NARDI FUNDULEA, ROMANIA ROMANIAN AGRICULTURAL RESEARCH, NO. 40, 2023
www.incda-fundulea.ro; doi.org/10.59665/rar4025 Print ISSN 1222-4227; Online ISSN 2067-5720

INFLUENCE OF THE PRESENCE OF WEEDS AND OTHER IMPURITIES IN NATURAL ALFALFA SEED ON FINISHING MACHINES WORK AND SEED QUALITY DURING THREE YEARS

Dragoslav Đokić[1*], Dragan Terzić[1], Jasmina Knežević[2], Aleksandar Vuković[2], Dobrivoj Poštić[3], Ratibor Štrbanović[3], Rade Stanisavljević[3*]

[1]University of Nis, Faculty of Agriculture in Krusevac, 37000 Kruševac, Kosančićeva 4, Serbia
[2]University of Priština - Kosovska Mitrovica, Faculty of Agriculture, 38219 Lešak, Kopaonička bb, Serbia
[3]Institute for Plant Protection and Environment, 11000 Beograd, Teodora Drajzera 9, Serbia
[*]Corresponding authors. E-mail: djdragosla01@gmail.com; stanisavljevicrade@gmail.com

ABSTRACT

The paper presents the results of three - year tests (I, II, III) of finishing alfalfa seed of three different purities. Natural alfalfa seeds were classified into three groups: 1) without the presence of quarantine weeds; 2) with the presence of quarantine weeds of *Cuscuta* spp. and *Rumex* spp., but in smaller quantities; 3) in which there were also quarantine weeds in larger quantities.

The alfalfa seeds were cleaned on a selector with sieves and on a magnetic separator manufactured by Emceka-Gompper. Depending on the purity of natural alfalfa seed, the finishing process had to take place in one to three passes through a system of machines, which caused different finishing output and losses of finishing processed alfalfa seed (9.2 to 38.0%). After finishing, the highest quality of processed seeds was from the group with the highest quarantine weeds (group 3), which was reflected in the lowest percentage of hard seeds (16%) and the highest percentage of germination (83%) in all years. This is also shown by a highly significant negative correlation between germination and hard seed (r=-430) after three years of seed processing.

Keywords: alfalfa seed, finishing, natural seed, quality.

INTRODUCTION

Alfalfa is grown in the northern hemisphere up to 69°N (Scandinavian countries), and in the southern hemisphere up to 45°S (New Zealand) as well as 55°S in Argentina and Chile, which makes about 80 countries and a total area of about 33 million hectares (Ivanov, 1988). Owing to its good adaptability to climatic conditions and fast regeneration (it is mowed several times during the growing season), it achieves high yields and excellent fodder quality (Melesse et al., 2017; Tan and Yolcu, 2021; Tesfay and Jones, 2021). However, intensive research is still needed for even higher adaptability to the external environment and expansion into regions where it was less represented (Schitea et al., 2007; Acharya et al., 2020; Achir et al., 2020). Alfalfa can be used in different ways (hay, silage, haylage, alfalfa flour). Because of all this, it was named "*Queen of Forage Plants*"). However, the seed production is associated with a number of problems: abundance, pollination and fertilization (Breazeale et al., 2008; Stanisavljević et al., 2012), the presence of weeds (Kaiser et al., 2015; Sarić-Krsmanović and Vrbničanin, 2015), leading to expensive seeds on the world market. However, alfalfa seed production is characterized by relatively low investment per unit area (499.8 € ha^{-1}, coverage margin 807 € ha^{1}, cost-effectiveness coefficient 2.47, profit rate 59.56%), as indicated by good economic indicators (Pajić and Marković, 2016). Seed finishing, which will enable as little seed loss as possible, can also contribute to the cost-effectiveness of alfalfa seed production. During the finishing for each batch of seeds, it is necessary to perform a seed analysis and, based on that, make the appropriate adjustment of the machines. The seed passes through a system of machines that separate impurities such as

Received 25 November 2022; accepted 8 February 2023. First Online: February, 2023. DII 2067-5720 RAR 2023-98

dry stems, weeds and broken seeds (Uhlarek et al., 2018).

According to the ISTA (2020), no seed of *Cuscuta* spp. and other quarantine weeds should be present in the declared seed. According to the same rulebook, after finishing processing of the seeds, the criteria for placing the seeds on the market must be met: moisture, purity, germination energy, total germination, hardness of the seeds. The aim of these tests was to collect as many seed lots as possible and to classify seeds and other impurities into three groups according to the content of weeds during three years. Further, in laboratory conditions, to identify the determination and quantity of weed seeds in natural seed (unprocessed), then remove weeds and other impurities by processing and obtain pure seeds. In addition, in laboratory conditions, after processing, determine the following parameters of seed quality: mass of 1000 seeds, germination energy, total germination, hardness of seeds.

MATERIAL AND METHODS

During three years (I, II, III) in Serbia, natural (unprocessed) alfalfa seeds were collected from the same plots on which alfalfa seed production took place. In all three years, 20 batches of seeds were collected (i.e., with twenty plots).

During all years of testing from all collected batches the seeds were grouped into three groups:

- Group 1 consisted of a sample in which there were weeds but no quarantine weeds (*Cuscuta* spp. and *Rumex* spp.);
- Group 2 in which, in addition to classic weeds, there were also quarantine weeds, but in smaller quantities;
- Group 3 in which there was a larger amount of classical and quarantine weeds.

