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Effect of nitrogen fertilizer on growth of seeded grassland dry biomass in process of deposol: Biological reclamation

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ABSTRACT

The paper presents the results of a three-year trial (2011-2013) on the variability of the yield of dry overhead biomass of the seeding grassland depending on the application of N fertilizer.Three grass-leguminous mixtures and one grass mixture has been researched (total of ten species of grass and leguminose) in the process of the biological phase of the reclamation of the technogenic soil, the type of Deposol. The research has been conducted on the Deposol at internal disposal area for overburden from Raskovac open pit in Stanari coal mine(Republic of Srpska, Bosnia and Herzegovina).The seeded grasslands stand for the significant driving force of pedogenetic processes in new soil reclamation. There are four treatments of doses of N fertilizers in application (N_1 144, $N_2$114, $N_3$100 and $N_4$130kg/ha). N fertilizer is used in basic and supplemented grassland nutrition. The application of N fertilizer in the seeded grassland has shown significant variation of dry biomass. The results have varied by years, different compositions and particular cuttings. In 2011 the N effect was lower in the first than in the second cutting. In 2012 and 2013 the N effect was better in the first cutting. The highest effect of N fertilizer is found with the TDS-3 mixture in every research year ($\bar{x}$ 1 kg N = 36.32 kg in 2011, $\bar{x}$ 1 kg N = 97.67 kg in 2012 and $\bar{x}$ 1 kg N = 115.93 kg of biomass in 2013). The highest effect of 1 kg N on the biomass yield is calculated at TDS mixture at N3 treatment in the first cutting in 2013 (190.12). The lowest effect of 1 kg N on the biomass yield is calculated at the TDS-1 composition at treatment N3 in the first cutting in 2011 (10.00). The better effect is achieved with the smaller dose of N fertilizer. This is the starting point in any future standardization of fertilizers when fertilizing the seeded grasslands in the process of Deposol reclamation.

Keywords: seeding grasslands, fertilization, nitrogen, dry mass, technogenic soil.

INTRODUCTION

Development of plant cover and mineralization of plant residues affect the process of formation of technogenic soils and accumulation of organic carbon at the soil surfaces in the reclamation process. On the other hand, the growth of plants and mineralization are mostly limited by the

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absence of N and P (Liendemann et al., 1989; Vimmerstedt et al., 1989; Stojanović et al., 1977). The vegetation plays significant role in reclamation when it comes to the prevention of newly formed technogenic soils from erosion providing the accumulation of fine soil matters (Tordoff et al., 2000; Conesa et al., 2007).

The task of seeded grasslands establishment (by seeding the grass-legume mixtures) is to decrease the intensity of water erosions, begin the formation of fertile technogenic soil surface layer followed by usage of over-ground biomass as bulky cattle food. The success of establishment of seeded grasslands depends on proper selection of species and genotypes of grass and legumes since the combination of these two gives best results (Kessler and Lehman, 1998).

Burger et al. (2009) gives the example for composition of one grass-legume mixture for deposal reclamation (with pH 5.0–6.5, ie. forest conditions) as it follows: *Lolium italicum* A. Braun, *Dactylis glomerata* L., *Phleum pratense* L., *Lotus corniculatus* L. and *Trifolium repens* L. with seeding standard of 69 kg/ha with the fertilizer applied in the following doses: N (50–75 kg ha^{-1}), P_2O_5 (80–100 kg ha^{-1}) and K_2O (180–230 kg ha^{-1}).

Growth of green and dry mass at the established grasslands greatly depends on fertilizers and methods of application (Stošić et al., 2004). The grasslands seeded without applying any fertilizers rapidly deteriorate; the growth may lack already in the first year, especially if there are no legumes applied. The goal with seeded grasslands is to support leguminous component to its maximum so to reduce nitrogen fertilizers and improve the quality of plants in later application.

According to Dubljević (2007), in his research activities, recorded the highest participation of grasses with the biggest doses of N fertilizer, and legumes and other plants with smallest doses of fertilizers.

