Biblid: 1821-4487 (2021) 25; 1; p 32-35
UDK: 633.31
DOI: 10.5937/jpea25-30920

Original Scientific Paper
Originalni naučni rad

THE INFLUENCE OF IMPURITIES IN NATURAL SEEDS OF ALFALFA AND RED CLOVER ON THE SEED CLEANING PROCESS

UTICAJ PRIMESA U NATURALNOM SEMENU LUCERKE I CRVENE DETELINE NA PROCES ČIŠĆENJA SEMENA

Dragoslav ĐOKIĆ[*], Dragan TERZIĆ[*], Vera RAJIČIĆ[*], Sanja ŽIVKOVIĆ[*], Violeta ORO[**], Jasmina MILENKOVIĆ[***], Ranko KOPRIVICA[****]
[*]University of Nis, Faculty of Agriculture in Krusevac, 37000 Kruševac, Kosančićeva 4, Serbia
[**]Institute for Plant Protection and Environment, 11000 Belgrade, Teodora Drajzera 9, Serbia
[***]Institute for Forage Crops, 37251 Globoder-Kruševac, Serbia
[****]University of Kragujevac, Faculty of Agronomy, 32000 Čačak, Cara Dušana 9, Serbia
e-mail: djokic.dragoslav@ni.ac.rs

ABSTRACT

The paper presents the results of the cleaning process of five different lots of natural alfalfa seeds and five different lots of natural red clover seeds. Natural alfalfa and red clover seeds had 75 % to 77 % purity. The experiment was performed in the seed processing center of the Institute for Forage Crops Kruševac. Seed cleaning is performed on different machines that work on the principle of differences in the physical properties of seeds. Significant parameters that define the quality of seeds after processing on the cleaning equipment are the amount of pure seed, weed seed, the seed of other crops, inert matter, amount of pure processed seed, seed losses and processing output. The obtained results enable the correct adjustment of the equipment for the seed processing, depending on the amount and type of weeds and other impurities found in the natural seed of alfalfa and red clover.

***Keywords**: impurities, alfalfa, red clover, equipment, cleaning.*

REZIME

U radu su prikazani rezultati ispitivanja pri procesu čišćenja na mašinama za čišćenje pet različitih partija naturalnog semena lucerke i pet različitih partija naturalnog semena crvene deteline. Naturalno seme lucerke i crvene deteline bilo je čistoće od 75 % do 77 %. Eksperiment je izveden u centru za doradu semena Instituta za krmno bilje u Kruševcu. Da bi se dobile dovoljne količine kabaste stočne hrane od ove dve krmne biljke potrebno je obaviti kvalitetnu setvu. Seme za setvu ovih biljaka mora da bude čisto, bez korova i stranih primesa, visoke čistoće, klijavosti i genetske vrednosti. Čišćenje semena se obavlja na različitim mašinama koje rade na principu razlika u fizičkim osobinama semena. Naturalno seme lucerke i crvene deteline u sebi sadrži osim semena osnovne kulture i seme drugih biljnih vrsta, primese organskog i neorganskog porekla, kao i različite korove koji značajno utiču na proces dorade. Sa povećanjem korova i primesa povećavaju se gubici i vreme dorade semena. Osnovni pokazatelji efikasnosti mašina pri procesu čišćenja semena bili su kvalitet i količina semena dobijenog na kraju procesa dorade semena. Značajni parametri koji definišu karakteristike mašina za čišćenje semena lucerke i crvene deteline su: količina čistog semena, seme korova, seme ostalih kultura, inertne materije, količina čistog dorađenog semena, gubici semena i randman dorade. Dobijeni rezultati omogućavaju da se izvrši pravilno podešavanje mašina i opreme u procesu čišćenja semena, u zavisnosti od količine i vrste korova i ostalih primesa koje se nalaze u naturalnom semenu lucerke i crvene deteline.