During all years, the presence of weeds from each group was determined on a sample of 5 g (according to the ISTA 2020 regulations). This was done by the staff in the accredited laboratory for quality control of seeds and planting material, the Institute for Plant Protection and the Environment in Belgrade. In addition, during each year, another sample of seeds in the amount of 900 kg was left from each group, which was divided into 3 parts, 300 kg each, which was a repetition on which the processing system was tested. Always after the first and other passes through the processing system, the purity and determination of weed seeds were determined on a control sample of 5 g, and at the end of processing, the obtained seed quantity, losses and seed quality were determined.

Finishing methods

Machines and devices used for seed cleaning consisted of: receiving basket with receiving belt, belt conveyors, bucket elevators, selectors with different sieve openings depending on the impurity in natural alfalfa seed. Alfalfa seed cleaning was performed on a selector with sieves and on a magnetic separator that works on the principle of electromagnets. The magnetic separator used is from the German manufacturer Emceka-Gompper type 4. It is used for cleaning the seeds and removing the seeds of *Cuscuta* spp. and other harmful weeds and impurities. Separation of weeds, especially weeds with wrinkled and unsmooth seeds and other impurities on this machine is done with a pair of magnetized rollers. Steel powder was used for the technological process of weed separation on a magnetic separator. The seeds, which have been previously cleaned of other particles and weeds, are mixed in a mixer with steel powder and water before going to the magnetic separator, which enables the separation of harmful quarantine weeds. Healthy alfalfa seeds have a smooth surface, and after mixing, the powder does not stay on that surface. Unlike alfalfa seeds, *Cuscuta* spp. is porous and the powder is retained on it, which enables its separation from alfalfa seeds.

When cleaning alfalfa seeds on a magnetic separator, laboratory analysis of seeds was performed using a small laboratory magnetic separator, primarily to establish the presence of quarantine weeds such as *Cuscuta* spp. and *Rumex* spp. There are three waste outlets on the magnetic seed cleaning separator. Seeds with the first two openings can be reprocessed if the weed content is low. At the third opening, the seed contains a large amount of weeds and impurities, goes to waste and is not processed again.

After seed processing after each year and after all groups (1-3) of processing in the same laboratory in which the purity and determination of seeds were done, seed quality parameters were performed: weight of 1000 seeds, germination energy, total germination, hardness of seeds, in accordance with ISTA regulations.

Statistical analysis

Applied to the influence of the treatment environment was Tukey's Multiple Range Test ($p \leq 0.05$) and the coefficient of variance (CV%). Standard error of the mean was calculated to indicate variation around the mean (± s.e.m.). The Pearson's correlation between germination and other examined parameters was calculated using simple correlation coefficients (r). Acquired experimental data were processed using the freeware software package, Minitab. Statistical analysis comprehended the three general phases.

RESULTS AND DISCUSSION

Seed cleaning has two purposes: 1) removing seeds of other species and inert matter and 2) separating the seeds that will be the final product, while removing seeds of inappropriate weight and colour (Đokić et al., 2008). This can be achieved on machines that work on the principle of differences in the physical characteristics of seeds and non-seed fractions such as: mass, particle size, shape, density, surface texture. Machines that work on the principle of air and sieve include: selectors, gravity separators, separators with velvet strips, as well as magnetic separators (Đokić et al., 2008, 2021). Depending on the amount of impurities present in natural seeds, the amount of processed seeds also depends. Primary finishing of alfalfa seeds is performed on a selector and a gravity table, and secondary on a magnetic separator (Beraković et al., 2021). Weed *Cuscuta* spp. is very widespread, lives on many plants and in many regions of the world (Demir et al., 2017; Albert et al., 2021), and is especially dangerous in alfalfa (Saric-Krsmanovic et al., 2019). Quarantine weed control *Cuscuta* spp. on alfalfa seed crops is very difficult (Sarić-Krsmanović and Vrbničanin, 2015; Sarić-Krsmanović et al., 2020), because the seeds in the soil can be dormant for decades, transmitted to domestic and wild animals, and it is often on weed plants. Dodder seeds (*Cuscuta* spp.) are especially problematic in alfalfa seed crop because it is similar to alfalfa seed in size, morphology of the seedling, and makes cleaning and separation difficult when mixed with alfalfa seed. For these reasons, seed finishing treatment has high costs for weed seed removal (Đokić et al., 2021).

Natural seeds in year I

For the analysis of the average purity of natural alfalfa seeds, three samples were taken from one batch of seeds. All tabular values of seed purity represent average purity values obtained as the arithmetic mean of three replicates.

Natural alfalfa seed of purity 1 in the first year of testing was 61.0% purity. The seed contained a high content of inert substances in the form of pods, stubble seeds and harvest residues and amounted to 37.2%. The weed content was 1.8% (Table 1).

In natural alfalfa seeds of purity 2, which amounted to 76.6%, inert substances accounted for 19.8% and were in the form of pods, crop residues and soil. Weeds were represented by 3.6%. Unlike seeds of purity 1 which did not have quarantine weeds such as *Cuscuta* spp. and *Rumex* spp. in this seed there were 5 seeds of *Cuscuta* spp. and 4 seeds of *Rumex* spp. Other weeds found in natural seeds are shown in detail in Table 1.