When researching the mountain grasslands in Macedonia, Prentović et al. (2007), recorded 0.27 t ha^{-1} of hay production with its maximum of 1.7 t ha^{-1} when treated with 80 kg ha^{-1} of N. The highest effects of N fertilizer on growth is achieved when 50 kg ha^{-1} of N is applied.

Vučković et al. (2007), in their two-year research on effects of mineral fertilizers on growth of green and dry mass at *Agrostietum vulgaris* grassland (Pavlović, 1955) in agro-ecological conditions in Valjevo, recorded maximal average results of dry mass of 8.17 t ha^{-1} achieved applying 200 kg ha^{-1} N, 150 kg ha^{-1} P_2O_5 and K_2O, but with the lowest effectiveness. The highest effects of nutrition on dry mass are achieved by applying 100 kg ha^{-1} N, 50 kg ha^{-1} P_2O_5 and K_2O.

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According to Stošić (1990), the research of effects of fertilizers on the growth of these mixtures on Kopaonik in the first and second year, the growth of dry mass is better at the places where the dose of 80 kg ha^{-1} P_2O_5 and K_2O (2.86 and 9.05 t ha^{-1}) fertilizer is applied. The growth is slower (1.74 and 8.87 t ha^{-1}) with the 80 kg ha^{-1} N, P_2O_5 and K_2O due to the effects of N on high grasses that suppress *Trifolium pratense* L.

The results of recent physical and chemical analysis of Deposol at the overburden landfills at the mine in Stanari indicated good physical-mechanical but poor chemical properties (Malić, 2015; Malić and Marković, 2012; Malić, 2010).

The goal of research is to analyze the effects of N fertilizer on production properties, i.e. dry mass of grass-legume mixture, at the seeded grasslands in the process of soil reclamation.

MATERIAL AND METHODS

The coal basin Stanari is located between 44°40' and 44°50'N and 17°45' and 18°00'E, in the northern part of the Republic of Srpska and Bosnia and Herzegovina. Research on biological reclamation of a direct type was carried out in an experimental field (GPS Coordinates: y = 6,486,822.33; x = 4,957,645.63; altitude 220 m a.s.l) at the internal disposal area for overburden of the excavation from the surface mine Raškovac in the lignite coal basin Stanari: "EFT - Mine and Thermal Power Plant Stanari". The research was conducted in a three-year period (2011-2013). Part of the disposal area for overburden site where the experimental field is located was formed during 2010.

Within the research of biological reclamation, the grasslands are seeded with three grass-legume and one grass mixture in the spring season in 2011.

Mixture TDS-1: *Festuca arundinacea* Schreb. 25%, *Festuca rubra* L. 20%, *Dactylis glomerata* L. 10%, *Phleum pratense* L. 10%, *Trifolium repens* L. 10%, *Trifolium pratense* L. 10%, *Medicago sativa* L. 10%, *Poa pratensis* L. 5%.

Mixtue TS-2: *Festuca arundinacea* Schreb. 40%, *Festuca rubra* L. 20%, *Poa pratensis* L. 20%, *Dactylis glomerata* L. 10%, *Phleum pratense* L. 10%.

Mixture TDS-3: *Festuca rubra* L. 50%, *Poa pratensis* L. 30%, *Lotus corniculatus* L. 10, *Trifolium repens* L. 10%.

Mixture TDS-4: *Dactylis glomerata* L. 30%, *Phleum pratense* L. 30%, *Lotus corniculatus* L. 20, *Arrhenatherum elatius* (L.) Mert. et Koch. 20%.

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The standard for seeding is 45 kg ha^{-1}. Treated Deposol was subject to seeding. Fertilization with mineral fertilizers NPK 15:15:15 in two doses: 90 and 60 kg ha^{-1} N (pure nutrients) was performed in pre-seeding phase. The N fertilizer KAN (27% N) was applied in two nutrition treatments with two doses in the second and third year of research (54 and 40 kg ha^{-1} N of pure nutrient). First dose was applied at the initial vegetation stage. The second dose was applied on the tenth day after mowing the first cutting. The grassland was mowed by mulching machine twice a year leaving the plants at the Deposol surface in the process of reclamation.

Total N doses in individual treatments: $N1_{90+54+54}$, $N2_{60+54+54}$, $N3_{60+40+40}$, $N4_{90+40+40}$ kg ha^{-1}.

