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SEED SIZE DEPENDENT GERMINATION OF SELECTED VEGETABLES*

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A b s t r a c t. Size classification of selected vegetable seed lots (beetroot, onion, cabbage, carrot, parsley, tomato, radish) was performed with a vibrating screen sifter constructed in the University of Technology and Agriculture in Bydgoszcz, Poland. Circular hole sieves series of diameter from 0.8 mm to 4.0 mm for every 0.2 mm or from 2.0 mm do 6.0 mm for every 0.5 mm were used. Seed size distribution within a lot was characterized according to the Rosin-Rammler-Sperling-Bennet theory. Germination capacity of resulting fractions was measured showing dependence on the seed size. Except for cabbage and tomato, germination capacity was found to increase with the seed size.

K e y w o r d s: seed size classification, seed germination

INTRODUCTION

After being harvested, vegetable seeds undergo cleaning by sifting. Vibrating sieves with airflow are most often used to remove seeds that are too light or empty [3]. Classification of seeds with respect to their size (diameter) is performed usually in various sieve separators.

Both laboratory and field tests of size-fractionated seeds have shown that the seed germination and the seed vigor are often dependent on the size of the seeds [5,7,8,9]. Larger and heavier seeds yield most often larger plants as well as better and more even crop establishment and increased further productivity [4].

Generally, extremely large seeds are full of cracks and contaminated by fungi and other pathogens while the smallest seeds are most often immature and germinate poorly.

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The aim of this study was to perform a vegetable seed classification with a vibrating screen sifter constructed in the University of Technology and Agriculture in Bydgoszcz, Poland [2], describe the size distribution in terms of the Rosin-Rammler-Sperling-Bennet function, and investigate the dependence of germination capacity of seeds of selected varieties of vegetables on their size.

MATERIALS AND METHODS

In this investigation a continuous vibrating sifter constructed in the University of Technology and Agriculture in Bydgoszcz, Poland [2] was applied.

This separator was equipped with stackable sheet metal sieves with circular holes of diameter series: from 0.8 mm to 3.6 mm for every 0.2 mm and also from 2 mm do 6 mm for every 0.5 mm. The sifter was fed from a feeder yielding 5-10 kg h^{-1}. The classification results were tentatively plotted in terms of Rosin-Rammler-Sperling-Bennet [1] theory using:

$$\Sigma R = exp^{-\left(\frac{d_i}{d^*}\right)^n} \qquad d_i = \sqrt{a_i \cdot a_{i-1}} \qquad d^* = exp-\left(\frac{b}{n}\right)$$

Where ΣR is calculated as $\Sigma R = (100 - Q)$ – i.e. cumulated leftover on a given sieve expressed as weight fraction, d^* – average diameter, n – uniformity coefficient [1].

The overall and fraction specific germination capacity (SG) were measured according to ref. 6.

The following varieties were used in the present study: beetroot Czerwona Kula, onion Wolska, cabbage Kamienna Głowa, carrot Kometa F1, parsley Berlińska, tomato Anulka, radish Mila.

RESULTS

The results of the size classification of the seeds studied are given in Table 1.

Legend: d_i – average sieve size according to Rosin-Rammler-Sperling-Bennet theory, *Share* – relative size of a given fraction by weight, Q – cumulative amount of seeds that was stopped on sieves, *SG* – seed germination according to ref. [6].

For classification of the beetroot and tomato seeds, sieves differing by 0.5 mm were applied, as a proper size sieve series differing by 0.2 mm was not available.

Fractions of extremely high diameter are relatively small in a seed lot and their germination was either very good (beetroot, onion, radish) or rather poor (cabbage, tomato, parsley). Fraction specific seed germination (SG) is dependent on the overall seed quality.

Table 1. Seed classification

Fraction number	Size (mm)	Diameter of seed d_i (mm)	Share (% weight)	Q (% weight)	SG (%)
1	2	3	4	5	6
		Beetroot Czerwona Kula SG 94%			
1	5.5	–	0.0	0.0	–
2	5.0	5.24	2.8	2.8	100%
3	4.5	4.74	19.5	22.3	99%
4	4.0	4.24	19.5	41.8	98%
5	3.5	3.74	27.4	69.2	93%
6	3.0	3.24	19.5	88.7	82%
7	2.5	2.74	9.4	98.1	52%
8	2.0	2.24	1.9	100.0	53%
		Onion Wolska overall SG 87%			
1	2.8	–	0.00	0.0	–
2	2.6	2.70	0.17	0.2	–
3	2.4	2.50	11.40	11.6	94%
4	2.2	2.30	75.67	87.2	88%
5	2.0	2.10	8.98	96.2	86%
6	1.8	1.90	3.11	99.3	83%
7	1.6	1.70	0.66	100.0	82%
		Cabbage Kamienna Głowa overall SG 89%			
1	2.6	–	0.00	0.00	–
2	2.4	2.50	0.89	0.89	58%
3	2.2	2.30	39.78	40.67	78%
4	2.0	2.10	48.82	89.49	89%
5	1.8	1.90	5.35	94.84	92%
6	1.6	1.70	4.76	99.60	89%
7	1.4	1.50	0.40	100.00	89%
		Carrot Kometa F1 overall SG 78%			
1	2.4	–	0.00	0.0	–
2	2.2	2.30	0.36	0.4	73%
3	2.0	2.10	6.43	6.8	71%
4	1.8	1.90	21.20	28.0	85%
5	1.6	1.70	35.61	63.6	76%
6	1.4	1.50	27.67	91.3	75%
7	1.2	1.30	7.90	99.2	76%
8	1.0	1.10	0.83	100.0	74%

Table 1. Cont.