Natural alfalfa seeds of purity 3 in the first year were 78.3% (Table 1). Inert substances in the form of pods of rough and damaged grain and harvest residues amounted to 21.2%. There were also 0.5% weeds in the seeds. This seed contained a larger amount of seeds of quarantine weeds *Cuscuta* spp. and *Rumex* spp. The presence of weed seeds in alfalfa and red clover seeds is by no means acceptable, and in natural seeds special attention is paid to the presence of quarantine weed seeds of *Cuscuta* spp. and *Rumex* spp. The numerical value of the seed content of other plants is shown in Table 1.

Table 1. The average purity on the natural alfalfa seeds purity 1, 2, 3 - I year

Purity	1	2	3
Seed structure	%	%	%
Pure seed	61.0	76.6	78.3
Other species	0	0	0
Inert matter	37.2	19.8	21.2
Quarantine weed seeds	1.8	3.6 5 *Cuscuta* spp., 4 *Rumex* spp.	0.5 15 *Cuscuta* spp., 18 *Rumex* spp.
Other seeds (number)	8 *Matricaria* sp., 5 *Polygonum* sp., 7 *Convulvulus arvensis,* 14 *Sorghum halepense,* 10 *Amaranthus retroflexus,* 5 *Setaria* spp.	11 *Matricaria* sp., 9 *Polygonum* sp., 12 *Convulvulus arvensis,* 18 *Sorghum halepense,* 17 *Amaranthus retroflexus*, 8 *Setaria* spp., 5 *Doucus carota,* 3 *Thlaspi arvense*.	15 *Matricaria* sp., 12 *Polygonum* sp., 14 *Convulvulus arvensis,* 21 *Sorghum halepense,* 19 *Amaranthus retroflexus,* 12 *Setaria* spp., 8 *Doucus carota,* 12 *Thlaspi arvense*.
Total	100	100	100

Natural seeds in year II

The purity of natural alfalfa seed 1 in the second year of testing was 85.4%. Inert substances in the form of pods, stubble seeds and crop residues amounted to 13.5%. Weeds were represented by 1.1% and are shown in Table 2.

Natural alfalfa seed of purity 2, which in the second year had an increased content of quarantine weeds that are undesirable in the seed crop, was 81.0% purity. The content of inert substances in the form of crop residues and sparse seeds was 18.7%. Weeds were represented by 0.3%, of which 7 were *Cuscuta* spp. and 7 seeds of *Rumex* spp. (Table 2).

The natural seeds of alfalfa of purity 3 in the second year (II) of testing had 69.0% of pure seeds with 28.9% of inert matter in the form of curtly seeds and harvest residues. Weeds accounted for 2.1% of which 17 were seeds of *Cuscuta* spp. and 16 seeds of *Rumex* spp.

Table 2. The average purity on the natural alfalfa seeds purity 1, 2, 3 - II year

Purity	1	2	3
Seed structure	%	%	%
Pure seed	85.4	81.0	69.0
Other species	0	0	0
Inert matter	13.5	18.7	28.9
Quarantine weed seeds	1.1	0.3 7 *Cuscuta* spp. 7 Rumex spp.	2.1 17 *Cuscuta* spp. 16 *Rumex* spp.
Other seeds (number)	5 *Matricaria* sp., 2 *Polygonum* sp., 4 *Convulvulus arvensis,* 8 *Sorghum halepense,* 7 *Amaranthus retroflexus,* 3 *Setaria* spp., 1 *Thlaspi arvense*.	9 *Matricaria* sp., 12 *Polygonum* sp., 6 *Convulvulus arvensis,* 11 *Sorghum halepense,* 13 *Amaranthus retroflexus,* 6 *Setaria* spp., 1 *Thlaspi arvense.*	13 *Matricaria* sp., 14 *Polygonum sp.,* 19 *Convulvulus arvensis,* 23 *Sorghum halepense,* 14 *Amaranthus retroflexus,* 19 *Setaria* spp., 12 *Thlaspi arvense*.
Total	100	100	100

Natural seeds in year III

Table 3 shows the purity for all three natural purities of alfalfa seeds in the third year of testing. The purity of 1 natural alfalfa seed in the third year of testing was 82.0%, with 18.0% of inert substances in the form of sparse seeds, crop residues and soil. Natural alfalfa seeds of purity 2 in the third year were 75.0% pure. Inert substances in the form of crop residues amounted to 24.0%. There were 1.0% of weeds, of which 11 seeds of *Cuscuta* spp. and 13 seeds of *Rumex* spp. were determined by sample analysis. Seeds of alfalfa of purity 3 in the third year of testing had 81.0% of pure seeds with 16.9% of inert substances in the form of sparse seeds and harvest residues. Weeds accounted for 2.1% of which 19 were seeds of *Cuscuta* spp. and 25 seeds of *Rumex* spp.