The obtained results were examined by analysis of variance (ANOVA). The significance of the differences between the basic factors and their interactions was tested with the F-test, while the differences between mean values determined by the LSD test.

For the purposes of laboratory pedological research, the average samples of the Deposol were taken before the research at the beginning of 2011, and the samples of Rekultisol at the end of the vegetation in 2013. The samples were taken from a depth of 0-20 cm. The analysis of the Deposol included the examination of the following parameters (Table 1): content of organic matter (dry burning method at 550 ^oC), humus (Tjurin method), soil reaction (pH) in H_2O and 1M KCl (electrometrically combined electrode in pH-metre), total N (semimycro Kjeldahl method), plant available P and K (AL-method). At the end of the research in 2013 year, the pH value was again analysed. The classification of Deposol and Rekultisol based on the chemical reaction was carried out according to Živković (1991) for pH in H_2O, and according to Šefer-Šahtašabel for pH in KCl.

Table 1. Results of the analysis of chemical properties of Deposol

Number of sample	pH		Organic matter	Humus	Total N	AL - P_2O_5	AL - K_2O
	H_2O	KCl	(%)	(%)	(%)	mg 100g^{-1} soil	
1	6.2	4.9	2.1	0.0	0.0	0.0	1.3
2	5.8	4.5	1.2	0.0	0.0	0.5	2.2
3	5.2	4.0	1.6	0.0	0.0	0.6	2.7

The basic climate indicators (precipitation and air temperature) within the three-year experimental period are shown in climate diagram (Fig. 1) (Walter and Lieth, 1964).

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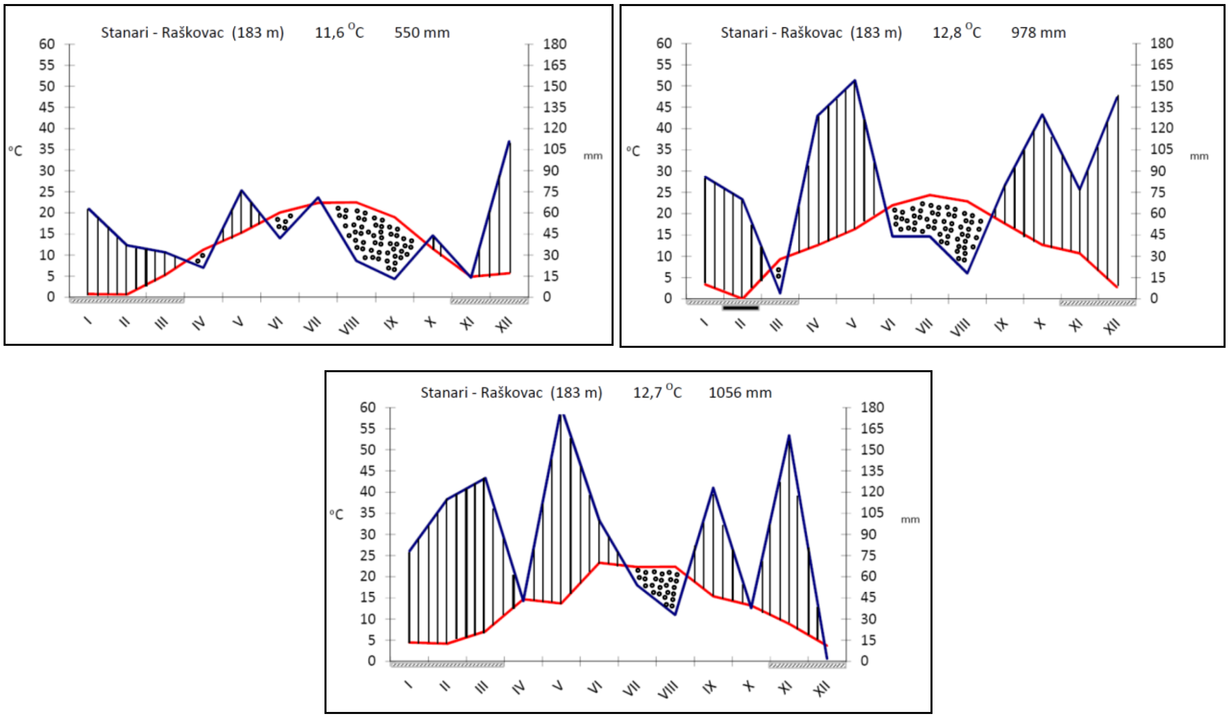

