Utilization of strong electric field for special cleaning buckwheat seeds

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Abstract. Buckwheat growers on ecological farms are confronted with a problem in seed cleaning – sorting - because they are not permitted to use chemical means to destroy weeds.

The paper presents data about a special method of cleaning of wild radish seeds (*Raphanus raphanistrum L.*) from buckwheat seeds (*Fagopyrum esculentum*). The seed-preparing machines used the electric field can to separate seeds according to the unit of mechanical (mass, friction property and other) and electrical (conductivity, dielectric penetration and other) features, sorting and simulating germination. During the research, conveyer-type electric separators with a corona discharge field and three kinds of conveyer belt were used: rubber, armoured and flannel (shaggy-texture fabric).

The following factors were determined during the cleaning tests: angle of friction with different belt surfaces; seed output in fractions of separator; number of weeds; germination and mass of 1000 seeds in fractions.

It was determined that buckwheat seeds' average angle of friction with armoured surface is 36^{o} (wild radish – 23^{o}); rubberized surface – 41^{o} (wild radish – 23^{o}); flannel surface – 51^{o} (wild radish – 36^{o}); the greatest difference between the criterion of removing (detachment angle) wild radish from buckwheat is on the flannel belt; by the cleaning of non-conditional buckwheat seeds it is possible to get 62–80% of seeds to correspond to the requirements of the B or C1 category; germination of seeds from the first fraction of electro – separator exceeds germination of control seeds 18–26% and the increase in germination is substantial.

Key words: strong electric field, special cleaning, buckwheat and wild radish seeds.

INTRODUCTION

Buckwheat (*Fagopyrum esculentum*) growers are confronted with a problem when sorting and cleaning weed seeds from grain seeds in ecological farming, because chemical means cannot be used to destroy weeds in the crops (The regulations of ecological farm, 1999).

After the initial separation, the main separation is completed with the help of the air flow and sieves requiring the use of expensive and complicated machinery (Strakšas, 1994). These machines are able to separate the seeds according to their size, i.e. width, length and thickness (Rawa & Kaliniewicz, 1998). When the number of defective seeds and premixes is large and their thickness varies widely, the buckwheat should be cleaned on the pneumatic separation table with the special installation for the differential air flow distribution (Dintcha & Pavlov, 2002) or in a photoelectric separator (Choszez et al., 2003).

While analyzing the physical-mechanical characteristics of weeds contaminating the buckwheat seeds, we have noticed that sieves and packet-type grain cleaners allow successful separation of the following weed seeds: wild radish (*Raphanus raphanistrum*), field bindweed (*Convolvulus arvensis L.*), catchweed bedstraw (*Gallium aparine L.*) and others (Zakareckas, 1999).

The remaining weed seeds cannot be separated with the traditional separators. Thus their separation requires the search for methods highlighting peculiarities of the seed surface and their electrical characteristics.

There are known methods (Yadov, 2000) for seed separation on a sloping cloth plane (Podobiedov & Tarushkin, 2000), on a fabric belt moving in the corona discharge field (Lynikienė & Požėlienė, 1999) or in the electrostatic field. The separation of two components is possible without an electric field according to the angle of friction when the least friction angle of the rougher seeds is larger than the average friction angle of the smooth seeds. The utilization of the electric field enables increasing the machine efficiency and improving the separation quality with less variance of the friction angles of the components (Shmigel, 2004).

The post-harvest seed processing is fulfilled during their maturation phase. The seed-sowing characteristics depend on the course of the maturation period and its completion. Thus the aim of the post-harvest period should be to prepare the seeds for storage so as to ensure their unchanged quality. The procedures of the main, special separation and sorting by grain thickness should be fulfilled after the termination of the seed maturation simultaneously with the seed preparation before sowing (Romanovska & Rožukas, 2006). The seed processing before sowing uses many physical actions of an electromagnetic nature (Lynikiene & Pozeliene, 2003; Rybinski & Garczyski, 2004; Palov & Sirakov, 2004; Carbonell et al., 2007). The use of the electric field is the most expedient from the point of view of technology, versatility, and energy saving (Borodin & Scherbakov, 1998; Bobryshev et al., 2000).The object of our research is to test the possibility of improving the quality of buckwheat seeds by special cleaning in the strong (corona discharge) electric field.

