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ANALYSIS OF THE PROCESS OF ALFALFA SEED CLEANING USING SEED PROCESSING EQUIPMENT

ANALIZA PROCESA ĆIŠĆENJA SEMENA LUCERKE NA MAŠINAMA ZA DORADU

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ABSTRACT

This paper presents an analysis of the process of cleaning three alfalfa seed lots using seed processing equipment. The effect of the initial quality of alfalfa seed on the losses and gains of processed alfalfa seed was examined. The quality of alfalfa seed during processing was also examined. During alfalfa seed processing, the losses and gains of processed alfalfa seed depend on the initial seed purity and the technology applied. The experiment was carried out at the seed processing centre of the Institute for Forage Crops in Kruševac. A total of three lots of natural alfalfa seed were processed using the fine-cleaning machine Alfa-4 (Damas, Denmark) and the magnetic machine IV (Emcek Gompper, Germany). The following seed processing parameters were observed in the present study: pure seed (%), weed and other seed crops (%), inert matter (%), seed mass (kg), seed loss (%) and processing output (%). On the basis of the results obtained, it is possible to analyse the processing of alfalfa seed and the required equipment adjustments during the process. The equipment adjustments during processing were made depending on the quantity and type of weeds and other substances found in the natural seed.

Key words: *alfalfa, seed processing, seed, processing output.*

REZIME

U radu je prikazana analiza procesa čišćenja tri partije semena lucerke na mašinama za doradu. Ispitivan je uticaj kvaliteta naturalnog semena lucerke na gubitke i dobijenu količinu dorađenog semena. Takođe je prikazan i kvalitet semena lucerke tokom procesa dorade. U procesu čišćenja semena lucerke količina dobijenog semena i gubici semena zavise od početne čistoće semena, kao i od primenjene tehnologije. Propusti prilikom procesa dorade semena lucerke mogu da dovedu do velikih gubitaka semena, to jest do ekonomskih gubitaka. Procesom dorade potrebno je dobiti što veću količinu čistog semena bez prisustva korova, a naročito bez karantinskih korova kao što su vilina kosica i štavelj. Seme koje se koristi za setvu mora da bude čisto, bez primesa i korova, visoke klijavosti i genetske vrednosti. Eksperiment je obavljen u doradnom centru Instituta za krmno bilje u Kruševcu. Dorađivane su tri partije naturalnog semena lucerke. Seme je dorađivano na mašini za fino čišćenje tip Alfa-4, danskog proizvođača Damas i na magnetnoj mašini, nemačkog proizvođača Emceka Gompper, tip IV. U radu su prikazani svi relevantni parametri za proces dorade semena: čisto seme (%), seme korova i seme drugih kultura (%), inertne materije (%), masa dorađenog semena (kg), gubici semena (%) i randman dorade (%). Na osnovu dobijenih rezultata moguće je da se izvrši analiza procesa dorade semena lucerke na mašinama za doradu i njihovo pravilno podešavanje pri procesu dorade. Podešavanje mašina vrši se u zavisnosti od količine i vrste korova, kao i ostalih primesa koje se nalaze u naturalnom semenu.

Ključne reči: *lucerka, dorada, seme, randman dorade.*

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is considered the leading and most important perennial fodder plant in the Republic of Serbia for the production of quality animal feed. In the diet of domestic animals, alfalfa is used as green fodder, i.e. grazing in pure stands or mixtures with herbs, preserved fodder (hay and silage), and dehydrated flour (*Karagić et al., 2011; Jakšić et al., 2013; Vučković, 1999*). Alfalfa is characterized by high biomass yield, feed quality and rapid regeneration after cutting. Its leaves are abundantly rich in protein. Neutral soils are required for the cultivation of alfalfa as it does not favour acidic soils (*Barnes et al., 1988; Burton, 1972; Lugić et al., 2000; Lukić, 2000; Stjepanović et al., 2009*).