Figure 1. Climate diagram to Walter and Lieth in 2011, 2012 and 2013

RESULTS AND DISCUSSION

The achieved maximum average growth of green and dry biomass of grass-legume and grasses mixture indicated significant variation of N doses in application of fertilizers. The usage of nutrition and fertilizers is best calculated through the effect of 1kg of N on the production of dry biomass in both cuttings. Average values are given in tables2-5, for each mixture separately. In the same tables are given the arithmetic meanings of the year factor ($\bar{x}_A$) and the dose of N ($\bar{x}_B$) for both cuts.

In the first year, for the first cutting, N is calculated out of NPK fertilizer applied in seeding, since the first nutrition is not applied while the second nutrition is applied. The calculation for the second and third year of research is made on the grounds of N from treatment (first and second nutrition treatment).

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Table 2. Effect of 1 kg N on the dry biomass yield, mixture TDS-1

Treatments		The first cutting		The second cutting		$\bar{x}_{1\ kg\ N}$	
Year (factor A)	Dose of N, kg (factor B)	Yield of biomass, kg ha^{-1}	Effect of 1kg N on the yield of biomass, kg	Yield of biomass, kg/ha	Effect of 1kg N on the yield of biomass, kg	$\bar{x}_B$	$\bar{x}_A$
2011	N_1: 144	1,900	**21.11**	2,500	**46.30**	***33.70***	***33.00***
	N_2: 114	1,200	**20.00**	1.900	**35.19**	***27.59***	
	N_3: 100	600	**10.00**	1,900	**46.91**	***28.46***	
	N_4: 130	2,050	**22.78**	2,500	**61.73**	***42.25***	
2012	N_1: 144	4,040	**74.81**	3,600	**66.67**	***70.74***	***80.73***
	N_2: 114	4,000	**74.07**	2,300	**42.59**	***58.33***	
	N_3: 100	3,500	**86.42**	3,700	**91.36**	***88.89***	
	N_4: 130	4,600	**113.58**	3,900	**96.30**	***104.94***	
2013	N_1: 144	6,200	**114.81**	3,400	**62.96**	***88.89***	***114.4***
	N_2: 114	6,400	**118.52**	3,800	**70.37**	***94.44***	
	N_3: 100	7,700	**190.12**	4,010	**99.01**	***144.57***	
	N_4: 130	6,900	**170.37**	3,600	**88.89**	***129.63***	

ANOVA		A	B	A x B	A	B	A x B
$F_{calc.}$		33.57**	0.98	0.87	2.56**	1.94	1.44
LSD	0.05	5.96	6.88	11.92	5.43	6.3	10.87
	0.01	7.89	9.11	15.79	7.2	8.3	14.40

Table 3. Effect of 1 kg N on the dry biomass yield, mixture TS-2

Treatments		The first cutting		The second cutting		$\bar{x}_{1\ kg\ N}$	
Year (factor A)	Dose of N, kg (factor B)	Yield of biomass, kg ha^{-1}	Effect of 1kg N on the yield of biomass, kg	Yield of biomass, kg ha^{-1}	Effect of 1kg N on the yield of biomass, kg	$\bar{x}_B$	$\bar{x}_A$
2011	N_1: 144	1,500	**16.67**	2,300	**42.59**	***29.63***	***30.32***
	N_2: 114	1,500	**25.00**	1,600	**29.63**	***27.31***	
	N_3: 100	1,200	**20.00**	1,400	**34.57**	***27.28***	
	N_4: 130	2,000	**22.22**	2,100	**51.85**	***37.04***	
2012	N_1: 144	4,200	**77.78**	3,300	**61.11**	***69.44***	***84.80***
	N_2: 114	4,000	**74.07**	3,400	**62.96**	***68.52***	
	N_3: 100	4,200	**103.70**	3,400	**83.95**	***93.83***	
	N_4: 130	4,700	**116.05**	4,000	**98.77**	***107.41***	
2013	N_1: 144	5,500	**101.85**	2,900	**53.70**	***77.78***	***94.98***
	N_2: 114	7,100	**131.48**	3,000	**55.56**	***93.52***	
	N_3: 100	6,100	**150.62**	3,300	**81.48**	***116.05***	
	N_4: 130	4,800	**118.52**	2,700	**66.67**	***92.59***	

