OBTAINING "ORGANIC SEEDS" OF VEGETABLE AND INDUSTRIAL PLANTS USING THE AERODYNAMIC PROPERTIES OF THE SEEDS
/
OBŢINEREA DE "SEMINŢE ECOLOGICE" DE PLANTE LEGUMICOLE ŞI TEHNICE UTILIZAND PROPRIETĂŢILE AERODINAMICE ALE SEMINŢELOR

Paun A[1]., Stroescu Gh[1]., Zaica Al.[1], Ştefan V[1]., Olan M[1]., Yasbeck Khozamy S.[2]
[1] National Institute of Research-Development for Machines and Installations designed to Agriculture and Food Industry – INMA / Bucharest, Romania;
[2] Schneider Electric / Romania
ani_paun@yahoo.com
DOI: https://doi.org/10.35633/inmateh-63-36

Keywords: *seed, conditioning, aerodynamic properties, vegetable species, impurities, floating velocity*

ABSTRACT

The production and quality of any agricultural crop is determined both by the factors acting from the moment of sowing until harvesting, as well as by those that directly influence the seeds before sowing. In the organic cultivation of cereals, industrial plants, vegetables, medicinal plants, the seeds must be clean without any impurities because the maintenance of these crops does not allow using chemicals. There is a number of technologies and pieces of equipment for separating impurities. In case of separating impurities from the mass of small seeds, especially vegetable and flower seeds, the use of separation on sieves is very expensive because compared to other crops, vegetable seeds are produced in small quantities (except for beans, peas, lentils, etc.) and have a wide variety of characteristics. Vegetables belong to a large number of plant families. This is why their seeds have a very different structure, shape, size and chemical composition. To overcome these challenges, the experimental model Seed conditioning module for vegetable species – MCSL, which separates impurities by using the aerodynamic properties of the seeds was developed. Seed conditioning module for vegetable species is designed to improve the technologies of organic seed production for vegetable seeds, flowers, industrial plants, cereals and to solve practical problems regarding seed production in the case of vegetable crops. Starting from these considerations, the paper will present theoretical and experimental information on the influence of some factors on the aerodynamic properties of cereal seeds, vegetables and industrial plants. The quality of seed separation in this module depends on the degree of uniformity of the air velocity field in the working area, on the stability of this field and on its extent.

REZUMAT

Producția și calitatea oricărei culturi agricole este determinată atât de factorii care acționează din momentul însămânțării până la recoltare, precum și de cei care influențează direct asupra semințelor înainte de însămânțare. În cultura ecologica de cereale, plante tehnice, legume, plante medicinale, semințele trebuie să fie curate fără nici o impuritate deoarece întreținerea acestor culturi nu permite utilizarea substanțelor chimice. Pentru separarea impurităților există o serie de tehnologii și echipamente. În situația separării impurităților din masa de semințe mici, in special semințe de legume si flori, utilizarea separării pe site este foarte costisitoare deoarece în comparație cu alte culturi de legume semințele se produc în cantități mici (excepție fasolea, mazărea, lintea etc.) și au caracteristici foarte variate. Legumele aparțin unui număr mare de familii botanice. Din această cauză semințele lor au o structură, formă, mărime și compoziție chimică foarte diferite. Pentru a răspunde acestor provocări a fost realizat modelul experimental Modul de condiționat semințe pentru speciile legumicole - MCSL care realizează separarea impurităților utilizând proprietățile aerodinamice ale semințelor. Modul de condiționat semințe pentru speciile legumicole este conceput în vederea perfecționării tehnologiilor de producere de sămânță ecologică la semințelor de legume, flori, plante tehnice, cereale, pentru rezolvarea unor probleme practice privind producerea de sămânță la culturile din legumicultură. Pornind de la aceste considerente în cadrul lucrării sunt prezentate informații teoretice și experimentale privind influența unor factori asupra proprietăților aerodinamice ale semințelor de cereale, legume și plante tehnice. Calitatea separării semințelor în acest modul depinde de gradul de uniformitate a câmpului vitezelor aerului din zona de lucru, de stabilitatea acestui câmp și de întinderea lui.