After harvest, the processing and storage of forage crop seeds are based on a number of different technological operations relative to the physical properties of the seed. The following physical properties of seeds are of paramount importance to seed processing: shape, humidity, dimensions, sphericality, mass of 1000 seeds, volume, porosity, hectoliter mass, density, static and dynamic angle of internal friction (free fall angle), and static coefficient of surface friction (*Babić and Babić; 1998, Babić and Babić, 2007; Baskakov et al., 2018; Black et al., 2006; Copeland and McDonald, 2004; Đokić, 2010; Đokić and Stanisavljević, 2012; Đokić at al., 2011; Đokić at al.,2013; Smith, 1988*). The construction of equipment for seed sowing, harvesting, transporting and storing, as well as for seed drying and processing, requires an excellent knowledge of the physical properties of seed crops (*Đokić at al., 2018*).

The natural seed for processing is a very complex mechanical mixture consisting of large and small weeds, small parts of organic and inorganic origin, and broken seeds. Therefore, seed processing is a demanding process with high energy requirements for producing seeds of appropriate quality (*Đokić et al., 2013; Đokić et al., 2015; Orobinsky et al., 2017*). After harvest, the purity of alfalfa seed approximates to 80 %, so it requires further cleaning. Consequently, seeds pass through a system of machines separating impurities such as dry stems, weeds and broken seeds (*Uhlarik et al., 2018*). To obtain quality seed, it is necessary to clean the natural seed immediately after harvest in order to avoid self-healing and seed contamination (*Tarasenko et al., 2017*).

Seed processing entails seed cleaning using the seed cleaning equipment such as pneumatic tables as well as friction and electromagnetic separators. The main advantage of electromagnetic cleaning is that there is a high cleaning quality that cannot be achieved by pneumatic cleaning, indented cylinders or sieve cleaning (*Kozlov, 2013*). Weed species found in alfalfa contaminate alfalfa seeds harvested and render the harvest process more difficult. The presence of quarantine weeds such as dodder (*Cuscuta* sp) and curly dock (*Rumex* sp) in alfalfa is especially harmful. Dodder (*Cuscuta* sp) belongs to the most dangerous and economically most detrimental weeds found in alfalfa and red clover plots. If control is not possible, dodder can cause enormous damage (*Đukić et al., 2004; Karagić et al., 2007; Šarić, 1991*). Production and cash seeds have to meet established standards of quality and package, i.e. seeds have to be of certain purity, germination and humidity. The Law on Seeds and Planting Material prescribes all the conditions relative to the method of production, processing, use, trade, import and testing of agricultural crop seeds (*Gazette of the Republic of Serbia, No. 45, 2005*). The quality of alfalfa seeds should be in keeping with the Rule on the Quality of Agricultural Crop Seeds (*Official Gazette of SFRY No. 47/87*). According to this rule, the reconstituted alfalfa seeds ought to have the lowest seed purity of 95 %, 2 % of seeds of other species, weeds not exceeding 0.5 % (no quarantine weeds of *Cuscuta* sp and *Rumex* sp), up to 2.5 % of inert matter, minimum 70 % germination, and a maximum moisture content of 13 %.

The objective of this study was to examine the quality, gains and losses of alfalfa seed during processing, as well as the equipment used therein.

MATERIAL AND METHOD

The experiment was conducted at the seed processing centre of the Institute for Forage Crops in Globoder-Kruševac. A total of three lots of alfalfa seed were processed in triplicate. The processing equipment consisted of an intake pit with belt conveyor, belt conveyors, bucket elevators and the fine-cleaning machine Alfa-4. In the upper shaker shoe of the fine-cleaning machine Alfa-4, six sieves were arranged in two levels (according to the size of perforation), as well as in the lower shaker shoe. In the upper shaker shoe of the fine-cleaning machine, the following sieve size openings were used: 2.75 mm, 2.5 mm, 2.25 mm, 2.0 mm, 2.0 mm and 1.9 mm. In the upper row of the lower shaker shoe, sieves with longitudinal 1.3 mm, 1.2 mm and 1.1 mm openings were used, whereas sieves with 0.6 mm, 0.5 mm and 0.5 mm openings were placed in the lower row of the lower shaker shoe (Figure 1).