ANOVA		A	B	A x B	A	B	A x B
$F_{calc.}$		112.9**	5.56**	2.8	34.55**	2.19	1.1
LSD	0.05	3.93	4.54	7.86	4.52	5.22	6.19
	0.01	5.2	6.01	10.41	5.98	9.04	11.98

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Table 4. Effect of 1 kg N on the dry biomass yield, mixture TDS-3

Treatments		The first cutting		The second cutting		$\bar{x}_{1\,kg\,N}$	
Year (factor A)	Dose of N, kg (factor B)	Yield of biomass, kg/ha	Effect of 1kg N on the yield of biomass, kg	Yield of biomass, kg/ha	Effect of 1kg N on the yield of biomass, kg	$\bar{x}_B$	$\bar{x}_A$
2011	N_1: 144	1,900	**21.11**	1,500	**27.78**	***24.44***	***36.32***
	N_2: 114	2,300	**38.33**	1,800	**33.33**	***35.83***	
	N_3: 100	2,600	**43.33**	1,800	**44.44**	***43.89***	
	N_4: 130	3,400	**37.78**	1,800	**44.44**	***41.11***	
2012	N_1: 144	4,060	**75.19**	5,900	**109.26**	***92.22***	***97.67***
	N_2: 114	4,900	**90.74**	3,200	**59.26**	***75.00***	
	N_3: 100	4,600	**113.58**	5,800	**143.21**	***128.40***	
	N_4: 130	4,300	**106.17**	3,400	**83.95**	***95.06***	
2013	N_1: 144	6,600	**122.22**	3,200	**59.26**	***90.74***	***115.9***
	N_2: 114	7,300	**135.19**	4,050	**75.00**	***105.09***	
	N_3: 100	7,100	**175.31**	4,600	**113.58**	***144.44***	
	N_4: 130	6,100	**150.62**	3,900	**96.30**	***123.46***	

ANOVA		A	B	A x B	A	B	A x B
$F_{calc.}$		20.35^{**}	1.55	2.06	$68{,}9^{**}$	13.74^{**}	5.32
LSD	0.05	6.52	7.53	13.05	4.4	5.04	8.73
	0.01	8.64	9.9	13.05	5.78	6.67	11.56

Table 5. Effect of 1 kg N on the dry biomass yield, mixture TDS-4

Treatments		The first cutting		The second cutting		$\bar{x}_{1\,kg\,N}$	
Year (factor A)	Dose of N, kg (factor B)	Yield of biomass, kg/ha	Effect of 1kg N on the yield of biomass, kg	Yield of biomass, kg/ha	Effect of 1kg N on the yield of biomass, kg	$\bar{x}_B$	$\bar{x}_A$
2011	N_1: 144	2,200	**24.44**	1,700	**31.48**	***27.96***	***29.52***
	N_2: 114	1,500	**25.00**	1,600	**29.63**	***27.31***	
	N_3: 100	1,300	**21.67**	1,700	**41.98**	***31.82***	
	N_4: 130	1,800	**20.00**	1,700	**41.95**	***30.99***	
2012	N_1: 144	4,400	**81.48**	2,500	**46.30**	***63.89***	***72.22***
	N_2: 114	4,000	**74.07**	3,900	**72.22**	***73.15***	
	N_3: 100	3,300	**81.48**	2,700	**66.67**	***74.07***	
	N_4: 130	3,800	**93.83**	2,500	**61.73**	***77.78***	
2013	N_1: 144	4,900	**90.74**	3,300	**61.11**	***75.93***	***88.01***
	N_2: 114	7,100	**131.48**	3,520	**65.19**	***98.33***	
	N_3: 100	4,600	**113.58**	3,200	**79.01**	***96.30***	
	N_4: 130	4,200	**103.70**	2,400	**59.26**	***81.48***	