MATERIALS AND METHODS

For the experiment, buckwheat ´Vokiai´ seeds left after the initial separation at an ecological farm were used. The seeds had been processed with a corona discharge field in the conveyor type electro–separator (Fig. 1.). Three kinds of conveyor belt, rubberized, armoured and flannel, were used.

The attempt to separate the weed seeds left after the cleaning and the results of the previously fulfilled tests (Požėlienė & Lynikienė, 1998) enabled us to determine the following operation regime: the strength of electric field $4{\cdot}10^5$ V m^{-1}, the line speed of the belt 0.6 m s^{-1} .

The device for measuring the angle of friction is shown in Fig. 2.

The ramp, which had a surface covered with rubber, armoured or flannel, with superjacent buckwheat or wild radish seed, is ascensional from horizontal position to seed landslip from plane. The frictional angle is deducted in the protractor.

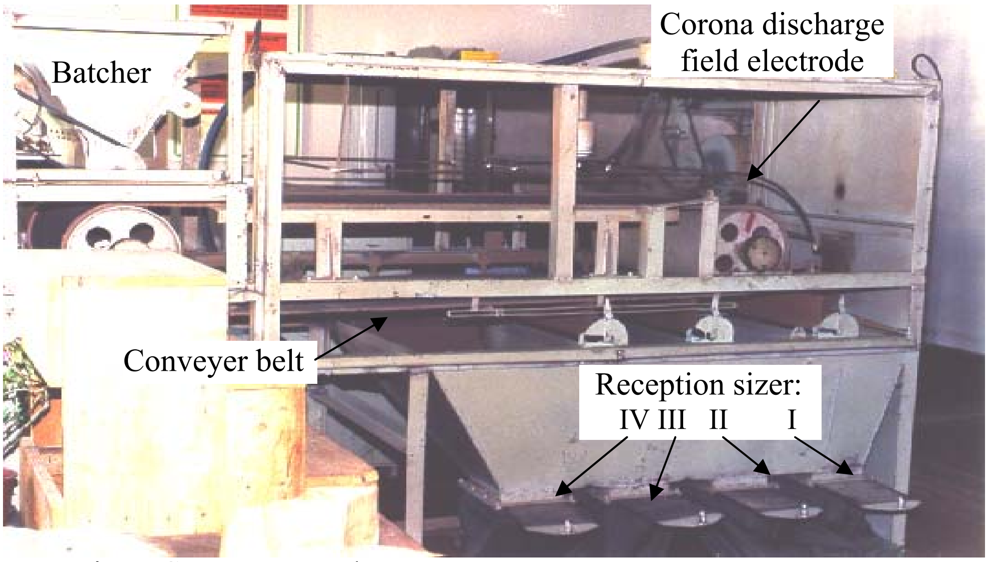


Fig. 1. Conveyer type electro–separator.