Table 3. The average purity on the natural alfalfa seeds purity 1, 2, 3 - III year

Purity	1	2	3
Seed structure	%	%	%
Pure seed	82.0	75.0	81.0
Other species	0	0	0
Inert matter	18.0	24.0	16.9
Quarantine weed seeds	0	1.0 11 *Cuscuta* spp. 13 *Rumex* spp.	2.1 19 *Cuscuta* spp. 25 *Rumex* spp.
Other seeds (number)	5 *Matricaria* sp., 7 *Polygonum* sp., 2 *Convulvulus arvensis,* 4 *Sorghum halepense,* 14 *Amaranthus retroflexus,* 8 *Setaria* spp., 10 *Doucus carota,* 3 *Thlaspi arvense*.	14 *Matricaria* sp., 17 *Polygonum* sp., 9 *Convulvulus arvensis,* 17 *Sorghum halepense,* 18 *Amaranthus retroflexus,* 9 *Setaria spp*., 6 *Thlaspi arvense*.	16 *Matricaria* sp., 15 *Polygonum* sp., 16 *Convulvulus arvensis,* 28 *Sorghum halepense,* 19 *Amaranthus retroflexus,* 20 *Setaria* spp., 10 *Thlaspi arvense*.
Total	100	100	100

Seed finishing in year I

The average purity of the obtained seed from natural seed of purity 1 in the first year of testing after the finishing process on the magnetic separator was 97.8%. The remaining 2.2% are inert substances in the form of sparse seeds (Table 4).

After the process of finishing the seeds of purity 2, the processed seeds were 96.87% pure with 3.13% inert substances. Of the weeds in the sample, 3 grains of *Rumex* spp. were found in a sample of 50 g. At the end of the finishing process, the purity of processed seed 3 was high and amounted to 98.7%. There were 1.3% inert substances in the form of coarse grain. Analysis of a 50 g sample on a small magnetic separator revealed 3 seeds of *Rumex* spp.

After demagnetization for three months, the seed of purity 3 is reprocessed by passing it through a system of finishing machines. The sample for seed analysis was taken from the receiving basket after emptying the bags with alfalfa seeds. Seeds from waste are not processed again due to the high content of harmful quarantine weeds.

Table 4. The average purity of processed of alfalfa seeds purity 1, 2, 3 - I year

Purity	1	2	3
Seed structure	%	%	%
Pure seed	97.8	96.87	98.7
Other species	0	0	0
Inert matter	2.2	3.13	1.3
Weed	0	0	0
Determination other seeds by number	-	3 seeds *Rumex* spp./50 g	3 seeds *Rumex* spp./50 g
Total	100	100	100

After laboratory analysis of alfalfa seed samples, depending on the purity and weed content, the optimal parameters for adjusting the cleaning selector are determined. This means selecting the appropriate sieves and arranging them correctly in the seed cleaning selector. After that, the optimal air flow rate is adjusted during the cleaning process, as well as the regulation of the inflow of seeds for processing from the receiving basket. On a magnetic separator, the quality of cleaning depends on the type and amount of weeds, then on the correctly determined ratio of water and magnetic powder for cleaning seeds, as well as on the amount of seeds that are passed through magnetized cleaning rollers (Đokić et al., 2008; Uhlarek et al., 2018; Beraković et al., 2021).

Using a MCK Gompper type 4 mixer, the listed components were mixed in a mixer for seven minutes, and then the seeds were passed through a trifolin machine. After the finishing procedure, primary sampling of processed seeds and waste was performed. From the primary samples, working samples of 50 g were obtained by the method of division and analysed in the laboratory. The amount of metal powder depends on the percentage of *Cuscuta* spp. in a natural alfalfa seed sample. The smaller the content of *Cuscuta* spp., the share of metal powder decreases and vice versa.

During the process of processing alfalfa seeds on a separator with sieves, a certain amount of quality alfalfa seeds is removed with impurities. In order to increase the percentage of seed utilization, this seed is collected in bags and returned to the receiving basket for processing at the end of the processing. Seeds from waste are processed according to the same technological procedure and on the same processing machines as natural seeds from which the waste was obtained. Seeds are also collected from a magnetic separator with the first two openings, where the content of weed seeds in alfalfa seeds is not high. Seeds from the third opening, which have a large weed content, are destroyed as waste.

Seed finishing in year II

The average purity of processed alfalfa seed 1 after the processing on a magnetic separator was 95.7%, and the remaining 4.3% are inert substances in the form of coarse seeds (Table 5). Weeds were not found in the seed sample of 5 and 50 g.

After the finishing processing, the obtained alfalfa of purity 2 seed with an initial purity of 81.0% was 97.3% pure, and the remaining 2.7% was coarse seed.

After the finishing processing of natural alfalfa seeds of purity 3, seeds of average purity of 95.5% were obtained. The analysis revealed the presence of 0.2% grass. Of inert substances, sparse seeds accounted for 4.3%. In the sample of 50 g, 4 seeds of quarantine weed *Rumex* spp. were determined. In this seed, due to the high content of *Cuscuta* spp. the seed was returned twice through the same machine system for processing, increasing the speed of the seed passing through the system, but decreasing the airflow of the machine for fine seed processing.

Table 5. The average purity of finishing processed alfalfa seeds purity 1, 2, 3 - II year

Purity	1	2	3
Seed structure	%	%	%
Pure seed	95.7	97.3	95.5
Other species	0	0	0.2
Inert matter	4.3	2.7	4.3
Weed	0	0	0
Determination other seeds by number	-	-	4 seeds *Rumex* spp./50 g
Total	100	100	100

Seed finishing in year III

After the process of finishing alfalfa seeds, the purity of 1 was 97.9%. The remaining 1.9% are inert substances in the form of coarse seeds and 0.2% of weeds, without harmful quarantine weeds (Table 6). After the process of finishing the seeds of purity 2, the obtained seeds were 97.6% purity. Inert substances in the form of coarse seeds amounted to 2.4%. Of the weeds, 3 seeds of *Rumex* spp. were present in a sample of 50 g. Table 6 shows the purity of the processed seed purity 3, which was 96.53% with 3.47% of inert substances in the form of coarse seeds. In the 50 g sample, 4 seeds of *Rumex* spp. were found.

