table 2. Average results for 1000 seed weight obtained by counter and statistical significance

Species	Average 1000 seed weight (g)		F value
	100% speed	50% speed	
Capsicum annuum	6.976	6.985	0.01993^{ns}
Beta vulgaris pelleted seed	20.84	21.01	0.628717^{ns}
Brassica napus	3.939	3.969	0.94021^{ns}
Medicago sativa	1.918	1.896	1.357932^{ns}
Raphanus sativus	7.460	7.378	0.443581^{ns}
Sinapis alba	5.735	5.733	0.001313^{ns}
Triticum aestivum	43.37	44.30	2.69897^{ns}
Helianthus annuus	66.15	65.98	0.292214^{ns}
Glycine max	141.2	144.2	3.545615^{ns}
Zea mays	336.1	330.5	1.212878^{ns}

ns – Not significant at P=0.05; F critical = 4.413873

Another, very important aspect is relationship between TSW and germination. Although the average value for 1000 seed weight in this paper is not affected by potential selection during counting replicates, trends in selection should be avoided since replicates are further used in the germination tests which can be affected. Positive correlation between germination and 1000 seed weight was observed by *Knezevic et al*. (2014) on wheat seeds, while *Stanisavljevic et al.* (2013) reported non-significant correlated between those two parameters in testing *Festuca rubra*.

The results of these analyses highlight the importance of monitoring the equipment both in terms of accuracy of counting and representativeness in order to obtain accurate test results for the 1000 seed weight.

CONCLUSION

Obtained results showed that the counter is precise in terms of counting, but weight results showed selection of smaller seeds (*Capsicum annuum* and *Glycine max*) at maximum counting speed. Trend of larger seed selection was observed in *Medicago sativa* and pelleted *Beta vulgaris*. Slower counting (50% of the maximum speed), is ensured precise counting without trends.

The results of these analyses indicate the importance of checking the equipment both in terms of accuracy of counting and selection of seeds in order to obtain accurate test results for the 1000 seed weight.

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