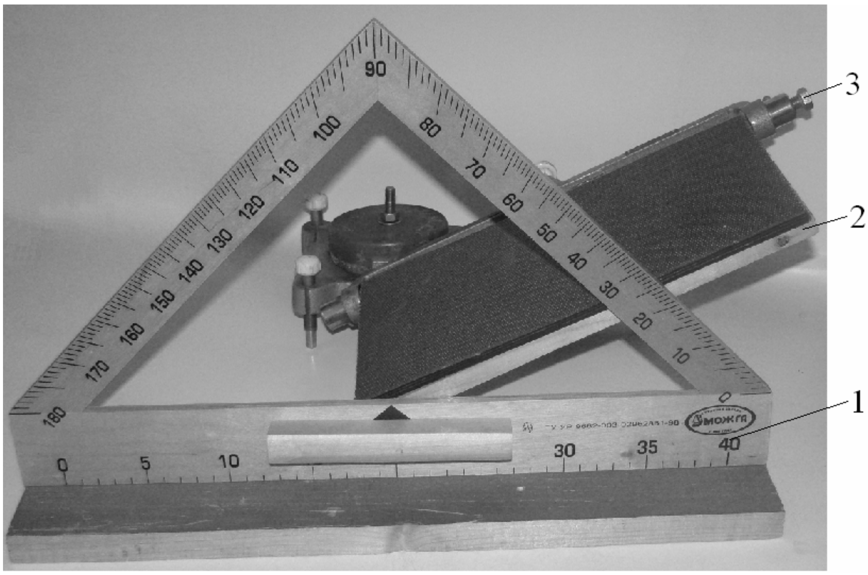


Fig. 2. Meter scheme of frictional angle: 1 – protractor; 2 – ramp; 3 – handle

For all surface types the frictional angle measured 100 buckwheat and 100 wild radish seeds with three replications. Then the mean lever frictional angle is counted for every surface type, and experimental data is processed according to suitable mathematical statistical methods (Nalimov, 1991).

Every cleaning test used 0.5 kg of seeds. The moisture content of seeds during the technological experiments is 13.2–13.4%. The following is determined: seed output to each fraction; the amount of weeds; 1000 seeds mass and germination in fractions (LST 1402–2:1995). The seeds were germinated on moist filtration paper in Petri dishes put into a thermostat TPS-2 at 20°C temperature. Each variant of 100 seeds was germinated in 4 repetitions. The number of germinated seeds in all variants was calculated every day. To evaluate mean germination values of control seeds and those treated with the field, Student's criterion was used.

The determination of the seed separation criteria (their detachment angle in the cylindrical part of the conveyor) has been described by (Lynikienė, 2001):

$$\alpha = \varphi + arcsin\left(\left(\frac{F_k + F_v}{F_p} - K_\omega\right) sin\,\varphi\right),$$

where: φ – the friction angle of the seeds, F_k, F_v – the forces of the electric field and the mirror reflection, N.

When the field strength is constant these forces depend on the mechanical and electric characteristics of the seeds. The correlation relation between the electric characteristics (dielectric permittivity and volumetric conductance) and seeds moisture are 0.966 – 0.982. F_p – the gravitational force, N; K_ω - the cinematic parameter of the separator that depends on the diameter of the cylinder and its rotation frequency.

RESULTS AND DISCUSSION

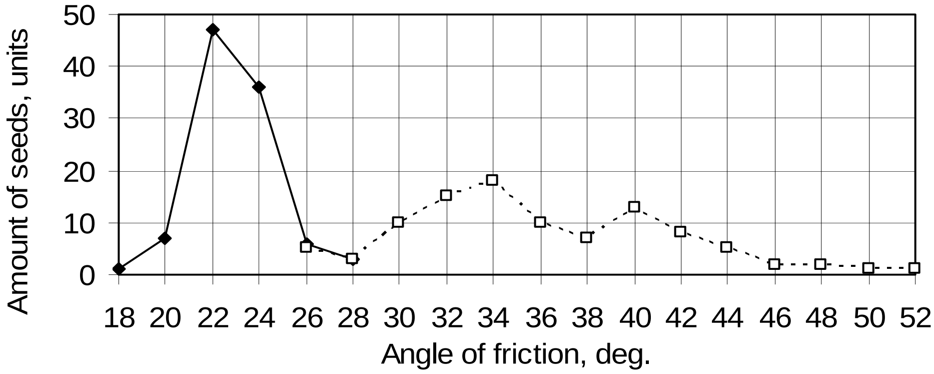
Fig. 3 shows the variation of distribution of buckwheat and wild radish seeds according to the angle of friction.

According to the variation curves, we can see that it is possible to separate wild radish from buckwheat seeds by using its friction properties. It is possible to separate wild radish on the all surfaces without loss of buckwheat seeds.