Table 6. The average purity of processed of alfalfa seeds purity 1, 2, 3 - III year

Purity	1	2	3
Seed structure	%	%	%
Pure seed	97.9	97.6	96.53
Other species	0	0	0
Inert matter	1.9	2.4	3.47
Weed	0.2	0	0
Determination other seeds by number	-	3 seeds *Rumex* spp./50 g	4 seeds *Rumex* spp./50 g
Total	100	100	100

Table 7 shows the consumption of metal powder and water in the processing of alfalfa seeds of all three seed purities for all three years of testing (I, II, III).

When processing seeds with an average purity (1) of 61.0% in the first year of testing, an average of 0.8 kg of metal powder and 2.1 l of water was used for processing seeds in the mixer, while 0.3 kg of metal powder and 0.7 l of water were used for processing seeds from waste, 1.1 kg of metal powder and 2.8 l of water.

In the first year of testing in seed treatment with an average purity (2) of 76.6% due to the presence of 5 seeds of *Cuscuta* spp. and 4 seeds of *Rumex* spp. the consumption of metal powder on the magnetic separator in the processing of seeds from waste increased, with an average of 0.8 kg of metal powder and 2.1 l of water used for processing seeds in the mixer, while 0.4 kg of metal powder and 0.7 l of water were used for processing seeds from waste (Table 7).

When finishing seeds of average purity (3) of 78.3% in the first year of testing, the seeds passes twice through the processing system and twice through the rollers of the magnetic separator. Due to the greater presence of quarantine weeds (15 seeds of *Cuscuta* spp. and 18 seeds of *Rumex* spp.), the metal powder on the magnetic separator was increased during the processing of seeds from waste, with an average of 2.8 kg of metal powder and 6.4 l of water for finishing after demagnetization of seeds, another 0.5 kg of metal powder and 1.7 l of water were used 0.1 kg of metal powder and 0.3 l of water were used for processing seeds from waste. Table 7 shows the total consumption of 3.4 kg of metal powder and 8.4 l of water for finishing this seed.

For seeds with an average purity of 85.4% in the second year of testing, an average of 1.0 kg of metal powder and 3.0 l of water was used for seed treatment in the mixer, while 0.2 kg of metal powder and 0.4 l of water were used for seed treatment from waste.

Table 7. Consumption of metal powder and water during alfalfa seed processing for all three years (I, II, III)

Year	Purity (%)		Repetition	Number of passes	Metal powder (kg)	Water (l)
I	1	61.0	I time	1	0.8	2.1
			Waste	1	0.3	0.7
			∑	2	1.1	2.8
	2	76.6	I time	1	0.8	2.1
			Waste	1	0.4	0.7
			∑	2	1.2	2.8
	3	78.3	I time	2	2.8	6.4
			Demagnet.	1	0.5	1.7
			Waste	1	0.1	0.3
			∑	4	3.4	8.4
II	1	85.4	I time	1	1.0	3.0
			Waste	1	0.2	0.4
			∑	2	1.2	3.4
	2	81.0	I time	1	0.8	2.2
			Waste	1	0.4	0.7
			∑	2	1.2	2.9
	3	69.0	I time	2	3.0	6.6
			Demagnet.	1	0.5	1.7
			Waste	1	0.1	0.4
			∑	4	3.6	8.7
III	1	82.0	I time	1	1.0	3.0
			Waste	1	0.2	0.5
			∑	2	1.2	3.5
	2	75.0	I time	2	1.2	3.1
			Waste	1	0.4	0.7
			∑	3	1.4	3.8
	3	81.0	I time	2	2.9	6.4
			Demagnet.	1	0.5	1.9
			Waste	1	0.1	0.3
			∑	4	3.5	8.6

Table 7 shows the consumption of metal powder and water during seed treatment with an average purity of 81.0% in the second year of testing. The seed contained 7 seeds of *Cuscuta* spp. and 7 seeds of *Rumex* spp. On average, 0.8 kg of metal powder and 2.2 l of water were used for seed processing in the mixer, while 0.4 kg of metal powder and 0.7 l of water were used for seed processing from waste. In the case of seeds with an average purity of 69.0% in the second year of testing, an average of 3.0 kg of metal powder and 6.6 l of water were used in the mixer. After demagnetization, another 0.5 kg of steel powder and 1.7 l of water were used in the seed mixer. 0.1 kg of steel powder and 0.4 l of water were used for processing the seeds from the waste.

The consumption of metal powder and water in the processing of seeds with an average purity of 82.0% in the third year of testing was 1.0 kg of metal powder and 3.0 l of water. Another 0.2 kg of steel powder and 0.5 l of water were used to process the seeds from the waste. A total of 1.2 kg of metal powder and 3.5 l of water were used to finish this seed.