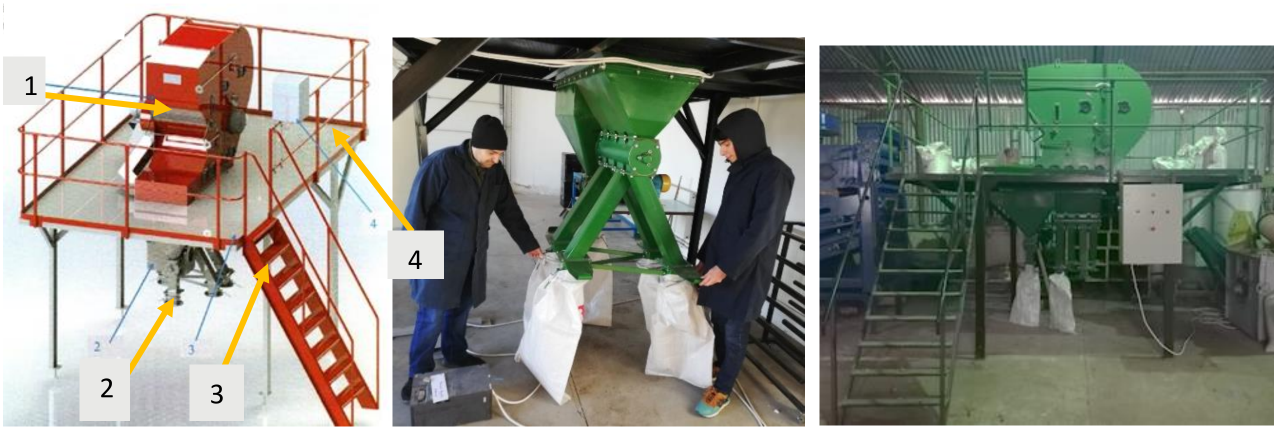
INTRODUCTION

Vegetable growing is a synthetic discipline, integrated in agricultural science and practice, with a well-defined field of activity. It is one of the most complex branches of specialization of plant production due to the great diversity of cultivated plants and with a permanent dynamism following the change of species and hybrids but also the emergence of new technologies and equipment related to specific crops, (*Jadhav et al., 2017*). Seed production for leguminous plants is of great importance, as the vast majority of species propagate this way, (*Panasiewicz et al., 2008*). Due to the fact that the production obtained depends on the quality of the seeds, seeds from varieties and hybrids with superior properties and from superior biological categories without foreign bodies (impurities) must be used (*Stroescu et al., 2019*). Through its position in the national economic system, vegetable growing is a determining factor for the creation or development of productive units that operate both downstream (for the production of construction elements of greenhouses and solarium, installations for heating, ventilation, watering, soil disinfection, chemical fertilizers and pesticides, production of specific machines and tractors, etc.) as well as upstream (design and manufacture of machinery and installations for sorting, calibration, conditioning of vegetables and seeds, production of specific packaging, transport machinery and equipment, storage facilities, canneries, vegetable markets). Quality seeds form the basis of the vegetable production system. Seed quality, in terms of viability and vigour, depends mainly on harvesting, extraction conditions, cleaning, transport and storage (*Stroescu et al., 2020*).

Seed production for vegetable species requires special attention due to the different types of seeds, their corresponding shapes and sizes. The conditioning of small vegetable seeds requires a high level of precision, therefore, cleaning must be performed in stages, paying special attention to the quality performance of each component equipment of the conditioning plants. (*Păun et al., 2018)*. A considerable increase of productivity in vegetable growing can be ensured only through increased efforts to mechanize and automate production processes, ensuring a very good quality seed material and reducing manual labour consumption (*Ciobanu et al., 2015*). The paper presents some theoretical aspects and experiments under operating conditions for the conditioning of mixtures of cereal seeds, vegetables and industrial plants based on the aerodynamic principle, *(Norkulova et al., 2016).*

MATERIALS AND METHODS

Because vegetable seeds have a wide variety of shapes and sizes, it is preferable to use, in the conditioning process, equipment that works on the principle of separation by aerodynamic properties, because separation by size using sieves requires a great financial effort (sieves with holes suitable for each species are necessary), (*Stroescu et al., 2018*). In order to meet the requirements of vegetable growing stations, in particular, but also of individual producers of vegetable seeds and not only, INMA Bucharest created within a complex project, in partnership with vegetable growing stations, a seed conditioning module for vegetable species - MCSL, which works on the principle of separation by aerodynamic properties of the seeds (fig.1). The seed conditioning module for vegetable species MCSL (figure 1, a) consists of the following main parts: 1 - aerodynamic sorter MCSL 1.0; 2 - sorts discharge system MCSL 2.0; 3 - working platform MCSL 3.0; 4 - electrical installation MCSL 4.0. (From: *Test report Seed conditioning method for vegetable species, 2020).*



a b c

Fig. 1 - Seed conditioning module for vegetable species: a – MCSL 3 D; b, c – MCSL operating