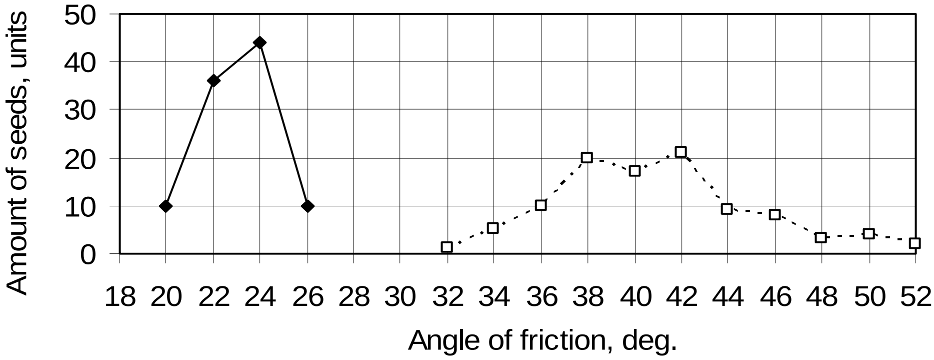
We calculated the separation criteria according to the mathematical dependence upon the angle of detachment and operating regime of the separator and on the electrical and mechanical characteristics of the seed (Lynikienė, 2001). Calculated results of detachment and friction angles are shown in Table 1.

The results show that increasing the moisture of seeds decreases its detachment angle which is influenced by the material of the conveyor belt. Also, the smaller the detachment angle, given the same belt speed and field strength, the more seeds get to fraction I.

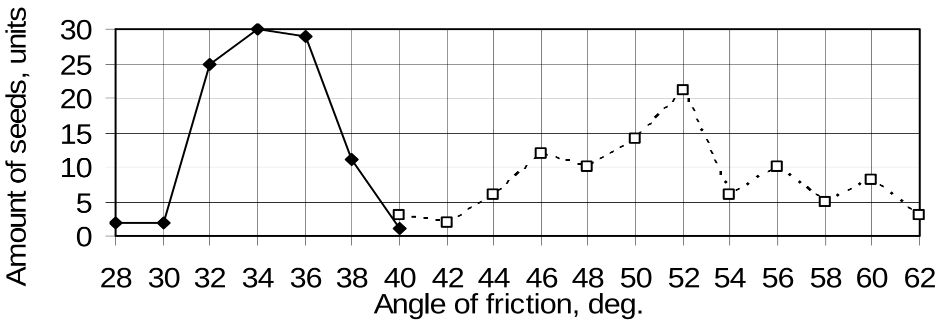
As we have mentioned above the conveyor-type electro-separator with the three kinds of belt surfaces has been used for the special cleaning of the seeds. Table 2 shows the separation results of the buckwheat seeds.



a)



b)



c)

Fig. 3. Variation curves of seed distribution according to angle of friction: a – with armour; b – with rubber; c – with flannel surfaces.

Table 1. Calculating results of detachment and friction angles.

Seed's moisture, %	Material of surface					
	rubber		armoured		flannel	
	Angle of detachment, deg					
	buckwheat	wild radish	buckwheat	wild radish	buckwheat	wild radish
10	99.5	169.0	85.9	169.0	124.4	>180
11	83.8	140.3	73.6	140.3	105.5	>180
12	72.9	102.5	63.6	102.5	89.4	170.7
13	62.3	79.0	55.1	79.0	77.1	130.2
14	53.8	60.2	47.5	60.2	66.8	94.7
15	46.2	45.8	40.7	45.8	57.6	68.5
16	39.2	33.5	34.4	33.5	49.6	49.8
	Average angle of friction, deg.					
~13	41.0	21.0	36.0	24.0	51.0	36.0

Table 2. Results of the buckwheat seed separation.

Charac-teristic	Fract-ions of electro-separator	Out-put, %	Purity of main cultura, %	The amount of admixtures, unit kg^{-1}				1000 seed mass, g	Ger-mina-tion, %	Cate-gory
				in total other species of plants	cultu-ral plants	weeds	wild radish			
Control		100	96	150	8	142	38	22.7	62	non con.
Rubber belt	I	70	98	44	4	40	24	23.5	80	C1
	II	30	91	400	18	380	70	20.8	73	non con.
Flannel belt	I	86	99	14	2	12	6	23.5	84	B
	II	14	76	985	45	940	234	17.5	40	non con.
Armour-ed belt	I	62	99	12	2	10	4	25.8	88	B
	II	28	90	123	23	100	120	20.0	69	non con.
	III	10	92	1083	3	1080	16	11.0	38	non con.