When finishing seeds with an average purity of 75.0% in the third year of testing, due to the higher content of weeds, the seeds had to pass 2 times on the machine system. There were 11 seeds of *Cuscuta* spp. in the natural seed and 13 seeds of *Rumex* spp. On average, 1.2 kg of metal powder and 3.1 l of water were used for seed processing in the mixer, while 0.4 kg of metal powder and 0.7 l of water were used for seed processing from waste. In the third year of testing during seed treatment of average purity, 81.0% of the seed passed twice through the processing system and twice through the rollers of the magnetic separator due to the larger amount of weeds. The presence of 19 seeds of *Cuscuta* spp. and 25 seeds of *Rumex* spp. the metal powder on the magnetic separator was increased during the processing of seeds from waste, where on average 2.9 kg of metal powder and 6.4 l of water were used for processing the seeds in the mixer, and another 0.5 kg of metal powder and 1.9 l of water were used for processing after demagnetization of seeds. 0.1 kg of metal powder and 0.3 l of water were used for processing seeds from waste. A total of 3.5 kg of metal powder was consumed, as well as 8.6 l of water in the mixing of the magnetic separator.

The quantities of natural alfalfa seed at the beginning of the finishing process and the amount of processed seed at the end of the process are expressed in kg and shown in Table 8. The table also shows seed yield and losses on processing machines, expressed in %. The highest seed yield was in the first year for seeds with a purity of 61.0% with the lowest content of quarantine weeds and amounted to 55.0%. The seeds of this batch also have the smallest losses on finishing machines amounting to 9.8%.

Table 8. Masses of natural and processed alfalfa seeds, processing output and seed losses on machines

Seed structure	Year								
	I			II			III		
	Purity (%)								
	61.0 b	76.6 ^{ab}	78.3 ^{ab}	85.4 ^{a}	81.0 a	69.0 ^{ab}	82.0 a	75.0 ^{ab}	81.0 a
Natural seed (kg)	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0
Processed seed (kg)	495 ^{ab}	456 ^{ab}	441 ^{b}	698 ^{a}	546 ^{ab}	435 ^{b}	668 ^{a}	437 ^{b}	452 ^{ab}
Processing output (%)	55.0 ^{ab}	50.6 ^{ab}	49.0 ^{b}	77.5 ^{a}	60.7 ^{ab}	47.9 ^{b}	74.2 ^{a}	48.5 ^{b}	50.2 ^{ab}
Losses (%)	9.8 ^{c}	33.8 ^{a}	37.4 ^{a}	9.2 ^{c}	25.1 ^{b}	29.9 ^{ab}	9.5 ^{c}	35.3 ^{a}	38.0 ^{a}

Tukey's test, p≤0.05, was applied to assess the significance by red, a.b…x

The utilization of alfalfa seeds in the processing during the three years of research averaged 76.14%, and ranged from 64.7-87.0% (Beraković et al., 2021). Seeds of purity 78.3% with a high content of quarantine weeds had the largest losses of 37.42%. Such large losses occur due to a larger number of seed passages through the machine system in order to remove harmful weed seeds from alfalfa seeds. In this way, the costs of processing this seed also increase. In the second year, when processing natural seeds of high purity of 85.4%, seed yield was high and amounted to 77.5% with small losses of 9.2%. Further, high purity seeds of 82.0% in the third year had a high yield of 74.2% with total losses of 9.48%. The largest losses in the third year were 38.0% for seeds with a very high weed content, with losses increasing in the finishing process to remove these weeds on the finishing machines. During the three years of testing, depending on seed purity after treatment for 1000 seed weight, germination energy and total germination, low variability was found (from CV% = 0.69 for germination energy to CV% = 5.25 weight of 1000 seeds in the second year), also for traits and the effect of year at each purity it had similar variability (CV% = 0.42 for 1000 seed weight to CV% = 5.52 for germination energy) (Table 9).

During all years of testing, the mass of 1000 seeds was always the highest after processing the seeds with the most impurities (group 3), which was statistically significantly higher than the purest seeds (group 1) ($P \leq 0.05$).

Table 9. Quality of alfalfa seeds after the finishing process, laboratory analysis three to five months after seed collection

Year	Seed quality parameters	After the process of finishing the seeds of purity from the groups			CV %
		1	2	3	
I	Weight of 1000 seeds g	1.885$^{\pm 1.11\ b\ B}$	1.967$^{\pm 1.36\ ab\ AB}$	1.989$^{\pm 0.81\ a\ A}$	2.82
	Germination energy	77$^{\pm 0.85\ a\ B}$	78$^{\pm 1.42\ ab\ AB}$	79$^{\pm 1.21\ b\ A}$	1.28
	Total germination	81$^{\pm 0.87\ b\ B}$	82$^{\pm 1.03\ ab\ AB}$	84$^{\pm 1.08\ a\ A}$	1.86
	Hard seed	18$^{\pm 1.23\ a\ A}$	15$^{\pm 0.77\ b\ B}$	13$^{\pm 1.23\ c\ C}$	16.4
II	Weight of 1000 seeds g	1.893$^{\pm 1.13\ b\ B}$	1.999$^{\pm 0.93\ ab\ AB}$	2.103$^{\pm 0.78\ a\ A}$	5.25
	Germination energy	84$^{\pm 0.33\ a\ B}$	84$^{\pm 0.23\ a\ B}$	85$^{\pm 0.19\ a\ A}$	0.69
	Total germination	86$^{\pm 0.87\ b\ B}$	87$^{\pm 0.65\ ab\ AB}$	89$^{\pm 1.02\ a\ A}$	1.75
	Hard seed	14$^{\pm 0.56\ a\ A}$	12$^{\pm 0.77\ b\ B}$	10$^{\pm 0.62\ c\ C}$	16. 7
III	Weight of 1000 seeds g	1.901$^{\pm 1.02\ b\ B}$	1.988$^{\pm 1.09\ ab\ AB}$	2.013$^{\pm 0.78\ a\ A}$	2.99
	Germination energy	76$^{\pm 1.05\ b\ B}$	77$^{\pm 1.21\ b\ B}$	79$^{\pm 1.02\ a\ A}$	1.98
	Total germination	80$^{\pm 0.55\ b\ B}$	81$^{\pm 0.91\ b\ B}$	83$^{\pm 1.02\ a\ A}$	1.88
	Hard seed	20$^{\pm 1.23\ a\ A}$	18$^{\pm 1.04\ ab\ AB}$	16$^{\pm 0.79\ b\ B}$	11.1
CV %, Depending on the year for:	Weight of 1000 seeds g	0.42	0.82	2.95	-
	Germination energy	5.52	4.75	4.28	-
	Total germination	3.90	3.86	3.77	-
	Hard seed	17.6	20.0	23.1	-

