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ALFALFA SEED PROCESSING ON DIFFERENT EQUIPMENT
DORADA SEMENA LUCERKE NA RAZLIČITIM SISTEMIMA MAŠINA

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ABSTRACT

For the establishment and exploitation of alfalfa, the seed must be of high purity, germination, and high genetic value. Most of these requirements is realized through processing or removal of foreign matter and seeds of lower quality. Alfalfa seed processing comprises a number of operations from which the most significant are: cleaning, packaging into ambalage, labeling, storage, disinfection and disinsection. In combine harvesting of alfalfa seeds, the obtained material is a mixture of seed of grown plant, seeds of other plants-cultivated and weed, and various impurities of organic and inorganic origin. The task is to remove all foreign matter and various impurities from the natural seed and extract pure grain of primary culture. The importance of processed seed is reflected in the fact that the seed must be prepared for sowing in the most favorable condition, quality and germination. In this study natural alfalfa seed was processed on three different equipment. The aim of this research was to determine relevant parameters of all tested equipment for alfalfa seed processing. Relevant parameters that define the characteristics of equipment for seed processing were: pure seed (%), weed seeds and seeds of other crops (%), inert matter (%), the quantity of processed seed (kg), seed processing time (h), consumption of active energy (kWh) and reactive energy (kVArh), seed losses (%) and output (%). Testing was conducted at the processing center of the Institute of Forage Crops in Globoder-Kruševac, with three replications. Natural alfalfa seed with purity of 78.0%, with an extremely high content of quarantine dodder weed (Cuscuta spp.), was processed. Based on these results it is possible to select an appropriate equipment and optimize and rationalize the alfalfa seed processing.

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

REZIME

Za zasnivanje i eksploataciju lucerke, seme mora biti visoke čistoće, klijavosti, kao i visoke genetske vrednosti. Veći deo ovih zahteva se ostvaruje kroz doradu, odnosno odstranjivanjem nečistoća i semena lošijeg kvaliteta. Dorada semena lucerke obuhvata veći broj operacija od kojih su najznačajnije: prečišćavanje, pakovanje u ambalažu, deklarisanje, skladištenje, dezinfekcija i dezinsekcija. Pri kombajniranju semenske lucerke materijal koji se dobija predstavlja mešavinu semena gajene biljke, semena drugih biljaka-kulturnih i korovskih, kao i razne nečistoće organskog i neorganskog porekla. Zadatak čišćenja je da se iz ovako dobijenog naturalnog semena sa primesama uklone sva zrna stranih primesa i razne nečistoće i izdvoji čisto zrno osnovne kulture. Značaj dorađenog semena se ogleda u tome da se seme blagovremeno pripremi u što povoljnije stanje za sejalicu i kvalitetnu setvu, klijanje i nicanje. U radu su prikazani rezultati ispitivanja naturalnog semena lucerke pri doradi na tri različita sistema mašina. Cilj ispitivanja bio je da se pri doradi semena lucerke odrede relevantni parametri za svaki sistem mašina. Relevantni parametri koji definišu karakteristike svakog sistema mašina za doradu semena bili su: čisto seme (%), seme korova i seme drugih kultura (%), inertne materije (%), količina dorađenog semena (kg), vreme dorade semena (h), utrošak aktivne električne energije (kWh) i reaktivne električne energije (kVArh), gubici semena (%) i randman dorade (%). Ispitivanje je obavljeno u doradnom centru Instituta za krmno bilje u Globoderu-Kruševcu, pri čemu je u tri ponavljanja dorađivano naturalno seme obične lucerke čistoće 78.0% sa ekstremno visokim sadržajem karantinskog korova viline kosice (Cuscuta spp.). Na osnovu dobijenih rezultata moguće je izvršiti izbor odgovarajućeg sistema mašina za doradu semena lucerke, odnosno optimizaciju i racionalizaciju u procesu njene dorade.