This module can be used with good results also for separating impurities from cereal seeds. The MCSL module sorts seeds of the same size, but with different shapes, weights and roughness in three fractions, while removing light impurities in two fractions. For a uniform distribution of the seed layer that is subjected to air flow, MCSL is equipped with a feed cylinder. Depending on the shape and size of the seed, one of the three variants of grooved jackets will be mounted on the feed cylinder shaft. Depending on the degree of infestation with impurities, pre-cleaning and destination of the seeds, one or more passes of the resulted useful fractions through the equipment can be performed. The foreign bodies that frequently appear in the seed mass are:

- inert organic foreign bodies (chaff, chopped stems and leaves, dead insects, etc.);
- inert mineral foreign bodies (lumps, loose or sticky dust on seeds, sand, gravel, metal pieces of various sizes;
- weed seeds;
- seeds from the basic crop degraded by various diseases such as: smut, bunt;

It should be emphasized that the separation processes in agriculture and the food industry are much more complicated than in other branches of the economy, because the material is very biologically diversified. These materials (cereal seeds, industrial plants, etc.) are characterized by high variability and low reproducibility (even within the same variety or species of grains) (*Brăcăcescu et al., 2016*).

From the analysis of the specialized literature, of the studies and experiments carried out by various researchers from universities, research centres or private companies, regarding the factors that influence the process of separation of impurities from the mass of vegetable seeds (cereals, industrial plants), it is found that often addressed factors such as: humidity, density, relative to the speed of floating in the situation of an air flow at a well-determined height in a vertically oriented pipe, which blows the mixture of seeds and impurities, (fig.2), (*Stroescu et al., 2019*).

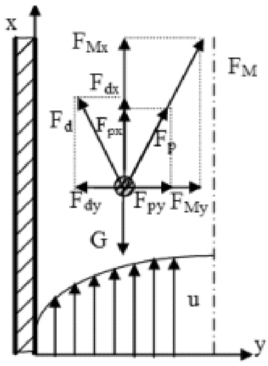


Fig. 2 - Distribution of forces acting on solid particles (seed assimilated to spherical shape) in turbulent vertical air flow: G – weight force; Fd – frontal dynamic pressure force; Fp – bearing force; FM – Magnus force

In the case of technical equipment using as a principle of separation the difference between the aerodynamic properties of the components, one must take into account the floating velocities of the seeds and impurities, but also the aerodynamic coefficient, respectively:

$$v_p = \sqrt{\frac{\rho_p \frac{\pi d^3}{6}}{0.124k\frac{\pi d^2}{4}}} \tag{1}$$

$$v_p = 2{,}4\sqrt{\frac{\rho_p}{k}\,d} \tag{2}$$

where:

v_p -floating velocity, m/s;

ρ_p - specific mass of the particle (spherical seed), kg/m^3;

d - particle diameter, m;

k - aerodynamic drag coefficient (depends on the condition of the particle surface).

The seed conditioning module for vegetable species MCSL sorts seeds of the same size, but with different shapes, weights and roughness in three fractions, while removing light impurities in two fractions. Depending on the degree of infestation with impurities, pre-cleaning and destination of the seeds, the passes of the seeds through the equipment can be repeated (fig.3). Under the influence of the ascending air flow, within the limits of floating velocities, the seeds fall to the bottom obtaining the fraction F_1, the others go up to the first hole where the fraction F_2 is separated, to the second hole where the fraction F_3 is separated, or leave the column at the top entering the settling chamber where the fraction F_4 of light bodies (impurities) is deposited.

The air sucked from the settling chamber is expelled by the fan into the second settling chamber where the dust and other very light impurities that form the sort (fraction) F_5 are separated. The five fractions (of which three are useful) pass through the discharge hoppers and the two locks into the exhaust pipes and then into the bags.