***Ključne reči:** primese, lucerka, crvena detelina, oprema, čišćenje.*

INTRODUCTION

Alfalfa is considered to be the highest quality fodder species and therefore occupies the largest production area. Acidic soils are very common in Serbia and that is why red clover is important because it has fewer requirements for soil quality. Red clover is grown on neutral to weakly acidic soils of poorer structure with a low pH value (pH 5.5-7). The soils are medium-heavy, moist, medium-fertile, such as groves, alluvium and smonitza (*Lugić et al., 2000; Lakić and Vojin, 2010*). Red clover is characterized by high biomass yield, feed quality and rapid regeneration after mowing. The leaves are rich in proteins whose content is about 25 % in the budding phase. It has a high content of pro-vitamin A, vitamins C, D, E, K, B1, B2, B3, as well as trace elements - molybdenum, cobalt, boron, copper and manganese (*Marković et al., 2007; Vasiljević et al., 2011*). Natural seed for processing is a very complex mechanical mixture in which there are large and small weeds, impurities of organic and inorganic origin, whole, sickly and broken seeds (*Orobinskij et al., 2017*). Immediately after harvesting, natural seeds need to be cleaned of weeds present, in order to avoid self-heating and contamination of the seeds and to obtain quality seeds (*Tarasenko et al., 2017*). Seed processing is performed on pneumatic tables, friction and electromagnetic separators. Electromagnetic seed cleaning provides a high quality of seed cleaning that cannot be achieved by pneumatic cleaning, triers, or screen cleaning (*Kozlov, 2013*). Seed processing is based on the physical properties of the seed. The most important physical properties of seeds are moisture, shape, dimension, sphericity, the mass of 1000 seeds, seed volume, the porosity of seeds, volume-hectoliter mass, density, static and dynamic angle of internal friction - the angle of free fall, static coefficient of friction on a known surface *(Babić and Babić 2007; 2012; Copeland et al., 2004; Black et al.,2006, Đokić and Stanisavljević 2012; Đokić et al., 2012; Baskakov et al., 2018; Uhlarik et al., 2018*). Domestic animals can use these two forage plants in different ways: as green fodder, as individual crops, or as a mixture with grazing grasses. They can be used for conservation as hay, silage, haylage and dehydrated as quality protein flour, in the form of pellets and briquettes (*Ocokoljić, 1974; Vučković, 1999*). The physical properties of seeds are very important for the process of seed processing and storage (*Koprivica R., 2018*). Before the seed processing, the quality of the natural seed in order to determine the optimal working parameters must be determined. By properly adjusting the

processing equipment, it is possible to obtain large quantities of quality seed in a short time according to the prescribed seed standards (*Đokić et al., 2013; 2017; 2018; 2019 a; 2019 b*). The size of the openings on the sieves of the fine cleaning machine should be taken into account, due to the size of the seeds (*Erić et al., 1996*). In the forage crops, weed species contaminate the seeds and make harvesting and processing more difficult. The presence of two quarantine weeds, dodder (*Cuscuta* sp) and curly dock (*Rumex* sp), is particularly harmful. Dodder (*Cuscuta* sp) is one of the most dangerous and economically harmful quarantine weeds on plots under red clover and alfalfa crops because it causes huge damage to crops (*Đukić et al., 2004; Karagić et al., 2007; Đokić et al., 2016*). The Law on Seeds and Planting Material prescribes all conditions related to the method of production, processing, use, trade, import and testing of seeds of agricultural plants (*Gazette of the Republic of Serbia no. 45, 2005*). The quality of alfalfa and red clover seeds should correspond to the Ordinance on the quality of seeds of agricultural plants (*Gazette of SFRJ no. 47, 1987*). Processed seeds of these two plants must have: the lowest purity of 95 %, 2 % of seeds of other species, weeds of 0.5 % (without weeds of *Cuscuta* sp), up to 2.5 % of inert substances, maximum moisture of 13 %, and minimum germination of 70 %.

The aim of this study was to determine the influence of impurities in natural alfalfa and red clover seeds on the seed cleaning process. The basic indicators of machine efficiency in the seed cleaning process were the quality and quantity of seeds obtained at the end of the seed cleaning process.