a, b… , different small letters, significant effect (P ≤ 0.05; Tukey's Multiple Range test) for the column, A, B... , different capital letters significant effect (P ≤ 0.05; Tukey's Multiple Range test) for the row, ± s.e.m., standard error of the mean.

The reason for this is probably that the seeds from group 3 were passed through the finishing machines several times, and on that occasion, the scanty seeds were removed from the seeds. Seeds that are scanty are often unformed and thus are with lower germination. This caused that after finishing the seeds from group (3) where the scanty seed was removed germination energy and the total germination in all years was the highest, which was also statistically significantly higher in relation to the seeds from group 1 (Table 9).

Generally taking into account all seed purities during three years, the decrease in the share of hard seeds affected higher germination energy and total germination, which shows a significant negative correlation between: weight of 1000 seeds and germination energy (r=-0.867- P ≤ 0.01), weight of 1000 seeds and total germination (r=-0.941- P ≤ 0.001), hard seed and total germination (r=-430), hard seed and germination energy r=-256) (Table 10).

Table 10. Coefficients of simple correlations (r) between alfalfa seed quality parameters after finishing of three natural purities during three years (n=9)

Characteristics	Total germination	Germination energy	Hard seed	Weight of 1000 seeds
Total germination	-	0.970 ***	-0.430 ns	-0.941 ***
Germination energy		-	-0.256 ns	-0.867 **
Hard seed			-	-0.555 ns
Weight of 1000 seeds				-

level of significance,*P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001, ns non-significant p ≥ 0.05.

Hard seed is one whose seedling contains more polyphenols, tannins, cutin, which gives it a more compact anatomical and morphological structure compared to a seed that will germinate immediately (Galussi et al., 2015). In order for the seedling to be permeable to water and gases, scarification is mainly used in practice (Kimura and Islam, 2012). After germination, normal seedlings develop from hard seeds, but due to late germination, seedlings in competition with already developed plants from normal seeds will not have any significance in the establishment of crops (Bass et al., 1988). These hard seeds are undesirable in planting alfalfa crops. In our tests after finishing the seeds from group 3 the content of these seeds was the lowest, it can be interpreted that the passing of seeds several times through the system of finishing machines had a similar effect as scarification, which in addition to seed mass affected germination after finishing this group of seeds to be the highest (Table 9).

CONCLUSIONS

The highest amounts of impurities, in the form of inert substances, other plant species and weeds, are separated by finishing on the selector. While in the secondary phase, the remaining quarantine weed species are separated on a magnetic separator. Alfalfa seed losses in the three-year study ranged from 9.2% to 38.0%. Such a large difference in waste is due to the uneven purity of the natural purity of alfalfa seeds. During the process of cleaning natural alfalfa seeds on a separator with sieves and on a magnetic separator, the ratio of input and output amount of obtained seed is directly dependent on the presence of seeds of *Cuscuta* spp. and other weeds in alfalfa seed, as well as the purity of natural alfalfa seed. After finishing natural seeds with the present quarantine weeds, high losses are inevitable, but the quality of pure seeds is the highest. This can be explained by the reduced share of hard and scanty seeds, which affects the higher percentage of germination energy and total seed germination, from r=-256 hard seed and germination energy to r=-0.941 weight of 1000 seeds and total germination.

ACKNOWLEDGEMENTS

Research was financed by the Ministry of Education, Science and Technological Development, Republic of Serbia (Contract reg. No. 451-03-68/2022-14/200383; 450-03-68/2022-14/200010; 451-03-9/2022-14/200133).

REFERENCES

Acharya, J.P., Lopez, Y., Gouveia, B.T., de Bem Oliveira, I., Resende, M.F.R. Jr., Muñoz, P.R., Rios, E.F., 2020. *Breeding alfalfa (Medicago sativa L.) adapted to subtropical agroecosystems*. Agronomy, 10(5): 742. https://doi.org/10.3390/agronomy10050742

Achir, C., Annicchiarico, P., Pecetti, L., Khelifi, H.E., Hammedi-Bouzina, M., Abdelguerfi, A., Laouar, M., 2020. *Adaptation patterns of sixteen alfalfa (Medicago sativa L.) cultivars across contrasting environments of Algeria and implications for the crop improvement*. Italian Journal of Agronomy, 15: 57-62.