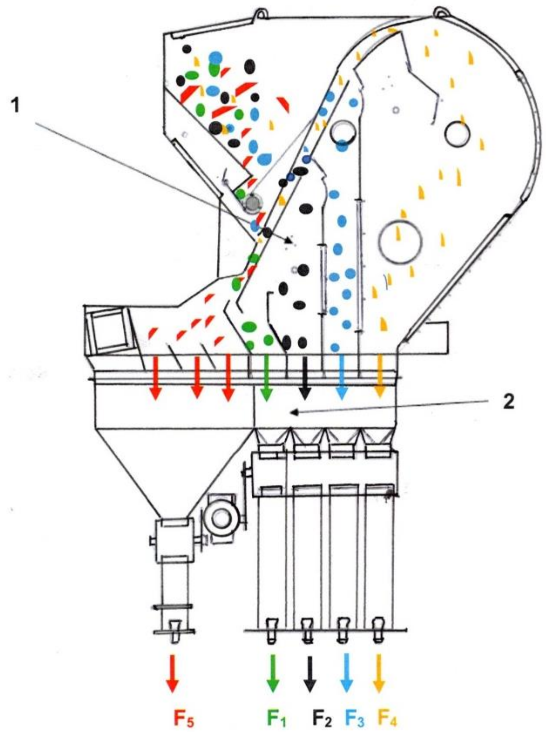


Fig. 3 - Technological flow scheme of seed conditioning module MCSL ***(Păun A., 2018)***

In order to verify the functional parameters of the Seed Conditioning Module MCSL and to analyse the aerodynamic properties of vegetable seeds, experiments were performed under operating conditions. The test of the Seed Conditioning Module for Vegetable Species MCSL was carried out within INMA under operating conditions and processed sorghum, wheat and sunflower seeds purchased on the market.

The technological effect of seed pre-cleaning module MCSL was analysed compared to the product standards and assessed on the basis of the results obtained in a single pass through the installation of the product to be processed.

The following determinations were made:

- E_{csM} - large foreign bodies removed, *%;*
- E_{csm} - small foreign bodies removed, *%;*
- E_{csu} - light foreign bodies removed, *%;*
- C_{ps}- good seeds of the product to be processed lost in by-products, *%.*

The calculation formulas for determining the technological effect of the pre-cleaning group used were:

$$E_{csM}= [(C_{sMi}- C_{sMe}) / C_{sMi}] \times 100 \ [\%] \quad (3)$$

$$E_{csm}= [(C_{smi}- C_{sme}) / C_{smi}] \times 100 \ [\%] \quad (4)$$

$$E_{csu}= [(C_{sui}- C_{sue}) / C_{sui}] \times 100 \ [\%] \quad (5)$$

$$C_{ps} = (\Sigma m_k / M) \times 100 \ [\%] \quad 6)$$

where:

C_{sMi} – content of large foreign bodies at the module input, (%);
C_{sMe} – content of large foreign bodies at the module output, (%);
C_{smi} - content of small foreign bodies at the module input, (%);
C_{sme} - content of small foreign bodies at the module output, (%);
C_{sui} - content of light foreign bodies at the module input, (%);
C_{sue} – content of light foreign bodies at the module output, (%);
Σm_k – sum of good seed masses, in the products collected at the module outputs, during the entire test and determined by laboratory analysis, based on the samples taken separately from each by-product, reported to the total mass of analysed sample, expressed as percentage;
M – good seed mass at module input, determined by laboratory analysis based on the samples taken at the module input of product to be processed and expressed as percentage reported to the total mass of samples, (*Păun et al., 2017*).

RESULTS

The results obtained from the experimental research activities carried out under MCSL Module operating conditions are presented in tables 1, 2, 3, 4. During the laboratory analyses, the moisture and impurity of the samples extracted from the supply and evacuation seed material were obtained, and their image is presented in figures 4, 5, 6, 7 and 8 (From: *** *Test report Seed conditioning method for vegetable species, 2020*).