MATERIAL AND METHOD

The experiment of cleaning alfalfa and red clover seeds was performed in the seed processing center of the Institute for Forage Crops Kruševac. In three replications, five lots of natural alfalfa seed and five lots of natural red clover seed were processed. The content of inert substances, as well as the amount and type of weeds, were different for each seed lot. Machines and devices from the Danish manufacturers Kongskilde and Damas were used for seed cleaning. The equipment consisted of receiving basket with receiving belt, belt conveyors, bucket elevators, fine cleaning machine type Alfa - 4. The fine seed cleaning machine has an upper and a lower shaker shoe. For processing alfalfa in the upper row are round sieves with a diameter of 2.75 mm to 1.9 mm, and in the lower row with longitudinal openings of width: 1.3 mm to 0.5 mm. For cleaning red clover seeds in the upper row are sieves with round sieves in diameters: 2.75 mm; 2.5 mm; 2.25 mm; 2.2 mm; 1.9 mm and 1.9 mm. In the lower row are sieves with longitudinal openings of width: 1.3 mm; 1.2 mm; 1.1 mm; 0.6 mm; 0.5 mm and 0.5 mm. A magnetic separator from the German manufacturer Emceka Gompper - type 4 was used to separate weeds with wrinkled and unsmooth seed coat and other impurities. In the magnetic separator mixer, the seeds are mixed with water and steel powder in a certain ratio.

The analysis of the samples of alfalfa and red clover seeds was done in the laboratory of the processing center using a magnifying glass with lighting. A precise electronic scale was used to measure the samples. The average sample for determination seed purity was 50 g from which the working sample for purity analysis was taken (5 g). The measurement of the weight of the processed seed was performed on an electronic scale with a measuring range of up to 300 kg. During the processing, the following parameters were determined and measured: quantity of pure seed (%), the seed of other species (%), inert matter (%), weed seed (%), and quantity of processed seed (kg). After processing, the yield of processing seed (%) and seed losses (%) on the processing equipment were calculated. The obtained results were processed by statistical analysis of variance (ANOVA), and the assessment of the significance of mean differences was tested by the Tukey test. The statistical program Minitab16.1,0 (statistics software package) was used for data processing.

RESULTS AND DISCUSSION

The purities of five different seed lots on natural alfalfa seed are shown in Table 1. The average purity of all five investigated seed lots was 76.0 %.

Table 1. The average purity on the natural alfalfa seeds

Lot	I	II	III	IV	V
Seed structure	%	%	%	%	%
Pure seed	76.0 a	76.0 a	76.0 a	76.0 a	76.0 a
Other species	0	0	0	0	0
Inert matter	18.5 b	24.0 a	18.8 b	24.0 a	24.0 a
Weed	5.5 a	0	5.2 a	0	0
Total	100	100	100	100	100

Tukey test statistical significance levels: p≤ 0.05, differences in a row marked in small letters a, b, c...

Inert matter ranged from 18.5 % (lot I) to 24.0 % (lot II, IV and V). Seeds of lot III had 18.8 % of inert matter, the difference in an inert matter between parties was statistically significant (p≤ 0.05). The inert matter was in the form of damaged and sickly seeds, pods, harvest residues and soil. There were 5.5 % weeds in the natural seed of lot I, and 5.2 % in the seed of lot III. The content of quarantine weeds was not high and was 6 dodder seeds in a sample of 5 g in lot I, 2 seeds in lot III and 5 seeds in lot IV.

The average values of the initial seed purity of red clover seeds were 75.0 % (for seed lots IV and V), and 76.5 % (for seed lot I). The initial seed purity of seed lots II and III was 77.0 % (Table 2).

Table 2. The average purity on the natural red clover seed

Lot	I	II	III	IV	V
Seed structure	%	%	%	%	%
Pure seed	76.5 a	77.0 a	77.0 a	75.0 a	75.0 a
Other species	0	0	0	0	0
Inert matter	15.3 b	23.0 ab	23.0 ab	25.0 a	25.0 a
Weed	8.2a	0	0	0	0
Total	100	100	100	100	100

Tukey test statistical significance levels: p≤ 0.05, differences in a row marked in small letters a, b, c...