Ključne reči: *dorada, seme, lucerka, sistem mašina.*

INTRODUCTION

Alfalfa (*Medicago sativa* L.), often called "Queen of Forage Crops", is the most important forage crop species due to its remarkable ability to produce high yields of rich, palatable and nutritious forage under a wide range of soil and climatic conditions (*Barnes et al., 1988; Burton, 1972*). In 2009 in Serbia, alfalfa was harvested on area of 188.008 ha (*Statistički godišnjak Srbije, 2010)*. Worldwide, alfalfa is extremely important perennial legume and is grown on about 35 million hectares (*Barnes et al., 1988*). Beside forage production, using corresponding practice and seed production can yield great financial effects on both domestic and foreign market due to great market value of seed (*Mišković, 1986; Stanisavljević, 2006*). High seed quality is important condition for germination and good quality of alfalfa crops. The factors that influence seed quality depend on agro-ecological conditions in the period of pollination, seed maturation, harvest and the application of agricultural practices during vegetation period, processing, mechanical damage and storage conditions (*Stjepanović et al., 2009*). Great material losses in alfalfa production may appear as a result of weed infestation in alfalfa crops grown for seed. These losses are due to reduced production and, also, due to increase of costs for growing, transport and seed processing during harvest so the produced seed is free of weeds. The amount of processed alfalfa seed directly depends on the presence of impurities. It also depends on the present weed species and on the amount of weed seed (*Đokić et al., 2009; Đokić, 2010*). Alfalfa seed is very small and, by size and shape, is indistinguishable from weed seed, so the separation of the two must be done in several phases and on various seed processing equipment (*Đukanović et al., 2009*). Seed processing is the process of removal of all the particles in the seed lot that will not produce a viable plant of the desired crop. There are a number of different processes available to condition seed. Depending on seed condition and level of contamination, an operator will select the proper order and setting for the equipment. The processing is based on the physical features of the seed. The processors have to be careful in analyzing each seed lot that comes from field and decide upon which equipment to use in order to achieve the best results in seed purifying (*Smith 1988; Copeland and McDonald, 2004; Black et al., 2006*). There are several technological schemes of alfalfa seed processing that are used in practice. Processing should satisfy legally recognized seed quality. According to the Law on Seed and Planting material (*Glasnik Republike Srbije, 2005*), processed alfalfa seed must be of, at least 95.0% purity with not more than 2.0% seed of other species, 0.5% of weeds (with no quarantine weeds), 2.5% of inert matter, germination of 70.0% and 13.0% of moisture.

MATERIAL AND METHOD

The research was carried out at the processing centre of The Institute for Forage Crops in Globoder-Kruševac. In three repetitions, natural alfalfa seed of 78.0% purity was processed by three different sets of equipment. The quantity of seed in each pass was 300 kg, i.e. 900 kg for each purity value (2700 kg in total). The first processing set (A1) is standard equipment consisted of following equipment: intake pit with belt conveyor, belt conveyors, bucket elevators, fine cleaning machine by a Danish manufacturer Damas-type Alfa-4, trier by a Danish manufacturer Damas (with three rollers)-type Hotyp, magnetic cleaner by a German manufacturer Emceka Gompper-type 4. Second set of processing equipment (A2), beside the equipment used in the first set A1, included pre-cleaner machine Vibam-Uni (by Danish manufacturer Damas), set before the fine cleaning machine. The third equipment set (A3) is similar to the second set, except that the processing on magnetic cleaner is done after the processing on the specific gravity separator "Oliver-240" (of German manufacturer Emceka Gompper). Gravity separator is used to separate two or more components of the same size with different specific weights (*Copeland and McDonald, 2004*). Purity of the natural alfalfa seed was in average 78.0%. The content of inert matter (as pods, sickly and damaged grains, harvest residues and dirt), was in average 17.87%. There was 4.13% of weed in the seed, with great ratio of dodder (*Cuscuta spp.*), which is harmful quarantine weed. The average number of dodder grains was 35 grains in the sample of 5 g of seed. Beside dodder, by the analysis of samples, it was determined the presence of certain amount of pigweed (*Amaranthus retroflexus* L.), foxtail (*Setaria spp.*), curly docks (*Rumex spp.*) and sorghum (*Sorghum spp.*). The analysis of the contents of additions in seed samples (5 g and 50 g) were conducted in laboratory conditions by using electronic scales and illuminated magnifying glass. The processing time was measured by a stopwatch. During the examination, the following parameters were measured: pure seed (%), seed of other crops (%), inert matter (%), weed seed (%), the amount of processed seed (kg), seed processing time (h), active power consumption (kWh) and reactive power consumption (kVArh), processing output (%) and seed loses on the processing equipment (%). The readings of power consumption were done by multifunctional digital three-phase power meter DMG 2. Based on these parameters, by the comparison of average values, it should be seen which of the processing equipment sets was optimal, meaning, which set yields the best quality and the largest amount of pure seed for the least time and with least power consumption.