Table 1

Determining the quality of the processed product

Measured parameter	Sample no.	Sorghum seeds		Wheat seeds		Sunflower seeds	
		Product inlet	Product outlet	Product inlet	Product outlet	Product inlet	Product outlet
Humidity [%]	S I	16.42	16.19	7.6	7.4	9.6	9.3
	S II	16.40	16.20	7.4	7.3	9.4	9.1
	S III	16.48	16.19	7.7	7.35	9.7	9.3
	Average value	**16.43**	**16.19**	**7.56**	**7.35**	**9.56**	**9.23**
Physical purity [%]	S I	*95.2*	97.45	*96.2*	98.9	*96.2*	98.30
	S II	*91.8*	97.35	*94.8*	99.1	*95.8*	97.85
	S III	94.1	97.28	95.1	97.7	95.7	98.32
	Average value	**93.7**	**97.36**	**95.37**	**98.56**	**95.90**	**98.15**
Light foreign bodies (weeds, dust, husks, plant debris, peels + dry seeds less than 1.5 mm thick) *(Csui and Csue)* [%]	S I	2.42	1.1	0.72	0.19	1.10	0.56
	S II	3.43	1.15	0.68	0.20	1.20	0.90
	S III	2.34	0.86	0.65	0.17	1.33	0.77
	Average value	**2.73**	**1.05**	**0.68**	**0.19**	**1.21**	**0.74**
	Ecsu	**61.5**		**72.05**		**39.1**	
Small foreign bodies(*Csmi and Csme*), [%]	S I	0.42	0.15	0.22	0.04	0.32	0.10
	S II	0.45	0.25	0.25	0.04	0.25	0.11
	S III	0.43	0.33	0.23	0.06	0.33	0.15
	Average value	**0.43**	**0.24**	**0.23**	**0.047**	**0.30**	**0.12**
	Ecsm*	**41.77**		**85.87**		**57.69**	
Large foreign bodies(*CsMi and CsMe*), [%]	S I	1.66	1.15	1.7	0.2	2.19	0.84
	S II	3.93	1.05	2.27	0.28	2.51	1.05
	S III	2.73	1.2	2.19	0.3	2.40	0.83
	Average value	2.77	1.13	2.05	0.26	2.37	0.91
	EcsM	**59.20**		**87.31**		**47.36**	

Table 1 (continuation)

Determining the quality of the processed product

Measured parameter	Sample no.	Sorghum seeds		Wheat seeds		Sunflower seeds	
		Product inlet	Product outlet	Product inlet	Product outlet	Product inlet	Product outlet
Sharps, [%]	S I	0.30	0.15	1.16	0.2	0.19	0.1
	S II	0.39	0.20	2,0	0.25	0.23	0.09
	S III	0.40	0.33	1.83	0.21	0.24	0.1
	Average value	0.36	0.22	1.66	0.22	0.22	0.1
Hectolitre mess, kg/hl	S I	14.3	14.1	74.3	80.1	74.3	80.1
	S II	14.3	13.6	79.3	79.05	79.3	79.05
	S III	14.5	13.9	79.1	78.95	79.1	78.95
	Average value	14.36	13.86	79.56	79.36	79.56	79.36

Ecsm* *includes sharps.*

Table 2

Determination of good seed loss coefficient in by-products in the case of sorghum

Measured parameter	Characteristic value/ Test determinations					Air flow speed, m/s
	F_1	F_2	F_3	F_4	F_5	
Good seed mass / at equipment outlet (M) / in fractions, [%]	78.4/79.8/83.2	14.6/13.6/11.28	1.8/1.6/1.3	-	-	3.5/5.5/ 8.2
Mass of good seeds in light and small foreign bodies (m_1) , [%]	-	-	-	1.4/1.2/0.9	-	
Mass of good seeds at the exit of the fan(m_2) , [%]	-	-	-	-	1.2/1.1/0.6	
The sum of good seed masses (Σmk), [%]	97.45 / 97.35 / 97.28					
Good seed loss coefficient in by-products, *Cps* [%]	4.51 /4 / 2.8					

Table 3

Determination of good seed loss coefficient in by-products in the case of wheat

Measured parameter	Characteristic value/ Test determinations					Air flow speed, m/s
	F_1	F_2	F_3	F_4	F_5	
Good seed mass / at equipment outlet (M) / in fractions, [%]	79.2/81.4/85.2	14.2/13.6/11.8	1.6/1.5/1.1	-	-	9 /10.2/11.3
Mass of good seeds in light and small foreign bodies (m_1) , [%]	-	-	-	1.5/1.4/0.7	-	
Mass of good seeds at the exit of the fan(m_2) , [%]	-	-	-	-	1.2/1.0/0.3	
The sum of good seed masses (Σmk) , [%]	97.7/98.9/ 99.1					
Good seed loss coefficient in by-products, *Cps* [%]	2.76/2.42/1					

Table 4

Determination of good seed loss coefficient in by-products in the case of sunflower

Measured parameter	Characteristic value / Test determinations					Air flow speed, m/s
	F_1	F_2	F_3	F_4	F_5	
Good seed mass / at equipment outlet (M) / in fractions, [%]	84.1/85.85/91.2	10.6/8.98/5.12	1.5/1.2/0.9	-	-	5.5/7.5/10
Mass of good seeds in light and small foreign bodies (m_1) , [%]	-	-	-	1.2/1.02 /0.7	-	
Mass of good seeds at the exit of the fan(m_2) , [%]	-	-	-	-	0.9/0.8/0.4	
The sum of good seed masses (Σmk) , [%]	98.30/97.85/98.32					
Good seed loss coefficient in by-products *Cps* [%]	3.66/3.08/2.03					