Inert matter in the form of harvest residues (parts of stems, leaves, pods) and flowers accounted for 15.3 % of seeds of lot I. In seeds lots II and III there was inert matter in the form of harvest residues of 23 %. The seeds of lots IV and V had 25 % of inert matter in the form of crop residues and soil. In inert matter, there was a statistically significant difference (p≤ 0.05) between lots IV, V and I (Table 2). In lot II was a total of 18 dodder seeds and two curly dock seeds. Apart from the 8 dodder seeds in the seed samples of seed lot I, there were greater plantain, bindweed and chamomile.

The average purity of the alfalfa seeds after the seed processing is shown in Table 3. After processing on a magnetic separator, the average purity of alfalfa seeds was high and amounted to 97.6 % (seed lots II and III). The average purity of processed seeds in seed lot V was 98.2 %, and in a seed lot IV was 98.4 %. The highest purity of 99.0 % was in the seeds of lot I. The content of other plant species, inert substances in the form of raw seeds and weeds was within the legally prescribed limits.

Inert matter in the form of sickly seeds and harvest residues ranged from 1.6 % to 2.4 %. In an average seed sample of 50 g, 4 seeds of the curly dock were found in the sample of seed lot II, which is the legally prescribed amount of a maximum of 4 seeds in a sample of 50 g.

Table 3. The average purity of processed alfalfa seeds after processing on a magnetic separator

Lot	I	II	III	IV	V
Seed structure	%	%	%	%	%
Pure seed	99.0 a	97.6 a	97.6 a	98.4 a	98.2 a
Other species	0	0	0	0	0
Inert matter	0	2.4 a	2.4 a	1.6 b	1.8 ab
Weed	1.0	0	0	0	0
Total	100	100	100	100	100

Tukey test statistical significance levels: p≤ 0.05, differences in a row marked in small letters a, b, c...

After passing the seeds through the fine cleaning machine, the seeds should be processed on a magnetic separator to remove weeds (*Uhlarik* et al., *2018*). Seed samples for quality analysis are taken after seed processing on a magnetic machine (*Đokić* et al., 2019a). Seed processing is a very hard job where a large amount of energy is used to obtain seeds of appropriate quality (*Orobinskij et al., 2017*). The final seed purity of red clover, after processing on a magnetic separator is shown in Table 4. The purity of processed red clover seeds ranged from 96.6 % (seed lot III) to 99.0 % (seed lots IV and V). The final seed purity for seed lot I was 98.4 %, and for seed lot II was 98.8 %. The content of other plant species, inert matters in the form of sickly seeds and weeds was within the legally prescribed limits. In an average seed sample (50 g) 3 seeds of the curly dock were found in seed lot III, which is allowed by law. In seed lots I and II, a detailed analysis of seed samples found 0.2 % of seeds of other species, which is significantly less than the legally allowed amount of seeds of other species (2 %).

Table 4. The average seed purity on processed red clover seeds after processing on a magnetic separator

Lot	I	II	III	IV	V
Seed structure	%	%	%	%	%
Pure seed	98.4 a	98.8 a	96.6 a	99.0 a	99.0 a
Other species	0.2	0.2	0	0	0
Inert matter	1.0 ab	0.8 b	1.4 a	1.0 ab	1.0 ab
Weed	0.4	0.2	2.0	0	0
Total	100	100	100	100	100

Tukey test statistical significance levels: p≤ 0.05, differences in a row marked in small letters a, b, c...

The quantities of alfalfa seed at the beginning, as well as the amount of processed seed at the end of the processing, are shown in Table 5. The processing output and losses on processing machines are also calculated and expressed as a percentage. The highest seed processing output was in lot IV seeds and amounted to 72.2 %, with the lowest losses on processing machines of 5.0 %. In the examined alfalfa seeds, the lowest seed processing output of 57.7 % was in seed lot II. This seed also had the largest losses on processing machines, amounting to 23.9 %.

The quantities of natural red clover seed at the beginning and the quantities of processed seeds at the end of the processing are shown in Table 6. The quantities of natural and processed seeds are expressed in kg. The table also shows seed processing output and losses on processing machines expressed in %. The highest seed processing output was in seed lot III (71.3 %). The seeds of this seed lot also had the lowest losses on processing machines (7.4 %). Seed lot II had a very similar seed processing output of 71.0 % and losses of 7.8 %.