1	2	3	4	5	6
		Parsley Berlińska	overall SG 63%		
1	2.0	–	0.00	0.00	–
2	1.8	1.90	0.98	0.98	62%
3	1.6	1.70	5.88	6.86	40%
4	1.4	1.50	27.33	34.19	71%
5	1.2	1.30	17.04	51.23	66%
6	1.0	1.10	47.60	98.83	59%
7	0.8	0.89	1.17	100.00	4%
		Tomato Anulka F1	overall SG 74%		
1	3.5	–	0.00	0.00	–
2	3.0	3.24	27.44	27.44	69%
3	2.5	2.74	55.96	83.40	81%
4	2.2	2.35	12.98	96.38	78%
5	2.0	2.10	1.63	98.01	60%
6	1.8	1.90	1.47	99.48	70%
7	1.6	1.70	0.52	100.00	74%
		Radish Mila	overall SG 91%		
1	3.5	–	0.00	0.00	–
2	3.0	3.24	23.09	23.09	95%
3	2.8	2.90	31.87	54.96	93%
4	2.6	2.70	22.18	77.14	94%
5	2.4	2.50	15.56	92.70	93%
6	2.2	2.30	5.35	98.05	97%
7	2.0	2.10	1.39	99.44	68%
8	1.8	1.90	0.56	100.00	48%

The results are presented in Figure 1 as Rosin-Rammler-Sperling-Bennet [1] plots characteristic for seed lots under investigation while the corresponding parameters are given in Table 2.

Generally, the germination capacity increases with seed diameter with the exception of cabbage where it decreases after showing a plateau for most of the fractions, and tomato, where the minimum for middle fractions is observed, Figure 2.

Table 2. Rosin-Rammler-Sperling-Bennet parameters for the investigated seed lots

No.	Sort	Variety	n	d*	Coefficient of determination R^2
1	beetroot	Czerwona Kula	7.0	3.90	99.26
2	onion	Wolska	18.3	2.26	98.95
3	cabbage	Kamienna Głowa	15.8	2.11	99.04
4	carrot	Kometa	9.9	1.69	98.62
5	parsley	Berlińska	8.6	1.33	92.38
6	tomato	Anulka	11.5	2.55	99.51
7	radish	Mila	13.3	2.80	99.22

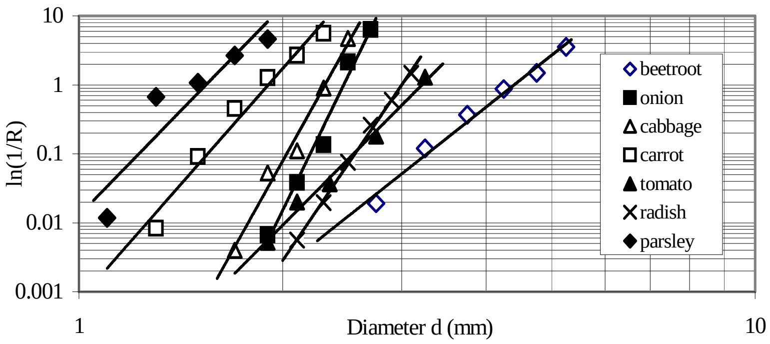

Fig 1. Rosin-Rammler-Sperling-Bennet plots of sieve residues for the investigated vegetable seeds

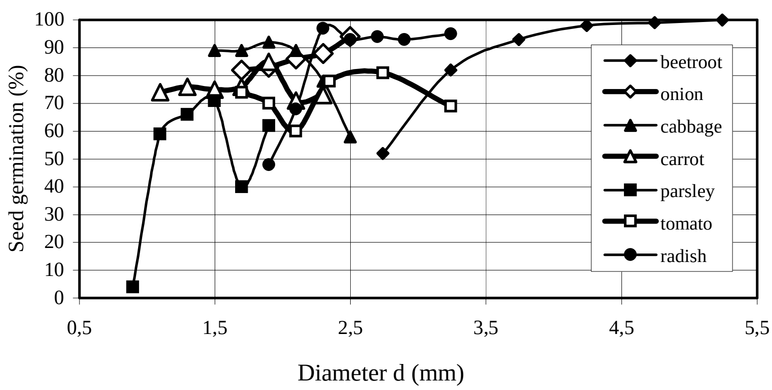

Fig. 2. Dependence of germination capacity on seed diameter

CONCLUSUIONS

Classification of various vegetable seed lots was performed resulting in diversified fraction specific SG (seed germination). Such a classification facilitates:

1. Separation of well germinating from poorly germinating seeds
2. Extraction, from the well germinating fractions, those of extremely high SG (quality extra fraction)
3. Rejection of poorly performing seeds and thus achievement of higher SG for the remaining seeds.

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WPŁYW WIELKOŚCI WYBRANYCH NASION WARZYW NA ICH KIEŁKOWANIE

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Streszczenie. Klasyfikacja partii nasion wybranych warzyw (burak, cebula, kapusta, marchew, pietruszka, pomidor, rzodkiewka) według wielkości nasion została wykonana przy pomocy wibracyjnego przesiewacza sitowego skonstruowanego w ATR w Bydgoszczy .Użyto wielkości sit o otworach okrągłych od 0,8 mm do 4 mm z odstępem, co 0,2 mm lub od 2 mm do 6 mm z odstępem, co 0,5 mm. Rozkład wielkości nasion w partiach został opisany według teorii Rosina-Rammlera-Sperlinga-Benneta. Pomiary zdolności kiełkowania poszczególnych frakcji sitowych wykazały zależność zdolności kiełkowania od średnicy nasion. Z wyjątkiem kapusty i pomidora zdolność kiełkowania rośnie ze wzrostem średnicy nasion.

Słowa kluczowe: kalibracja nasion, kiełkowanie nasion