RESULTS AND DISCUSSION

Average values for alfalfa seed purity processed on equipment set A1 are shown in table 1. The seed of initial purity of 78.0% was passed three times trough the equipment and twice trough magnetic cleaner. After the second passage trough magnetic cleaner, the dodder grains in the sample of 50 g was determined on the small magnetic cleaner. Seed, according to practice, was not processed for the third time using magnetic cleaner because, otherwise, the losses would be too big. Due to that, seed is put into storage for demagnetization for three months. After demagnetization, seed was processed once again. Quality of this alfalfa seed, after processing on A1 equipment, is presented in table 2. Sample was taken from intake pit after pouring alfalfa seed into them.

Table. 1. Seed processing on the equpment A1

Seed structure	%	Weed species
Seed purity after first pass through equipment A1 (sample from big seed hopper)		
Pure seed	89.0	
Other species	0	
Inert matter	9.4	sickly grain, damaged seed
Weed	1.6	29 *Cuscuta spp.* in 5 g, *Setaria spp.*
Seed purity after second pass through equipment A1 (sample from mixer)		
Pure seed	94.1	
Other species	0	
Inert matter	5.1	sickly grain, damaged seed
Weed	0.8	16 *Cuscuta spp.* in 5 g, *Setaria spp.*
Seed purity after first pass through magnetic separator (sample from bag)		
Pure seed	96.7	
Other species	0	
Inert matter	2.9	sickly grain
Weed	0.4	*Setaria spp., Rumex spp., Cuscuta spp.*
Seed purity after second pass through magnetic separator (sample from bag)		
Pure seed	98.0	(obtained seed goes to demagnetizing)
Other species	0	
Inert matter	1.9	sickly grain
Weed	0.1	*Cuscuta spp.*

Table 2. Seed processing after demagnetizing

Seed structure	%	Weed species
Seed purity after demagnetizing (sample from the intake pit)		
Pure seed	96.8	
Other species	0	
Inert matter	3.1	sickly grain
Weed	0.1	*Rumex spp., Amaranthus retroflexus* L.
Seed purity after first pass through equipment A1 (sample from mixer)		
Pure seed	97.8	
Other species	0	
Inert matter	2.2	germinated and sickly grain
Weed	0	*Rumex spp.*
Seed purity after first pass through magnetic separator (sample from bag)		
Pure seed	99.0	
Other species	0	
Inert matter	1.0	sickly grain
Weed	0	3 *Rumex spp.*in 50 g

After first passage trough equipment, the curly docks seed (*Rumex spp.*) was determined in the sample. Due to this, the seed was reprocessed trough entire equipment and trough the small magnetic cleaner for the first time. After processing on the small magnetic cleaner, average of three grains of curly docks (*Rumex spp.*) were determined in the sample of 50 g by laboratory analysis, which is in accordance with legal norms. The purity of processed seed is high (99.0%) with 1.0% of inert matter (sickly grains). To achieve larger quantity of seed from waste, the waste from lower trier, lower sieve of lower shaker shoe of fine cleaning machine and from magnetic cleaner, and was processed again trough equipment. In the seed sample from intake pit, the average seed purity was 76.7%; other plant species were not present, inert matter (harvest residues and sickly grain) were presented by 21.7% and 1.7% were the weed species (dodder, pigweed and foxtail). In the first passage of seed from waste trough processing equipment, weed seed was completely removed, inert matter were decreased by 5.7% and seed purity was increased by 7.3%. Good seed quality, with only one grain of curly docks in the sample of 50 grains, which is in accordance with legal norms, was achieved by processing on magnetic cleaner. Average purity of alfalfa seed processed on A2 equipment set is shown in table 3. As with A1 set, seed of initial purity 78.0% was passed three times trough equipment set A2 and twice trough magnetic cleaner. After the passage trough equipment, in the sample of 50 g on the small magnetic cleaner, the dodder seed was found by analysis. Seed that was passed trough magnetic cleaner twice, by technological norms were not to be processed for the third time on the magnetic cleaner due to great losses of seed if it was done. Seed is stored for three months for demagnetization, and afterwards the processing is done once more.