ANOVA		A	B	A x B	A	B	A x B
$F_{calc.}$		72.37^{**}	0.41	1.6	68.23^{**}	2.62	9.9
Lsd	0.05	3.98	4.6	7.96	3.82	4.41	7.64
	0.01	5.27	6.08	10.5	5.06	5.84	10.12

The effects of total quantities of nutrition from fertilizers through the effect of application of pure N on the values of dry biomass production yielded much different results. Comparing the results

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by years, the lowest effect was achieved in 2011 with all mixtures. This is direct consequence of soil moisture deficit in the entire vegetation period. In 2011, the effect of N is lower in the first than in the second cutting, even though the first cutting had bigger growing ratio due to the participation of weed in total biomass (Malić, 2015).

The highest effect of 1 kg of N on dry mass production in the first cutting (of 7,700 kg/ha) is recorded with the TDS-1 mixture, in the third year of research, with the application of 40kg/ha of N. The highest effect of pure N (5,800 kg biomass/ha) is recorded in the second cutting in 2012 with the TDS-3 mixture, with the application of 40kg/ha of N (table 3). The average values of 1kg of N effect on dry biomass production in both cuttings, by years and mixtures, are between 29.52 and 36.32 kg of biomass in 2011, 72.22 and 97.67 kg of biomass in 2012, 88.01 and 115.93 kg of biomass in 2013.

In 2012 and 2013 the effects of N were higher in the first cutting than in the second cutting. This fact is in correlation with the drought started after the first mowing (late June and early July). The effects of application of two nutritious doses of N fertilizer are different with various mixtures and treatment of agromeliorative measures.

The highest effect of application of N fertilizer is recorded with TDS-3 mixture in every year of research (table 3). The smallest average effect is recorded with the TDS-4 mixture (table 4). The best reaction to nutrition affected the results of biggest average values of dry biomass production. The biggest effects by treatments of various mixtures are achieved in the first cutting in 2013. The best effect of nitrogen fertilizers is achieved with precipitation in April-May. As shown in tables indicating the effects of N on the biomass production, the biggest effect is achieved by applying smaller doses of nutrition (40 kg/ha N).

Table values confirm the identical results in N fertilization optimal effect research, pure *Festuca arundinacea* Schreb., seeding in the process of Deposol reclamation at the mine in Stanari where Malić and Lakić (2011) quoted the smallest dose of N nutrition of 40kg/ha. The effects of N gradually declined with the increase of dose. This is similar to the results of other researchs of grassland fertilization intensity (Pamićet al., 1978). According to Prentovićet al. (2007), the best effect is achieved with N doses of 50 kg/ha in the research of mountain grassland fertilization in Macedonia. When researching the production properties of mountain grassland type *Agrostietum vulgaris*, Dubljević (2007) recorded the biggest effect of applied nutrition on increased growth with 90 kg/ha of N, as bigger dose in relation to the effect of fertilizer

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application on technogenic soils. Similar results in fertilization researching for the same type of grassland in western Serbia were found by Vučkovićet al. (2007) who proved that the doses of 100 kg/ha N, 50 kg/ha P_2O_5 and K_2O had the biggest effect in hay increase. Additionally, Stevovicet al. (2011) recorded the highest effect in hay production increase with the smallest dose of N in relation to checking point (50.75 kg of hay out of 1 kg/ha of applied N). Very important fact is that the highest effect is achieved with smaller dose of nutrition (40 kg/ha N) and this fact should be used in future fertilizer standardization with grass-legume mixtures in the process of biological reclamation of technogenic soils in given agro-ecological conditions.