Table 5. Amounts of processed seeds, processing output and losses of alfalfa seeds on the processing machines

Lot	I	II	III	IV	V	*F test*
Natural seed (kg)	990.0 b	2334.0 a	2250.0 a	769.0 b	2247.0 a	**
Processed seed (kg)	690.0 c	1545.0 a	1300.0 b	555.0 c	1516.0 a	**
Processing output (%)	69.7 ab	66.2 ab	57.7 b	72.2 a	67.5 ab	*
Losses (%)	8.3 c	12.9 b	23.9 a	5.0 d	11.2 b	**

*F test, statistical significance levels: *p≤ 0.05, **p≤ 0.01, ***p≤ 0.001, ns – not significant (p ≥0.05)*

Tukey test statistical significance levels: p≤ 0.05, differences in a row marked in small letters a, b, c...

The seed lot IV had the lowest processing output (48.8 %), and the largest losses on processing machines which amounted to 35.8 %.

Table 6. Amounts of processed seeds, processing output and losses of red clover seeds on the processing machines

Lot	I	II	III	IV	V	*F test*
Natural seed (kg)	184.0 d	1072.0 a	624.0 b	378.0 c	1199.0 a	***
Processed seed (kg)	108.0 c	761.0 a	445.0 b	182.0 c	741.0 a	**
Processing output (%)	58.7 b	71.0 a	71.3 a	48.8 c	61.8 b	*
Losses (%)	23.3 a	7.8 c	7.4 c	35.8 a	17.6 b	***

*F test, statistical significance levels: *p≤ 0.05, **p≤ 0.01, ***p≤ 0.001, ns – not significant (p ≥0.05)*

Tukey test statistical significance levels: p≤ 0.05, differences in a row marked in small letters a, b, c...

For the alfalfa seeds, losses ranged from a minimum of 5.0 % to 23.9 %. In the red clover seeds, these losses were even higher and ranged from 7.4 % to 35.8 %. Such a large variation in losses can be the result of several factors: seed purity and weed content, especially quarantine weeds, can significantly affect the loss and amount of seed obtained. In our earlier investigations, during the seed processing of alfalfa seeds (initial purity from 70 % to 86 %), seed losses ranged from 14.43 % to 15.56 %. In the case of red clover seeds (initial purity from 74 % to 80 %), seed losses ranged from at least 11.3 % to 18.56 % (*Đokić et al., 2020*). If there are quarantine weeds in the seed samples (especially dodder seeds), each repeated passing of the seeds through the processing machines leads to the seed losses (*Đokić and Stanisavljević, 2012*). Also, the adjustment of the machines during the seed processing and the selection of appropriate sieves on the fine cleaning machine, as well as the ratio of water and metal powder on the magnetic machine, can significantly affect the number of losses. Any defect in the cleaning process can lead to significant seed losses (*Erić et al., 1996; Uhlarik et al., 2018*). Proper adjustment of machines, as well as proper selection of machines for seed processing, could reduce losses and increase the amount of obtained quality seed (*Kozlov V., 2013*).

CONCLUSION

The purity of natural alfalfa seeds was 76.0 % in all five seed lots. The natural alfalfa seed contained inert matters and weeds in different percentages in different seed lots and inert matters ranged from 18.5 % to 24.0 %. The maximum of weed seed was 5.5 %. Natural red clover seeds of different seed lots had seed purity from 75.0 % to 77.0 %. Inert matters in the form of harvest residues ranged from 15.3 % - 25.0 %. By increasing the content of weeds and impurities in natural seeds, the technological processes are longer, energy consumption is

higher, as well as the cost of processed seeds. With each repetition of seed processing, the obtained seed quality is reduced. The high content of seeds of dodder (*Cuscuta* sp) as well as curly dock (*Rumex* sp) is harmful because their removal makes it more difficult and increases the cost of processing the seeds. The basic indicators of the efficiency of processing machines are the obtained quantities of seeds and their quality. It is necessary to achieve the largest possible amount of processed seeds in a short time by appropriate combination and adjustment of the processing machines. In general, it can be said that the presence of weeds is extremely harmful in seed processing because it is very difficult to remove them from the seeds of the basic culture. This further increases the cost of the whole process of obtaining seeds for sowing. Proper adjustment of the processing machine can help reduce these costs.