Albert, M., Axtell, M.J., Timko, M.P., 2021. *Mechanisms of resistance and virulence in parasitic plant-host interactions*. Plant Physiology, 4: 1282-1291. doi:10.1093/plphys/kiaa064

Bass, N.L., Runn, G.C., Hesterman, B.O., Roos, E.E., 1988. *Seed physiology, seedling perfomance, and seed sprouting.* In: Hanson, A.A., Barnes, D.K., Hill Jr., R.R. (eds.), Alfalfa and alfalfa improvement, ch. 31. Medison, Wisconsin, ASA, CSSA, SSSA: 961-985.

Beraković, I., Krizmanić, G., Tucak, M., Jukić, G., Josipović, M., Plavšić, H., Ivanišić, I., 2021. *Efficiency of finishing machines in the business process of alfalfa seed production/In Summary*. Seeds, 1: 15-24.

Breazeale, D., Fernandez, G., Narayanan, R., 2008. *Modeling pollination factors that influence alfalfa seed production in North-Central Nevada*. Journal of Central European Agriculture, 9: 107-116.

Demir, I., Kaya, I., Benli, M., Altınoglu, K.M., 2017. *Investigation of palynological features of taxa belonging to the genus Cuscuta distributed in Turkey*. International Journal of Agriculture and Biology, 19: 746-750.

Đokić, D., Đević, M., Stanisavljević, R., Terzić, D., Cvetković, M., 2008. *Quarantine weeds in alfalfa seed and their influence on processing efficiency. In Summary*. Agricultural Engineering, 33: 1-9.

Đokić, D., Terzić, D., Rajičić, V., Živković, S., Oro, V., Milenković, J., Koprivica, R., 2021. *The influence of impurities in natural seeds of alfalfa and red clover on the seed cleaning process*. J. on Processing and Energy in Agriculture, 25: 32-35.

Galussi, A.A., Argüello, J.A., Cerana, M.M., Maximino, M., Moya, M.E., 2015. *Anatomical and chemical characteristics of the seed coat of Medicago sativa L. (alfalfa) cv. Baralfa 85 seeds and their association with seed dormancy*. Phyton Intern. J. of Experim. Bot., 84: 163-175.

ISTA, 2020. *International rules for seed testing*. Basserdorf, Switzerland.

Ivanov, I., 1988. *Alfalfa*. Oxonian Press Pvt., New Delhi.

Kaiser, B., Vogg, G., Fürst, U.B., Albert, M., 2015. *Parasitic plants of the genus Cuscuta and their interaction with susceptible and resistant host plants*. Frontiers in Plant Science, 6: 45.

Kimura, E., and Islam, M., 2012. *Seed scarification methods and their use in forage legumes*. Research Journal of Seed Science, 5: 38-50.

Melesse, A., Steingass, H., Schollenberger, M., Rodehutscord, M., 2017. *Screening of common tropical grass and legume forages in Ethiopia for their nutrient composition and methane production profile in vitro*. Tropical Grasslands-Forrajes Tropicales, 5: 163-175.

Pajić, N., and Marković, T., 2016. *Economic results in alfalfa seed production*. Field and Vegetable Crops, 53: 111-115.

Sarić-Krsmanović, M., and Vrbničanin, S., 2015. *Field dodder - How to control it? Pestic*. Pesticides and Phytomedicine, 30: 137-145.

Saric-Krsmanovic, M., Bozic, D., Radivojevic, L., Gajic-Umiljendic, J., Vrbnicanin, S., 2019. *Response of alfalfa and sugar beet to field dodder (Cuscuta campestris Yunck.) parasitism: physiological and anatomical approach*. Canadian Journal of Plant Science, 99: 199-209.

Saric-Krsmanovic, M., Uludag, A., Bozic, D., Radivojević, L., Gajic-Umiljendić, J., Vrbničanin, S., 2020. *The effect of glyphosate on anatomical and physiological features of alfalfa infested with field dodder (Cuscuta campestris Yunck.)*. Journal of Agricultural Sciences, 26: 181-189.

Schitea, M., Varga, P., Martura, T., Petcu, E., Dihoru, A., 2007. *New Romanian cultivars of alfalfa developed at NARDI Fundulea*. Rom. Agric. Res., 24: 47-50.

Stanisavljević, R., Beković, D., Đukić, D., Stevović, V., Terzić, D., Milenković, J., Đokić, D., 2012. *Influence of plant density on yield components, yield and quality of seed and forage yields of alfalfa varieties*. Rom. Agric. Res., 29: 245-254.

Tan, M., and Yolcu, H., 2021. *Current status of forage crops cultivation and strategies for the future in Turkey: A review*. Journal of Agricultural Sciences, 27: 114-121.

Tesfay, T., and Jones, C.S., 2021. *Varietal differences in yield and nutritional quality of alfalfa (Medicago sativa) accessions during 20 months after planting in Ethiopia*. Tropical Grasslands, 9: 89-96.

Uhlarik, A., Popov, S., Karagić, Đ., Ponjičan, O., Turan, J., 2018. *Alfalfa seed cleaning using a magnetic separator*. Journal on Processing and Energ., 4: 192-195.