F_1 *F_2* *F_3* *F_4* *F_5*

Fig. 4 - Samples collected during sorghum seed conditioning (air flow speed 5.5 m/s)

F_1 *F_2* *F_3* *F_4* *F_5*

Fig. 5 - Samples collected during wheat seed conditioning (air flow speed 9 m/s)

F_1 *F_2* *F_3* *F_4* *F_5*

Fig. 6 - Samples collected during sunflower seed conditioning (air flow speed 7.5 m/s)

Analysing the collected samples, but also the results obtained from the table above, we notice the existence of good seeds within the fractions F2 and F5. To reduce the good seed mass in these fractions we have the possibility to adjust the feed flow (for a uniform distribution of the seed layer) with a feed cylinder. Depending on the shape and size of the seeds, one of the three variants of grooved jackets can be mounted on the feed cylinder shaft. Another solution is to modify the section of the sorting column.

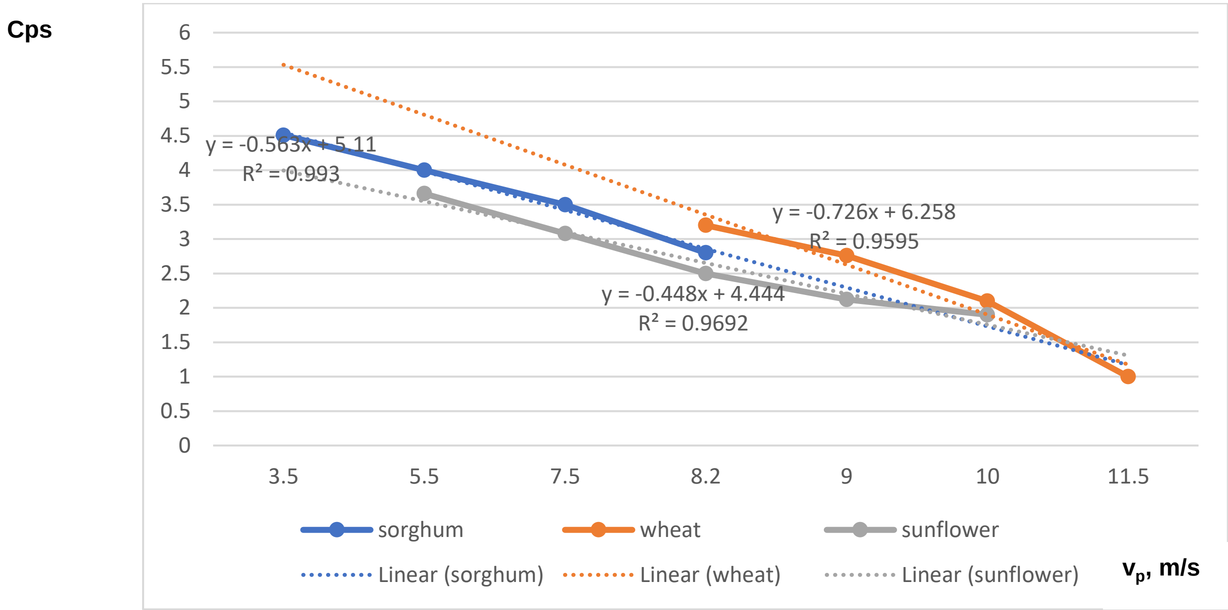


Fig. 7 - Variation of loss coefficient Cps depending on the floating velocity

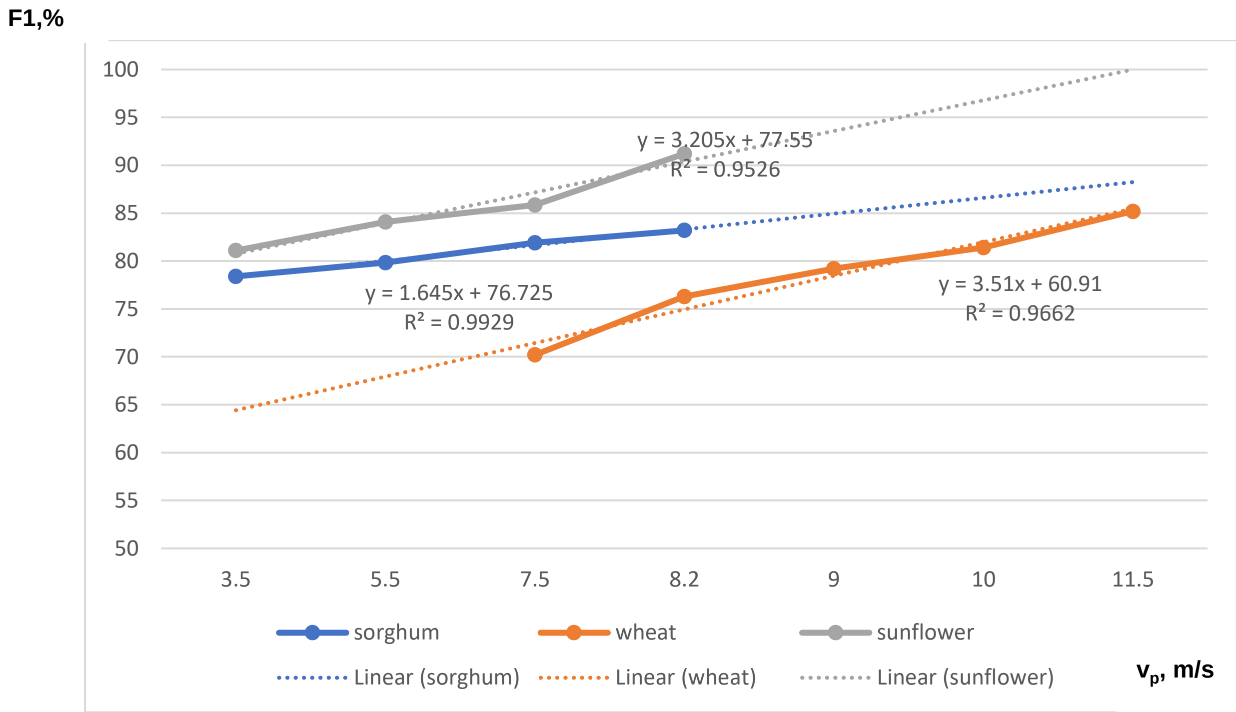


Fig. 8 - Good seed mass F1 at the equipment outlet depending on the floating velocity

From the analysis of the results presented in the tables and figures above, obtained during the experiments, the following phenomena were found:

- the pre-cleaning capacity and the technological effect are influenced by the floating velocity, the degree of impurities and the feed cylinder of the equipment by the type of jacket and the speeds used;
- the humidity of the processed product influences the aerodynamic properties of the seeds (*Stroescu et al., 2020*).
- there are situations when the degree of impurities existing in the seed mass leads to the pass of the seeds through the separator twice;
- the appearance of good seeds in fractions F3, F4 and F5 is due to the fact that these seeds were not threshed, detached from the husks.