CONCLUSION

Based on the results of research of biological phase of Deposol reclamation at the landfills of overburden from Raskovac open pit in Stanari Mine, by grassland seeding and application of N fertilizer the following may be concluded:

- in the production of dry biomass in the first cutting, the highest average value is recorded with the TDS-3 mixture (2.5 t/ha and 4.5 t/ha) in the initial two years of research and TDS-1 mixture (6.8 t/ha) in the third year;
- the lowest average growth in the first year recoreded with TDS-1 mixture (1.4 t/ha) and the lowest average growth in the following two years with TDS-4 (3.9 t/ha and 5.2 t/ha);
- the biggest average growth of dry biomass in the second cutting in the first year of research is recorded with the TDS-1 mixture (2.2 t/ha), and the biggest average values of 4.6 and 3.9 t/ha are recorded with TDS-3 mixture in the following two years;
- the lowest average values are recorded with the TDS-4 mixture (1.6 t/ha and 2.9 t/ha) in the initial two years of research and with the TS-2 mixture (3.0 t/ha) in the last year;
- the biggest average effect of 1kg of N on dry biomass yield (in both cuttings) in the first year of research is recorded with TDS-1 (42.25 kg of dry biomass), TS-2 (37.04 kg of dry biomass), TDS-3 (43.89 kg of dry biomass) and TDS-4 (31.82 kg of dry biomass);
- the biggest average effect of 1 kg N on dry biomass in the second year is recorded with TDS-1 (104.94 kg of dry biomass), TS-2 (107.41 kg of dry biomass), TDS-3 (128.40 kg of dry biomass) and TDS-4 (77.78 kg of dry biomass);
- maximum application of nutrition had in the third year(effect of 1kg of N = 144.57 kg of dry biomass for TDS-1, 107.41 kg of dry biomass for TS-2, 128.4 kg of dry biomass for TDS-3 and 98.33 kg of dry biomass for TDS-4);

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- the lower dose of N in nutrition had the highest effect on total production of dry biomass with all researched mixtures in initial two years of research, and with TDS-1, TS-2 and TDS-3 in the third year of research.

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Efekat primjene azotnog đubriva na prinos suve biomase sijanog travnjaka u procesu biološke rekultivacije deposola

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IZVOD

U radu su prikazani rezultati trogodišnjeg istraživanja (2011-2013) varijabilnosti ostvarenog prinosa suve nadzemne biomase sijanog travnjaka u zavisnosti od primjene N đubriva. U proučavanju su korišćene tri travno-leguminozne i jedna travna smjesa (ukupno 10 vrsta trava i leguminoza) u procesu biološke faze rekultivacije tehnogenog zemljišta, tipa deposol. Poljsko istraživanje je provedeno u ugljenom basenu Stanari, u Republici Srpskoj (BiH), na platou unutrašnjeg odlagališta otkrivke sa površinskog kopa Raškovac. Sijani travnjaci predstavljaju važnu pokretačku energiju pedogenetskih procesa u rekultivaciji novih zemljišta. Primijenjena su četiri tretmana doza N đubriva (N_1 144, N_2 114, N_3 100, i N_4 130 kg/ha N). N đubrivo je korišćeno u osnovnoj i dopunskoj ishrani travnjaka. Primjena N đubriva na sijanom travnjaku pokazala je značajno variranje prinosa suve biomase. Rezultati su varirali po godinama istraživanja, različitim smjesama i pojedinim otkosima. U 2011. godini efekat N bio je niži u prvom nego u drugom otkosu. U 2012. i 2013. godini efekat N je bio veći u prvom otkosu. Najveći prosječan efekat primjene N đubriva bio je kod smjese TDS-3 po svim godinama istraživanja ($\bar{x}$ 1 kg N iznosio je 36,32 kg u 2011, 97,67 kg u 2012. i 115,93 kg biomase u 2013. godini). Najveći efekat 1 kg N na prinos biomase izračunat je kod smjese TDS-1 na tretmanu N3 u prvom otkosu 2013. godine (190,12). Najmanji efekat 1 kg N na prinos biomase izračunat je kod smjese TDS-1 na tretmanu N3 u prvom otkosu 2011. godine (10,00). Veći efekat je ostvaren kod niže doze primjene N đubriva, što treba uzeti za buduća normiranja đubriva pri đubrenju sijanih travnjaka u procesu rekultivacije deposola.

Ključne riječi: sijani travnjaci, đubrenje, azot, suva masa, tehnogeno zemljište.

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