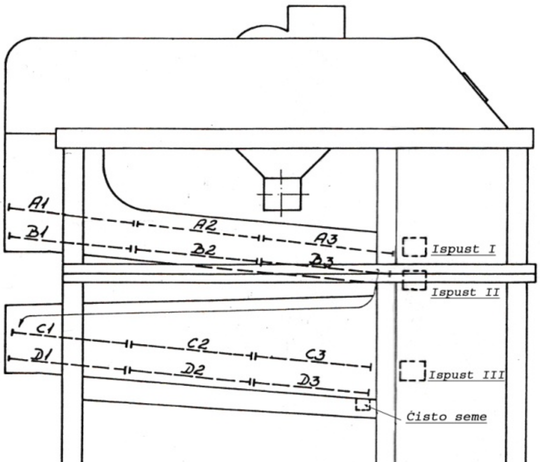

Fig. 1. Fine-cleaning machine Alfa-4 (cross-section)

The modes of operation and the screening scheme were the same for all three lots and replications. During seed processing, seeds with admixtures were collected in the waste bins from the lower and upper sieves, as well as from the ventilator. Subsequently, the weight of seeds was measured and their purity was determined. This is very important in order to determine the total seed losses and where they arise. A magnetic separator of the German manufacturer Emcek Gompper type 4 was used for the advanced purification from weeds. Magnetic separators are intended for purification of seeds and separation of weed seeds, wrinkled seeds and other impurities. All seeds are mixed in a blend with a certain amount of steel powder and water, and passed on magnetic rollers of the machine. Good alfalfa seeds feature a smooth surface (without cracking), so the powder is not retained on the seed surface after mixing. Unlike alfalfa seeds, *Cuscuta* sp seeds are porous and the steel powder is retained on their surface (Fig. 2). This allows for their separation from the alfalfa seed on magnetic rollers. The US steel powder NutraFine RS was used for seed cleaning.

The magnetic separator is fitted with three apertures for waste. The quantity and quality of seeds with admixtures were determined for all three apertures. The seeds from the first and second aperture can be reprocessed provided the weed content is low. In the case of the seeds from the third aperture, only the mass of the seeds was recorded in order to determine the total losses during processing. The seeds from the third aperture contained a large amount of weeds and admixtures, thus went to waste.

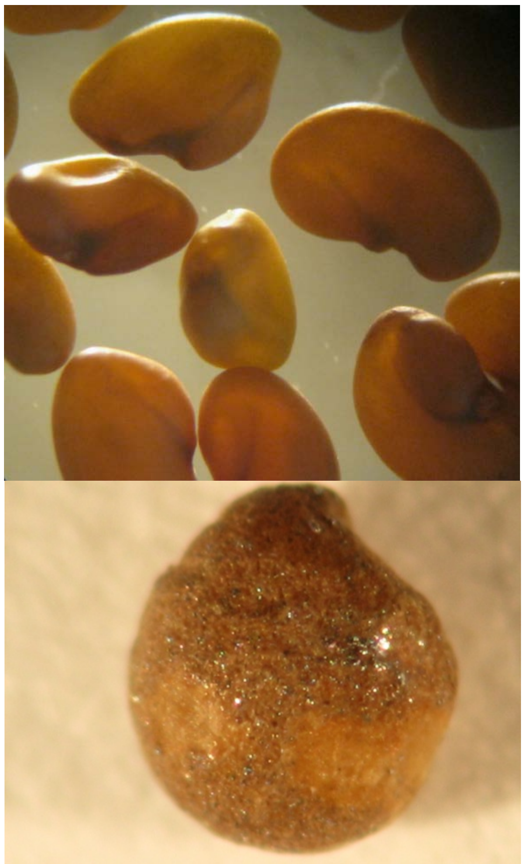

Fig. 2. Good seeds of alfalfa and Cuscuta sp *seeds with the steel powder*

The content analyses of alfalfa seeds and impurities were performed in a laboratory of the Institute for Forage Crops in Globoder-Kruševac. The 5 g and 50 g seed samples were analyzed (Figure 3) using an illuminated magnifying glass and a precision electronic scale for the sample mass measurement.