- the increase of the air flow speed leads to the decrease of the good seeds in by-products;

- the increase of the air speed in the sorting column over the floating velocity of the seeds has a negative effect because in by-products a higher percentage of good seeds appears

CONCLUSIONS

An analysis of the results obtained led to the conclusions:

- it was found that both the intensity of the air flow and the mode and speed of the seed mixture supply in the working area of the separator had the greatest influence on the separation of the components;

- precise regulation of the air flow rate led to good results in the separation process;

The quality of seed separation in these systems depends on the degree of uniformity of the air speed field in the working area, the stability of this field and its extent.

From the experiments performed under operating conditions it was found that: the coefficient of good seed losses in by-products *Cps* decreases from 4.5% to 2.8% with the increase of the floating velocity v_p from 3.5 m/s to 8.2 m/s for sorghum; *Cps* decreases from 3.2% to 1% for v_p increase from 8.2 m/s to 11.5 m/s for wheat; *Cps* decreases from 3.66% to 2.03% for v_p increase from 5.5 m/s to 10 m/s for sunflower.

The separation module has the possibility to regulate the flow rate of the air flow from the sorting column by modifying the geometry of its cross section by actuating some control flaps.

ACKNOWLEDGEMENTS

This paper was financed with the support of National Agency for Scientific Research and Innovation, Farming Tomorrow - Ensuring Environmental Sustainability by Increasing Competitiveness of Improvement for Organic Agriculture Programme (UEFISCDI PN-III-P1-1.2-PCCDI-2017- 0850, Contract: 14PCCDI/06.03.2018), project component 4 “Making efficient the technology of producing organic seeds for vegetable species by creating a seed conditioning module”.