Table. 3. Seed processing on the equipment A2

Seed structure	%	Weed species
Seed purity after first pass through equipment A2 (sample from big seed hopper)		
Pure seed	89.0	
Other species	0	
Inert matter	9.6	sickly grain, damaged seed,
Weed	1.4	51 *Cuscuta spp.* in 5 g
Seed purity after second pass through equipment A2 (sample from mixer)		
Pure seed	94.33	
Other species	0	
Inert matter	4.97	sickly grain, damaged seed
Weed	0.7	14 *Cuscuta spp.* in 5 g, *Setaria spp.*
Seed purity after first pass through magnetic separator (sample from bag)		
Pure seed	97.7	
Other species	0	
Inert matter	2.13	sickly grain
Weed	0.2	*Setaria spp., Rumex spp., Cuscuta spp.*
Seed purity after second pass through magnetic separator (sample from bag)		
Pure seed	98.1	(obtained seed goes to demagnetizing)
Other species	0	
Inert matter	1.9	sickly grain
Weed	0	*Cuscuta spp.*

Procedure of processing after demagnetization is shown in table 4. In the analyzed sample, the average quality of seed from intake pit after the demagnetization have shown that the 95.7% was pure seed, and the rest of 4.3% were inert matter (sickly grain). After the first passage trough the equipment, the seed purity was increased for 1.57% and was 97.72%. In the equipment used for the processing of the demagnetized seed, pre-cleaning machine was not used because the quality of processed seed is extremely high, and the pre-cleaning machine is used only for the removal of rough matter in the seed material in the first processing. After the first seed processing, the percentage of inert matter was decreased, and by analyzing the sample of 5 g from the mixer of magnetic cleaner, only the quarantine weed curly docks (*Rumex spp.*) was determined. Seed was, after mixing with metal powder and water, processed on magnetic cleaner. The quality of processed seed is very high (98.93%), without weed and with 1.06% of inert matter (sickly grain). Seed from waste from lower triers, lower sieve of lower shaking shoe of fine cleaner machine and magnetic cleaner are collected and processed once more. The equipment used for processing seed from waste comprised the same machines as set A1. Seed from the waste contains 80.2% of pure seed and 19.8% of sickly grains.

Table 4. Seed processing after demagnetizing

Seed structure	%	Weed species
Seed purity after demagnetizing (sample from the intake pit)		
Pure seed	95.7	
Other species	0	
Inert matter	4.3	sickly grain
Weed	0	
Seed purity after first pass through equipment (sample from mixer)		
Pure seed	97.27	
Other species	0	
Inert matter	2.73	germinated and sickly grain
Weed	0	*Rumex spp.*
Seed purity after first pass through magnetic separator (sample from bag)		
Pure seed	98.93	
Other species	0	
Inert matter	1.06	sicly grain
Weed	0	

There were weeds, including dodder (*Cuscuta spp.*) in the sample. After the first passage of seeds through the equipment, the weed seed were not found in the sample from mixer. The percentage of cleaned seeds increased to 89.0% and the other 11.0% were sickly grains. After seed was mixed with steel powder and water, seed was processed on the magnetic cleaner, and the high quality seed of 97.73% purity were achieved, and in the sample of 50 g from the small magnetic cleaner, only one grain of quarantine weed curly docks was found. Average purity of alfalfa seed processed on equipment set A3 is shown in table 5. Seed, passed trough processing equipment, was sent from trier to big hopper, and was then returned into intake pit via bucket elevators and is, afterwards, passed to gravity separator for further processing.

Table. 5. Seed processing on the equpment A3

Seed structure	%	Weed species
Seed purity after first pass through equipment (sample from big seed hopper)		
Pure seed	93.53	
Other species	0	red clover (*Trifolium pratense* L.) in traces
Inert matter	6.0	sickly grain, harvesters residues,
Weed	0.47	*Cuscuta spp., Setaria spp., Sorghum halepense* L.
Seed purity after gravity separator (sample from bag)		
Pure seed	95.93	
Other species	0	
Inert matter	3.8	sickly grain, germinated seed
Weed	0.27	*Setaria spp.*
Seed purity after first pass through magnetic separator (sample from bag)		
Pure seed	97.57	
Other species	0	
Inert matter	2.37	sickly grain
Weed	0.06	*Sorghum halepense* L.