ACKNOWLEDGMENT: Research was financed by the Ministry of Education, Science and Technological Development, Republic of Serbia (Contract reg. no. 451-03-68/2020-14/ 200383)

REFERENCES

Babić, M., Babić, Ljiljana (2007). Fizičke osobine poljoprivrednih materijala. Autorizovana predavanja. Poljoprivredni fakultet, Novi Sad, 1-38.

Babić, M., Babić, Ljiljana (2012). Sušenje i skladištenje. II izdanje. Univerzitet u Novom Sadu, Poljoprivredni fakultet, Novi Sad, Srbija.

Баскаков, И., Карпенко, Р., Оробинский, В. (2018). Зерноочистителъные машины и элеваторное оборудование производства ООО "Воронежселъмаш", ФГБОУ ВО "Воронежский государственный аграрный университет имени императора Петра I". г. Воронеж, Россия.

Black, M., Bewley, J., Halmer, P. (2006). The Encyclopedia of Seeds Science, technology and uses. Wallingford, UK.

Copeland, O., Lawrence, McDonald, Miller (2004). Seed Drying. Seed Science and Technology, Norwell, Massachusetts, p. 268– 276.

Đokić, D., Stanisavljević, R. (2012). Possibility of Improving Seed Processing of Red Clover (*Trifolium pratense* L.) and Alfalfa (*Medicago sativa* L.). Book of the proceedings International Conference on BioScience: Biotechnology and Biodiversity – Step in the Future – The Forth Joint UNS – PSU Conference, June 18-20, Novi Sad, Serbia, 135-148.

Đokić, D., Stanisavljević, R., Terzić, D., Marković, J., Radivojević, G., Anđelković, B., Barać, S. (2012). Primena različitih tehnoloških procesa u doradi semena crvene deteline. Poljoprivredna tehnika, br. 3, 1-10.

Đokić, D., Terzić, D., Milenković, J., Dinić, B., Anđelković, B., Stanisavljević, R., Barać, S. (2013). Značaj i stanje semenarstva krmnih biljaka u poljoprivredi Republike Srbije. Selekcija i semenarstvo, 19(2): 11-25.

Đokić, D., Stanisavljević, R., Terzić. D., Milenković. J., Lugić. Z., Barać. S., Vuković, A. (2016). Uticaj korovskih vrsta na efikasnost dorade semena crvene deteline (*Trifolium pratense* L.). 18 Naučni skup sa međunarodnim učešćem. Aktuelni problemi mehanizacije poljoprivrede. Univerzitet u Beogradu, Poljoprivredni fakultet, Beograd. 29-37.

Đokić, D., Stanisavljević, R., Terzić, D., Milenković, J., Lugić, Z., Koprivica, R., Barać, S. (2017). The impact of the natural seed purity on the final quantity of seeds of red clover (*Trifolium pratense* L.) after processing. Book of proceedings, VIII International Scientific Agriculture Symposium, Jahorina, October 05.-08. 2017, Jahorina, Bosnia and Herzegovina. p. 513-518.

Đokić, D., Stanisavljević, R., Terzić, D., Milenković, J., Lugić, Z., Radović, J., Knežević, J. (2018). Određivanje relevantnih parametara pri doradi semena crvene deteline (*Trifolium pratense* L.). Selekcija i semenarstvo, Vol. 24. br. 1. str. 57-64.

Đokić, D., Stanisavljević, R., Terzić, D., Milenković, J., Kozlov, V., Koprivica, R., Vuković, A. (2019) a. Parametri efikasnosti mašina za dorado semena crvene dateline i lucerke. XLIV, 1, 10-18. UDK 631.3, doi: 10.5937/PoljTeh 1901010D.