Fig 3. Alfalfa seed samples for the impurity analysis

After each purification process, a laboratory analysis of the seed samples was performed using a small laboratory magnetic separator. A laboratory magnetic separator is used to determine the presence of weed seeds, especially *Cuscuta* sp. To measure the weight of natural and processed seeds, an electronic scale of a measuring range up to 300 kg was used. The following seed sample parameters were measured: amount of pure seed (%), seeds of other species (%), inert matter (%), and weeds (%). Upon seed processing, the amounts of produced seeds and seeds for waste were determined using a fine machine and a magnetic separator (kg). The seed output (%) and losses due to the processing equipment used (%) were determined by calculations. All the analyses were performed in triplicate. The Tukey's multiple range test was used to determine differences between the treatments and seed lots, whereas the coefficient of variation was utilised for computing the parameter variability (CV, %).

RESULTS AND DISCUSSION

The natural seed purity of three different alfalfa seed lots is shown in Table 1. The purity of natural alfalfa seeds was uniform and ranged from 85.0 % (for seeds of lots I and II) to 86.0 % (for seeds of the lot III), i.e. the seed lots did not differ statistically ($p \geq 0.05$). The remainder of the inert material was in the form of harvest residues (stems, leaves and pods), sickly and damaged seeds, and soil. In the 5 g alfalfa seed sample of the lot III, one seed of the quarantine *Cuscuta* sp weed was found.

Table 1. The average purity of natural alfalfa seeds

Lot	I	II	III	CV %
Seed structure	%	%	%	
Pure seeds	85.0 [a]	85.0 [a]	86.0 [a]	0.677
Other species	-	-	-	-
Inert matter	15.0 [a]	15.0 [a]	14.0 [a]	3.93
Weed	-	-	in 5 g/1 *Cuscuta* sp	-
Total	100	100	100	-

Tukey's test, $p \leq 0.05$

The purity of alfalfa seeds after passing through a fine-cleaning machine is shown in Table 2. The values shown in the table are the average values obtained from three replications. The seed samples for quality analysis were taken after processing with a fine seed cleaning machine. The purity of the lot I seeds averaged 89.8 % with 10.2 % of the inert matter in the form of sickly seeds. *Plantago* sp seeds were found in the 5 g seed sample. The seed lot II had the highest purity of 91.9 % with 8.1% of the bulky seeds. The seed lot III had a purity of 90 % with 10 % of the inert matter.

Table 2. Alfalfa seed purity after the first pass through a fine-cleaning machine (sample from a big seed hopper)

Lot	I	II	III	CV %
Seed structure	%	%	%	
Pure seed	89.8 [a]	91.9 [a]	90.0 [a]	1.28
Other species	-	-	-	-
Inert matter	10.2 [a]	8.1 [a]	10.0 [a]	12.3
Weed	in 5 g/1 *Plantago* sp	-	-	-
Total	100	100	100	-

Tukey's test, $p \leq 0.05$

After mixing with steel powder and water, the seeds were recovered using a magnetic separator. A magnetic separator was used for the separation of weed species, in particular the seeds of *Cuscuta* sp. For all the seed lots examined, a total of 0.3 kg of steel powder and 1.4 l of water per a single blend were used, i.e. for a seed mass of 92.7 kg. The purity of the seed after processing with a magnetic separator is shown in Table 3. After the first passage through the processing machine and the magnetic separator, the lot I had a purity of 97.1 % with 2.9 % of the inert matter in the form of bulky seeds. The purity of the lot II seeds was 96.8 % with 3.2 % of sickly seeds. In the alfalfa seed of the lot III, the purity of the restored seeds was 96.7 %, with 3.3 % of the inert matter.