On the gravity separator, three seed fractions are achieved: good seed that is, after first passage trough equipment, processed on the magnetic cleaner, seed that is, along with seed from waste, processed again and the waste that is not processed any further. The quality of processed alfalfa seed, after the processing on gravity separator, is within legal norms. To remove possible remains of weed seed, so called corrective processing was conducted on magnetic cleaner, although high seed purity was achieved after processing on the gravity separator. After the processing on magnetic cleaner, the analyzed sample had 97.57% of pure seed, 2.37% of sickly grains and 0.06% of sorghum (*Sorghum halepense* L.) seed, without quarantine weed seed.

The waste from first passage on the fine cleaner from lower trier cylinders and from gravity separator was collected in bags and was processed again to increase the amount of seed. Equipment for waste processing is same as the aforementioned equipment sets. After the processing of seed from waste, the quality of obtained seed was not within the legal norms, and is not added to the total amount of good seed. The average values of all relevant parameters obtained after the processing of seed of 78.0% purity on three different equipment sets are shown in table 6.

Table. 6. The time of the processing, power consumption, average quantity of processed seed, output of processing and seed loss for A1, A2 and A3 processing set

Equip-ment	Processing time (min)	Power con-sumption		Seed quantity (kg)			Processing output (%)	Grain loss (%)
		Active (kWh)	Reactive (kVArh)	From processing	From waste	∑		
A1	301.7	132.1	174.94	135.3	13.76	149.0	49.7	36.4
A2	313.7	132.6	179.27	142.7	20.33	163.0	54.33	30.34
A3	160.7	59.8	89.3	157.7	-	157.7	52.57	32.6
CV (%)	32.9	38.7	34.3	7.9	27.3	4.5	4.5	9.2

Analyzing the data from table 6, obtained during processing of the seed with high content of dodder, it can bee seen that the parameters of processing on A3 equipment set are significantly different than the first two sets. Total processing time was shortest in A3 set, so in relation to the first set, the time is shorter for 141.0 min or 87.74% shorter. Compared to the second processing set A2, the processing time of the third set is shorter for 153.0 min or 95.20%. The consumption of active and reactive electric energy in the first and second set are slightly different, while the power consumption in the third set is significantly lower than in the first two sets. Also, by processing on the gravity separator, the largest amount of processed seed was obtained on this equipment set (157.7 kg). By processing the seed from waste from this set, the seed of sufficient quality was not obtained, so that seed is not added to the total amount of seed on the end of processing. The equipment had the most significant influence on the active electric power (CV=38.7%). A little less significant was the influence on reactive electric power (CV=34.3%), processing time (CV=32.9%) and quantity seed from waste (CV=27.3%). The least significant influence, the equipment had on the overall quantity of obtained seed (CV=4.5%).

CONCLUSION

By processing the natural alfalfa seed, start purity 78.0%, with high amount of quarantine weed species (35 grains of dodder in the sample of 5 g), on three processing equipment sets, different results were obtained. Especially significant difference was in the third processing equipment set A3 in relation to the other two sets. The processing time, power consumption (active and reactive energy), as well as the amount of obtained processed seed, were optimal in the third processing equipment set. In this set, the gravity separator was used for processing, so significantly better results were achieved than in the other two sets. The most favorable ratio of active and reactive energy consumption was achieved in the third processing equipment set. All of this is in favor of the set that utilizes the gravity separator, based on the principle of separation by different specific mass of seed. To decrease total loss of electric energy, and by that, the costs of production, it is necessary to decrease the consumption of active and reactive energy. Losses of alfalfa seed in the processing are directly dependent on the type and quantity of weeds, other impurities, organic and inorganic components present in the natural seed. If the percentage of impurities in their natural seed is larger, the longer the processing is, which increases energy consumption, and therefore the cost of processed seed. It is particularly harmful to a large content of dodder (*Cuscuta spp.*) seeds, which is similar in size to alfalfa and makes cleaning and separation harder. For these reasons, seed processing requires expensive equipment and large consumption of labor for the removal of weed seeds. In order to perform seed processing more efficiently, a better quality of processed seeds for the shortest possible time must be achieved by an appropriate combination of equipment, and by which the seed quality should correspond to the stipulated standards. The third processing equipment set is very good for processing the alfalfa seed with high content of dodder weed, by which the highest amount of processed seed is achieved.

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