REFERENCES

[1] Brăcăcescu C., Găgeanu I., Popescu S., Kemal C.S., (2016), Researches concerning impurities separation process from mass of cereal seeds using vibrating sieves in air flow currents, in *Proceedings of 5th International Scientific Conference "Engineering for rural development 2016*”, Jelgava/ Latvia, ISSN1691-5976, pp.364-370;

[2] Ciobanu V.G., Vişan A.L., Păun A, Nedelcu A., (2015), Comparative study regarding seed sorting equipment and the importance of implementing smart systems within the working process, *JoKULL Journal*, vol.64, no.9, ISSN 0449-0576, pp.91-100;

[3] Jadhav M.L., Pramod M., Shelake P.S. (2017), Investigation of Engineering Properties of Vegetable Seeds Required for the Design of Pneumatic Seeder, *International Journal of Current Microbiology and Applied Sciences*, Vol. 6 No. 10, Journal homepage: http://www.ijcmas.com, ISSN: 2319-7706, pp. 1163-1171;

[4] Norkulova K., Safarov J., Sultanova S., (2016), Research on Aerodynamics Separator for Medicinal Plants, *Journal of Food Process Technol* 7:5, vol.7, Issue 5, 1000586, Tashkent State Technical University, Republic http://dx.doi.org/10.4172/2157-7110.1000586, ISSN: 2157-7110 JFPT;

[5] Panasiewicz M., Zawiślak K., Kusińska E., Sobczak P., (2008), Purification and separation of loose materials in a pneumatic system with vertical air stream, *Department of Food Engineering and Machines, TEKA Kom. Mot. Energ. Roln. – OLPAN*, pp. 171–176, University of Life Sciences / Lublin;

[6] Păun A., Stroescu Ghe., Bogdanof G., Vlăduţ V., (2018), *Module to clean vegetable seeds*, Patent application no. A 0986, RO;

[7] Păun A., Brăcăcescu C., Milea D., Bunduchi G. (2017), Researches in producing organic certified seeds and planting material, *Proceedings of 16th International Scientific Conference “Engineering for Rural Development*”, Jelgava, Latvia, ISSN1691-5976, pp.503-508;

[8] Păun A., Stroescu Gh., Vişan A., Olan M., Zaica A., Moiceanu G., (2018) - Researches regarding the optimization of impurities removal technology from the cereal and industrial plant seeds for establishing ecological crops, *INMATEH - Agricultural Engineering*, vol. 56, no.3, pag.83-91;

[9] Stroescu Gh., Păun A., Matache A., Persu C., Dumitraşcu A., Dumitru I., Iuga D., Epure M., Fătu V., (2018). Technology for obtaining environmentally-friendly seeds and sowing material for vegetable species, *Proceedings of International Symposium ISB-INMA TEH’ 2018 “Agricultural and Mechanical Engineering”,* pp. 467-472, http://isb.pub.ro/wp-content/isbinmateh/2018/Volume_Symposium_2018.pdf

[10] Stroescu Gh., Păun A., Brăcăcescu C., Olan M., (2019), Streamlining organic seed production technologies for vegetable species by making seed conditioning module, *Proceedings of 18th International Scientific Conference "Engineering for Rural Development",* Jelgava, Latvia, ISSN 1691-5976, pp. 34-38, http://www.tf.llu.lv/conference/proceedings2019/Papers/N026.pdf

[11] Stroescu Ghe., Păun A., Voicu Ghe., Brăcăcescu C., Popa R., Popa V., (2019), Researches on the separation of impurities from a seed flow based on the aerodynamic principle, *The 8th International Conference on Thermal Equipment, Renewable Energy and Rural Development, TE-RE-RD*, vol. 112. https://doi.org/10.1051/e3sconf/201911203011

[12] Stroescu Gh., Paun A., Voicea I., Persu C., Matache A., Bunduchi G., (2020) - Influence of moisture content on aerodynamic properties of agricultural products in separation of impurities process, Engineering for Rural Development Jelgava, pp. 1277 – 1283, DOI:10.22616/ERDev.2020.19.TF315;

[13] *** Test report Seed conditioning method for vegetable species, (2020). *National Institute of Research – Development for Machines and Installations Designed for Agriculture and Food Industry – INMA Bucharest*.