Note: non con. – non–conditional.

Table 3. Evaluation of results of the corona discharge field impact on seed germination

Material of belt	Fraction	$\bar{x}$	s	$t_{calc.}$	Note
	Control	62	5,16		
Rubber	I	80	4,69	5,16	Increase substantial
	II	73	3,83	3,42	Increase substantial
Flannel	I	84	4,40	6,49	Increase substantial
	II	40	3,56	7,02	Decrease substantial
Armoured	I	88	1,83	9,50	Increase substantial
	II	69	6,06	1,76	Increase incidental
	III	39	2,45	8,05	Decrease substantial
$t_{(0,05,6)}=2,45$					

Note: $\bar{x}$ – arithmetic mean of germination; s – estimated standard deviation; $t_{calc.}$, $t_{(0.05;6)}$ – calculated Student's criterion and Student's criterion value form the table.

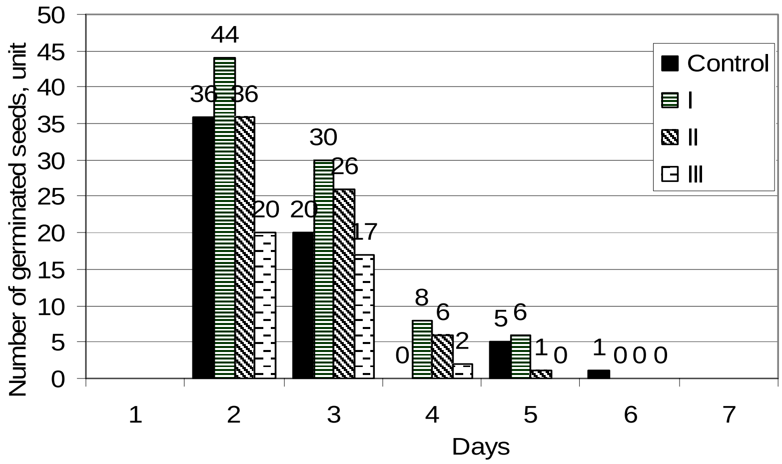


Fig. 4. Germination dynamics of buckwheat seeds.

With the average quality indices in mind we can see that the heavier seeds have fallen into the first fractions of the reception sizer and the lighter than control seeds have passed to the last fractions of the sizer. From non–conditional buckwheat seeds we get 62–86% seeds corresponding to the requirements of B or C1 categories. Under the influence of the electric field the seed germination in the first fraction was greater than control. The average increase of germination in the first fraction was 18–26% greater than control. Thus we can state that the utilization of the electric field enables the separation of biologically valuable seeds.

The germination dynamics using buckwheat seeds on the armoured belt is shown in Fig. 4. The results obtained show that the seeds from first fraction of the electro-separator germinate in a more compatible manner and their germination is also better than that of control seeds. In judging the substantial or incidental increase (decrease) in germination of the specially cleaned seeds, Student's criterion was used. The evaluation of the influence of the electric field on seed germination is given in Table 3.

Statistical processing of data shows that the material covering the conveyor belt has not influenced seeds' germination; the increase in germination of seeds in the first fraction of the electro – separator is substantial in comparison with the control.

CONCLUSIONS

1. It was determined that buckwheat seeds' average angle of friction with armoured surface is 36^{o} (wild radish – 23^{o}; rubberized surface – 41^{o} (wild radish – 23^{o}); flannel surface – 51^{o} (wild radish – 36^{o}).

2. The greatest difference between the criteria of cleaning (detachment angle) wild radish from buckwheat is on the flannel belt.

3. By the cleaning of non-conditional buckwheat seeds, it is possible to get 62–80% seeds to correspond to the requirements of the B or C1 category.

4. Germination of seeds from first fraction of the electro–separator exceeds germination of control seeds 18–26% and the increase in germination is substantial.

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