Table 3. Purity of processed alfalfa seeds

Lot	I	II	III	CV %
Seed structure	%	%	%	
Pure seed	97.1 [a]	96.8 [a]	96.7 [a]	0.215
Other species	-	-	-	-
Inert matter	2.9 [b]	3.2 [a]	3.3 [a]	6.64
Weed	-	-	-	-
Total	100	100	100	-

Tukey's test, $p \leq 0.05$ difference for the rows marked with a, b, etc.

The amounts of waste on all the apertures of the fine machine and the magnetic separator, as well as the total waste of all three seed lots, are shown in Table 4. The total amounts of waste were 498.4 kg, 595.0 kg and 698.0 kg for the lots I, II and III, respectively. Differences were found between the initial quantities of natural seeds and processed seeds attributable to the losses caused by the seed transporter and the air cleaning system. A lot I seed loss of 31.6 kg was recorded, whereas losses of 27.4 kg and 35.0 kg were recorded in the lots II and III, respectively. These losses cannot be avoided, but can be minimized with the correct adjustment and use of the processing equipment. Seed processing machines include dust extraction systems in cyclones, as well as a dust extraction hole on the central dust collector. Certain amounts of inert materials, dust, different plants, as well as broken, small and sickly alfalfa seeds, pass through the dusting system. These quantities cannot be collected or measured during processing and are considered losses due to equipment inefficiency.

Table 4. Masses of fine-cleaning machine and magnetic separator waste

Machine	Seed lot			CV %
	I	II	III	
Fine machine Alfa 4	311.1 [c]	405.9 [b]	504.4 [a]	23.7
Magnetic separator	187.3 [a]	189.1 [a]	193.6 [a]	1.71
Total (kg)	498.4 [c]	595.0 [b]	698.0 [a]	-

Tukey's test, $p \leq 0.05$ difference for the rows marked with a, b, etc.

The amounts of natural and processed alfalfa seeds are shown in Table 5. The processing output and the losses due to the processing equipment inefficiency were also calculated and expressed in percentages. The highest seed utilization of 83.0 % was recorded in the seed lot III, as well as the smallest seed loss of 3.6 %. The smallest seed utilisation of 80.1 % was recorded in the seed lot I, as well as the greatest seed loss of 5.8 %. A seed utilisation of 81.5 % and a seed loss of 4.1 % were recorded in the seed lot II. A significant difference ($p \leq 0.05$) was established between the seed lots relative to natural and processed seeds. This confirms high variability rates of processed seeds (CV = 25.6 %) and natural seeds (CV = 23.7 %) (Table 5).

Table 5. Amounts of processed seeds using the processing machines

Seed structure	Lot (kg)			CV %
	I	II	III	
Natural seed	2662.0 [c]	3363.0 [b]	4288.0 [a]	23.7
Processed seed	2132.0 [c]	2740.6 [b]	3555.0 [a]	25.4
Processing output (%)	80.1 [a]	81.5 [a]	83.0 [a]	1.79
Losses (%)	5.8 [a]	4.1 [b]	3.6 [c]	25.6

Tukey's test, $p \leq 0.05$ difference for the rows marked with a, b, etc.

CONCLUSION

Losses in the processing of alfalfa seeds are dependent on the initial alfalfa seed purity, the type and quantity of weeds present, and other impurities found in the natural alfalfa seeds. For more efficient alfalfa seed processing, proper equipment adjustments are of paramount importance.

Upon examining the experimental seed lots, the results obtained confirmed that the presence of harmful quarantine weeds was not significant. The purity of the seed was increased after each treatment stage, especially after seed processing using a magnetic separator. The percentages of seed utilization and losses were found to depend on the initial seed purity and the techniques and technology used during processing. The utilization of alfalfa seeds can be determined on the basis of the initial amount of alfalfa natural seeds, the seed purity obtained by laboratory analysis and the restored amount of seeds at the end of the seed processing.

Certain seed losses cannot be avoided due to the inefficiency of the dusting system, the seed conveyor system and the processing equipment. However, seed losses during processing can be minimized by proper equipment adjustments and the use of appropriate techniques and technology.

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