Đokić, D., Stanisavljević, R., Terzić, D., Milenković, J., Kozlov, V., Koprivica, R., Barać, S. (2019) b. Analysis of the process of alfalfa seed cleaning using seed processing equipment. (Analiza procesa čišćenja semena lucerke na mašinama za doradu). Journal on Processing and Energy in Agriculture, 23(1), 10-13.

Đukić, D., Moisuc, A., Janjić, V., Kišgeci, J. (2004). Krmne, korovske, otrovne i lekovite biljke. Novi Sad, Poljoprivredni fakultet.

Erić, P., Đukić, D., Ćupina, B., Mihailović, V. (1996). Krmno bilje (praktikum). Novi Sad, Poljoprivredni fakultet.

Glasnik Republike Srbije br. 45 (2005). Official Gazette of the Republic of Serbia, 45, (2005).

Karagić, Đ., Katić, S., Vasiljević, S., Milić, D. (2007). Semenarstvo lucerke u Vojvodini. XI simpozijum o krmnom bilju Republike Srbije sa međunarodnim učešćem, Novi Sad, Srbija, 87-98.

Koprivica, R. (2018). Uticaj sorte i vremena berbe na osnovne fizičke i mehaničke osobine ploda i zrna uljane repice. Doktorska disertacija. Univerzitet u Kragujevcu, Agronomski fakultet u Čačku.

Козлов, В. (2013). Пневномагнитная сепарация. Совершенствование процесса сепарации мелкосеменных кулътур. LAP LAMBERT Academic Publishing, Saarbrücken, Deutschland.

Lakić, Ž., Vojin, S. (2010). Variability of agronomic traits of red clover genotypes (*Trifolium pratense* L.). Biotechnology in Animal Husbandry. Publisher: Institute for Animal Husbandry, Belgrade-Zemun, 26 (spec. issue), book 2: 35-40.

Lugić, Z., Radović, J., Terzić, D., Tomić, Z., Spasić, R. (2000). Semenarstvo višegodišnjih leguminoza u centru za krmno bilje Kruševac. XI savetovanje, Semenarstvo krmnog bilja na pragu trećeg milenijuma, Sombor, Srbija, 47-55.

Marković, J., Ignjatović, S., Radović, J., Lugić, Z. (2007). Uticaj faze razvića na sadržaj makro i mikroelemenata u lucerki i crvenoj detelini. Zbornik radova Instituta za ratarstvo i povrtarstvo, Novi Sad, 44: 401-406.

Ocokoljić, Stojanka (1974). Leptiraste biljke u ishrani stoke (lucerka, crvena detelina, žuti zvezdan), Nolit, Beograd.

Službeni list SFRJ br.47/87. Pravilnik o kvalitetu semena poljoprivrednog bilja (1987). (Official gazette SFRY, No. 47/87. Rule on the quality of seeds of agricultural plants. 1987).

Оробинский, В., Корнев, А., Тертычная, Т., Шварц, А. (2017). Совершенствование технологии получения качественных семян подсолнечника. Вестник Воронежского государственного аграрного университета, ФГБОУ ВО, Воронежский ГАУ, Воронеж, 4(44): 103-106.

Тарасенко, А., Оробинский, В., Гиевский, А., Тарабрин, Д., Анненков, М. (2017). Обоснование принципиалъной схемы воздушно-решетного сепаратора семян. Вестник Воронежского государственного аграрного университета, ФГБОУ ВО, Воронежский ГАУ, Воронеж, 4(44): 95-102.

Uhlarik, A., Popov, S., Karagić, Đ., Ponjičan, O., Turan, J. (2018). Alfalfa seed cleaning using a magnetic separator. Journal on Processing and Energy in Agriculture, 22(4), 192-195.

Vasiljević, S., Katić, S., Mihailović, V. (2011). Oplemenjivanje crvene deteline (*Trifolium pratense* L.) na poboljšan kvalitet krme. Zbornik referata, 45 savetovanje agronoma Srbije, Zlatibor, 30. 01.-05. 02. 2011, 127-137.

Vučković, S. (1999). Krmno bilje. (Forage Crops). Institut za istraživanje u poljoprivredi "Srbija", Beograd, "Bonart" Nova Pazova.

Received: 03. 03. 2021. Accepted: 06. 04. 2021.